BAY AREA AIR QUALITY MANAGEMENT DISTRICT

RESOLUTION NO. 2017- 02

RESOLUTION NO. 2017- 03

Resolution No. 2017- 02: A Resolution of the Board of Directors of the Bay Area Air Quality Management District To Certify the Final Environmental Impact Report for the 2017 Clean Air Plan

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Resolution No. 2017- 03: A Resolution of the Board of Directors of the Bay Area Air Quality Management District To Adopt the 2017 Clean Air Plan

WHEREAS, Health & Safety Code Section 40911 requires the air district for a region that has been designated a nonattainment area for a state ambient air quality standard for ozone, carbon monoxide, sulfur dioxide, or nitrogen dioxide to prepare a plan for attaining and maintaining the standard;

WHEREAS, the San Francisco Bay Area Air Basin has been designated by the California Air Resources Board as a nonattainment area for the state ambient eight-hour ozone standard of 0.070 ppm and a "serious" nonattainment area for the state ambient one-hour ozone standard of 0.09 ppm (jointly, "state ozone standards") in accordance with sections 39608 and 40921.5 of the California Health & Safety Code, but as an attainment area for the other pollutants listed in Health and Safety Code Section 40911;

WHEREAS, the Bay Area Air Quality Management District ("District") is therefore required by Health and Safety Code Section 40911 to prepare a plan to attain the state ozone standards;

WHEREAS, the District initially adopted a Clean Air Plan pursuant to Health & Safety Code Section 40911 in 1991;

WHEREAS, Health & Safety Code Section 40925 requires air districts to update or revise their plans every three years;

WHEREAS, the District has periodically adopted subsequent Clean Air Plans since 1991 to update and revise the District's plan in accordance with Health & Safety Code Section 40925;

WHEREAS, District staff have prepared the 2017 Clean Air Plan, as presented to the Board of Directors and proposed for adoption at a public meeting of the Board of Directors on April 19, 2017, a copy of which is attached hereto and incorporated herein by reference, in order to further and update and revise the District's plan in accordance with Health & Safety Code Section 40925;

WHEREAS, Health & Safety Code Section 40914 requires the plan to be designed to achieve a District-wide reduction of ozone precursors of five percent per year averaged over three years, or alternatively, if a five percent per year reduction cannot be achieved, to include in the plan all feasible measures on an expeditious adoption schedule;

WHEREAS, the District is not able to achieve a five percent per year reduction in ozone precursor emissions, but in accordance with Health & Safety Code Section 40914(b) the 2017 Clean Air Plan instead includes all feasible measures, an expeditious adoption schedule, and a commitment to continue to measure progress toward attainment of the state ozone standards using the best available information and techniques;

WHEREAS, Health & Safety Code Section 40924(b) requires air districts to assess their progress toward attainment of the state ambient air quality standards every three years and to incorporate that triennial assessment into their triennial plan updates or revisions;

WHEREAS, the 2017 Clean Air Plan includes the assessment of the District's progress toward attainment of the state ambient air quality standards as required by Health & Safety Code Section 40924(b);

WHEREAS, the Health and Safety Code imposes certain other requirements and obligations on the District as described in Appendix A of the 2017 Clean Air Plan, which the Air District is complying with as described in Appendix A and elsewhere in the 2017 Clean Air Plan;

WHEREAS, the 2017 Clean Air Plan is intended to serve as a multi-pollutant plan addressing not only ground level ozone and its precursor pollutants, but also particulate matter and its precursor pollutants, air toxics, and greenhouse gases, in order to reduce pollution, protect public health and the environment, and address global climate change;

WHEREAS, the 2017 Clean Air Plan was developed through an extensive public outreach process, which included (i) a kick-off public workshop in February 2014 to begin the process of updating the 2010 Clean Air Plan, (ii) eight county stakeholder meetings in February and March of 2014 to introduce interested members of the public to the air quality planning process, (iii) an initial round of public working group sessions, comprising nine meetings in total from December of 2014 through April of 2015, to review and develop the Plan's economic sector analyses of potential control measures, (iv) six "open house" public meetings in January and February of 2016 to provide the public with information about the development of the Plan's control measures and solicit additional ideas for control measures, (v) a second round of public working group sessions in April of 2016, comprising a further four meetings, to review the revised economic sector analyses, and (vi) eight additional open houses in January and February of 2017 to present and receive comments on the Draft 2017 Plan;

WHEREAS, District staff also engaged in a variety of written outreach efforts, including email notices and a web page on the District's website to keep interested members of the public up to date with current information and documentation regarding the development of the 2017 Plan;

WHEREAS, in addition to English, District staff conducted its public outreach efforts in Spanish, Vietnamese, Tagalog, and Chinese in an effort to engage as many different stakeholders as possible throughout the Bay Area;

WHEREAS, as a result of these public outreach efforts, the District received comments, suggestions and input on the Draft 2017 Plan from approximately 370 individuals, organizations and other entities;

WHEREAS, District staff have reviewed and considered all of the comments received and have revised the Draft 2017 Plan accordingly, as reflected in the Final 2017 Plan, and have prepared written responses to the comments that have been provided to the Board of Directors for review;

WHEREAS, the 2017 Clean Air Plan complies with the applicable terms and conditions of Health & Safety Code Sections 40910 et seq. governing district plans to attain the state ambient ozone standards, including but not limited to the provisions referred to above, and specifically including Health & Safety Code Section 40914(b)(2), which authorizes and requires the preparation of a plan that includes all feasible control measures with an expeditious adoption schedule for those measures;

WHEREAS, the proposed adoption of the 2017 Clean Air Plan constitutes a "project" pursuant to the California Environmental Quality Act ("CEQA") (Public Resources Code §§ 21000 et seq.);

WHEREAS, the District is the lead agency for this project under CEQA Guidelines section 15050 (14 California Code of Regulations section 15050);

WHEREAS, District staff caused to be prepared an environmental impact report ("EIR") analyzing the potential environmental impacts of the 2017 Clean Air Plan in accordance with the requirements of CEQA;

WHEREAS, District staff caused a Draft EIR to be prepared and publicized for review and comment by interested members of the public and others as required by CEQA;

WHEREAS, on or before February 17, 2017, the District published the Draft EIR and provided notification to the public and to other interested parties, via newspaper advertisement, email notifications, and on the District's website (among other means), that the Draft EIR was complete and was available for public review and comment;

WHEREAS, the public notification materials published by the District (i) informed the public that the Draft EIR was available on the District website and by request to the District and (ii) invited public comments on the Draft EIR during the period from February 17, 2017, to April 3, 2017;

WHEREAS, on March 20, 2017, the District held a public meeting to discuss the Draft EIR and to receive comment from the public and other interested parties on the Draft EIR;

WHEREAS, the District received 17 written comment letters during the 45-day public review and comment period, as well as three oral comments at the March 20, 2017, public meeting;

WHEREAS, District staff considered all of the comments received and has prepared a Final EIR, which incorporates certain revisions to the Draft EIR based on the comments received as well as other considerations, and which includes copies of the comments received as well as written responses to the comments prepared by District staff;

WHEREAS, the Final EIR, a copy of which is attached hereto and incorporated herein by reference, was presented to the Board of Directors and proposed for certification by the Board of Directors at a public meeting of the Board of Directors on April 19, 2017,

WHEREAS, none of the revisions to the Draft EIR include any significant new information that would require recirculation of the Draft EIR under CEQA Guidelines Section 15088.5;

WHEREAS, the EIR found that the 2017 Clean Air Plan will have the potential to create a significant adverse impact on water demand that cannot be mitigated to a level that is less than significant, as described in Chapter 3.5 of the Final EIR;

WHEREAS, the EIR includes mitigation measures as specified in Section 3.5.8 of Chapter 3.5 which, if adopted, will constitute changes or alterations required for the project to avoid or substantially lessen the significant water demand impact identified in the EIR, as explained in detail in Section 1.2.5 of Chapter 1 of the Final EIR;

WHEREAS, substantial evidence in the record demonstrates that approval of the 2017 Clean Air Plan involves specific considerations related to the need to reduce air pollution and protect public health and the environment that make the alternatives identified in the EIR that would avoid or substantially lessen the significant water demand impacts infeasible, as explained in detail in Section 1.2.5 of Chapter 1 of the Final EIR;

WHEREAS, substantial evidence in the record demonstrates that the significant and unavoidable water demand impact is acceptable as provided in Guidelines Section 15093 because the public health, air quality and climate protection benefits from the 2017 Clean Air Plan outweigh the Plan's significant unavoidable water demand impact, as explained in detail in Section 1.2.6 of Chapter 1 of the Final EIR;

WHEREAS, this matter has been duly noticed and heard in compliance with applicable requirements of the Health & Safety Code and the Public Resources Code;

WHEREAS, the documents and other materials that constitute the record of proceedings on which the 2017 Clean Air Plan and the Final EIR are based are located at the Bay Area Air Quality Management District, 375 Beale Street, Suite 600, San Francisco, 94105, and the custodian for these documents is Marcy Hiratzka, Clerk of the Boards;

WHEREAS, District staff provided copies of (i) the 2017 Clean Air Plan, and (ii) the Final EIR, including the comments received on the Draft EIR and staff's responses thereto, to each of the members of the Board of Directors for their review and consideration in advance of the public meeting of the Board of Directors on April 19, 2017;

WHEREAS, District staff has recommended that the Board of Directors adopt the 2017 Clean Air Plan, which includes the triennial assessment of the Bay Area Air Quality Management District's progress toward attaining the state ambient ozone standards, as being in compliance with all applicable Health & Safety Code sections;

WHEREAS, the Board of Directors concurs with recommendations of District staff regarding the 2017 Clean Air Plan;

WHEREAS, District staff has recommended that the Board of Directors certify the Final EIR, which was prepared as the CEQA document for the 2017 Clean Air Plan, as being in compliance with all applicable requirements of CEQA;

WHEREAS, the Board of Directors concurs with recommendations of District staff regarding the Final EIR for the 2017 Clean Air Plan;

WHEREAS, the Board of Directors took a vote on certifying the Final EIR for the 2017 Clean Air Plan;

WHEREAS, the Board of Directors subsequently took a separate vote on adoption of the 2017 Clean Air Plan;

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RESOLUTION NO. 2017-02
TO CERTIFY THE FINAL EIR FOR THE 2017 CLEAN AIR PLAN

NOW, THEREFORE, BE IT RESOLVED that the Board of Directors of the Bay Area Air Quality Management District does hereby certify and adopt the Final EIR for the 2017 Clean Air Plan, a copy of which is attached hereto and incorporated herein by reference.

BE IT FURTHER RESOLVED that in support of and as part of its certification and adoption of the Final EIR for the 2017 Clean Air Plan, the Board of Directors hereby makes the following findings and certifications:

1. The Final EIR for the 2017 Clean Air Plan has been prepared in accordance with all requirements of CEQA.

2. The Final EIR for the 2017 Clean Air Plan was duly presented to the Board of Directors for its consideration in accordance with CEQA and other applicable legal requirements.

3. The Board of Directors has reviewed and considered the information in the Final EIR and the evidence in the record described and summarized in the Final EIR, including but not limited to (i) the Final EIR's conclusion that the 2017 Clean Air Plan will have a significant water demand impact as described in Chapter 3.5 of the Final EIR, (ii) the mitigation measures proposed to mitigate the significant water demand impact outlined in Section 3.5.8 of Chapter 3.5 of the Final EIR, and (iii) the alternatives considered to avoid or substantially lessen the significant water demand impact that are evaluated in Chapter 4 of the Final EIR.

4. The Board of Directors specifically approves and adopts the mitigation measures outlined in Section 3.5.8 of Chapter 3.5 of the Final EIR, which are incorporated by reference as if fully set forth herein, to mitigate the 2017 Clean Air Plan's significant water demand impact. No additional feasible mitigation measures have been identified that can further mitigate the significant water demand impact.

5. The Board of Directors finds that the mitigation measures specified in Section 3.5.8 of Chapter 3.5 of the Final EIR and adopted pursuant to this Resolution constitute changes or alterations required for the project to avoid or substantially lessen the significant water demand impact identified in the Final EIR. In making this finding, the Board of Directors has considered and agrees with the reasons supporting this finding as set forth in Section 1.2.5 of Chapter 1 of the Final EIR, which are incorporated by reference as if fully set forth herein and which the Board of Directors adopts as its own.

6. The Board of Directors specifically approves and adopts the Mitigation Monitoring and Reporting Program set forth in Section 1.9 of Chapter 1 of the Final EIR, which is incorporated by reference as if fully set forth herein.

7. The analysis of alternatives set forth in Chapter 4 the Final EIR has provided the Board of Directors with a basis for considering ways in which the significant water demand impact could be avoided or substantially lessened while still achieving all or most of the Plan's objectives. The alternatives analysis in the Final EIR is sufficient to carry out the purposes of such analysis under CEQA.

8. The Board of Directors finds that there is a pressing need to reduce air pollution and to protect public health and the environment, which the 2017 Clean Air Plan addresses. The Board of Directors finds that the benefits that will be obtained from the 2017 Clean Air Plan in addressing this need constitute specific considerations that make the alternatives identified in the Final EIR to avoid or significantly lessen the Plan's significant water demand impact infeasible. In making this finding, the Board of Directors has considered and agrees with the reasons supporting the finding as set forth in Section 1.2.5 of Chapter 1 of the Final EIR, which are incorporated by reference as if fully set forth herein and which the Board of Directors adopts as its own.

9. The Final EIR (including responses to comments) is complete, adequate and in full compliance with CEQA as a basis for considering and acting upon the proposed 2017 Clean Air Plan.

10. The Final EIR reflects the independent judgment and analysis of the Bay Area Air Quality Management District.

11. The Board of Directors has exercised its own independent judgment in reviewing, considering and certifying the Final EIR and in making the findings and certifications set forth in this Resolution, which reflects the independent judgment and analysis of the Board of Directors.

12. The documents and other materials that constitute the record of proceedings upon which the Board of Directors bases this Resolution and the findings and certifications contained herein are located at the Bay Area Air Quality Management District, 375 Beale Street, Suite 600, San Francisco, 94105; and the custodian for these documents and other materials is Marcy Hiratzka, Clerk of the Boards.

* * * * *

The foregoing Resolution was duly and regularly introduced, passed and adopted at a regular meeting of the Board of Directors of the Bay Area Air Quality Management District on the Motion of Director GROOM, seconded by Director BARRETT, on the 19th day of April, 2017, by the following vote of the Board:

AYES: ABE-KOGA, BARRETT, CANEPA, CHAVEZ, CUTTER, GIOIA, GROOM, HUDSON, JUE, KIM, MITCHOFF, RICE, RONEN, ROSS, SANCHEZ, SINKS, SPERING, WAGENKNECHT

NOES: NONE

ABSTAIN: NONE

ABSENT: HAGGERTY, KAPLAN, KNISS, MILEY, SHEEHY, ZANE

Hon. David Hudson
Vice-Chairperson of the Board of Directors

ATTEST:

Hon. Katie Rice
Secretary of the Board of Directors

RESOLUTION NO. 2017-03
TO ADOPT THE 2017 CLEAN AIR PLAN

NOW, THEREFORE, BE IT RESOLVED that the Board of Directors of the Bay Area Air Quality Management District does hereby adopt the 2017 Clean Air Plan, a copy of which is attached hereto and incorporated herein by reference.

BE IT FURTHER RESOLVED that in support of and as part of its adoption of the 2017 Clean Air Plan, the Board of Directors hereby makes the following findings and certifications:

1. The 2017 Clean Air Plan provides for attainment of the state ozone standards as expeditiously as practicable.

2. The 2017 Clean Air Plan includes every feasible measure to reduce emissions of ozone-forming precursors and an expeditious adoption schedule.

3. The 2017 Clean Air Plan fulfills all of the District's clean air plan obligations under Health & Safety Code Sections 40910 et seq. for attainment of the state ozone standards, including but not limited to the applicable requirements to address transported air pollution.

4. The Board of Director's approval of the 2017 Clean Air Plan is based on and supported by (among other things) the Board's consideration of the Final EIR for the 2017 Clean Air Plan.

5. The Board of Directors has balanced the benefits of the 2017 Clean Air Plan against the Plan's unavoidable environmental risks in determining whether to approve the Plan. The Board of Directors finds that the 2017 Clean Air Plan's benefits in reducing air pollution and protecting public health and the global climate outweigh the adverse impact from the increase in water demand that is expected to result from implementing the Plan. The Board of Directors therefore finds that the significant water demand impact from the 2017 Clean Air Plan is acceptable pursuant to Section 15093 of the CEQA Guidelines, 14 Cal. Code Regs. § 15093; and makes this finding as a "Statement of Overriding Considerations" pursuant to Section 15093. The specific reasons supporting this finding and Statement of Overriding Considerations are as follows:

    a. The Board of Directors has considered the water demand increase of 2.5-3.5 million gallons per day that is expected to result from the 2017 Clean Air Plan, which the Board of Directors has evaluated in light of the significant adverse impact the increase will have on the region's water supply resources as described in Chapter 3.5 of the Final EIR, and also in light of the Bay Area's total water usage of over one billion gallons per day, as well as the fact that the recent drought that has made water supply issues an especially acute concern over the past few years is now over.

b. The Board of Directors has balanced the adverse impact from this increase in water demand against the very significant air quality, public health, and climate benefits that the 2017 Clean Air Plan will achieve, which include (i) emission reductions of approximately 23,000 pounds per day of reactive organic gases, 19,000 pounds per day of oxides of nitrogen, 6,000 pounds per day of fine particulate matter, and over 16,500 pounds per day of sulfur dioxide; (ii) substantial reductions in emissions of toxic air contaminants such as diesel particulate; and (iii) a reduction in greenhouse gas emissions of 4.4 million metric tons CO_2-equivalent (MMT CO_2e) calculated using 100-year global warming potential (GWP) factors, or up to 5.6 MMT CO_2e if 20-year GWP factors are used.

c. These emission reductions will provide benefits to air quality and public health throughout the Bay Area, as well as helping to address the global challenge of climate change. The 2017 Clean Air Plan estimates that these benefits will include 76 fewer cases of premature mortality, 296 fewer cases of chronic and acute bronchitis, 16 fewer hospital admissions, 29 fewer asthma emergency room visits, 44 fewer nonfatal heart attacks, 10,189 fewer respiratory symptoms, 9,128 fewer lost work days, and 51,403 fewer minor restricted activity days. In terms of economic benefits, the total estimated benefits from reduced incidence of illness and premature mortality is on the order of $736 million per year.

d. These emission reductions will also help the Bay Area Air Quality Management District comply with its legal obligations to meet state and federal clean air goals, including but not limited to the state ozone standards.

e. The greenhouse gas emission reductions embodied in the 2017 Clean Air Plan represent an important step on the road to achieving the Bay Area's and California's greenhouse gas emission reduction goals. Global climate change cannot be addressed without aggressive action to reduce greenhouse gas emissions at the local, regional, state, national and global level. The 2017 Clean Air Plan will allow the Bay Area Air Quality Management District to play its part in addressing this challenge.

f. In addition to the reasons outlined in subparagraphs a.-e. above, the Board of Directors has reviewed and considered the more detailed summary of reasons why the 2017 Clean Air Plan's benefits in reducing air pollution and protecting public health and the global climate outweigh the Plan's adverse water demand impact set forth in Section 1.2.6 of Chapter 1 of the Final EIR for the 2017 Clean Air Plan. The Board of Directors agrees with the reasons set forth therein, and it adopts those reasons as its own and incorporates them by reference as if fully set forth herein as specific reasons supporting this finding and Statement of Overriding Considerations.

g. The Board of Directors further declares that it will be the goal of the Air District to achieve an interim greenhouse gas reduction target of 40% below 1990 levels by 2030 within the Bay Area, consistent with the Statewide 2030 goal codified in SB32.

The foregoing Resolution was duly and regularly introduced, passed and adopted at a regular meeting of the Board of Directors of the Bay Area Air Quality Management District on the Motion of ~~Director~~ SECRETARY RICE, seconded by Director WAGENKNECHT, on the 19th day of April, 2017, by the following vote of the Board:

AYES: ABE-KOGA, BARRETT, CANEPA, CHAVEZ, CUTTER, GIOIA, GROOM, HUDSON, JUE, KIM, MITCHOFF, RICE, RONEN, ROSS, SANCHEZ, SINKS, SPERING, WAGENKNECHT

NOES: NONE

ABSTAIN: NONE

ABSENT: HAGGERTY, KAPLAN, KNISS, MILEY, SHEEHY, ZANE

Hon. David Hudson
Vice-Chairperson of the Board of Directors

ATTEST:

Hon. Katie Rice
Secretary of the Board of Directors

Pertaining to BAAQMD Resolution No. 2017-03,
Adopting the 2017 Clean Air Plan

SPARE THE AIR· COOL THE CLIMATE

A BLUEPRINT FOR CLEAN AIR AND CLIMATE PROTECTION IN THE BAY AREA

FINAL 2017 CLEAN AIR PLAN

BAY AREA
AIR QUALITY
MANAGEMENT
DISTRICT

ADOPTED APRIL 19, 2017

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

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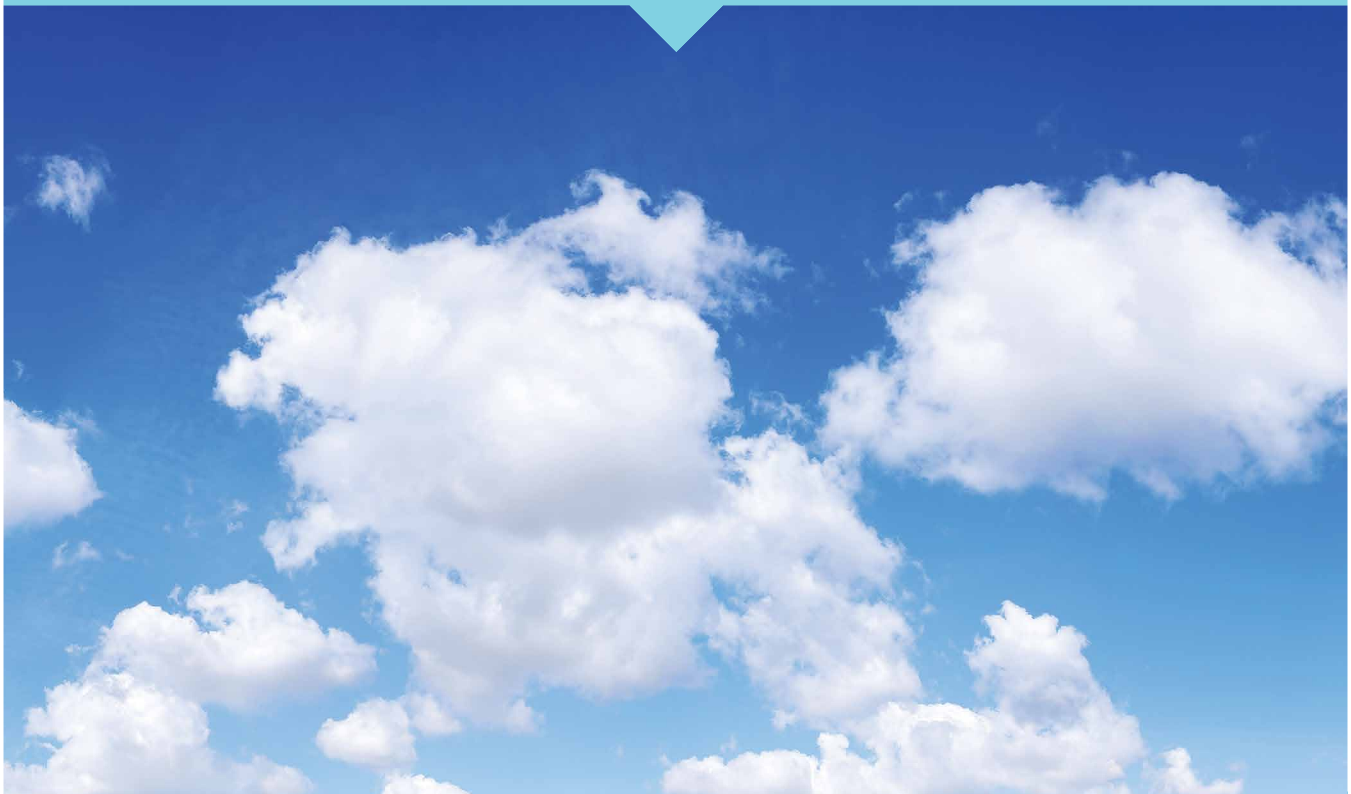


EXECUTIVE SUMMARY

The Challenge

Since its formation in 1955 as the first regional air quality agency in the nation, the Bay Area Air Quality Management District (Air District) has led the effort to reduce air pollution and protect public health in the region. Over the past 60 years, we have made great progress in improving air quality throughout the San Francisco Bay Area, while the population and economic output of the region have increased tremendously. Population exposure to unhealthy levels of ozone and particulate matter, and cancer risk from exposure to toxic air contaminants, have all been greatly reduced.

But further progress is needed. As science has improved and progressed, we continue to learn more about the harmful impacts of air pollution. Some Bay Area communities and populations are disproportionately impacted by air pollution. And climate change—which has already begun to impact the region, state and world—threatens to degrade air quality and to potentially jeopardize the health and well-being of Bay Area residents, especially in the most vulnerable communities. To protect public health and stabilize the climate, we must take aggressive action to eliminate fossil fuel combustion and transition to a post-carbon economy.

Transitioning to a post-carbon economy presents a daunting challenge. But this challenge provides a tremendous opportunity for the region to develop new technologies, solutions, and ideas that will help California continue to lead the nation and ensure our continued viability and prosperity as a region. By so doing, we can protect the environment and the climate that make the Bay Area a great place to live, while leading the way toward the innovative policies and technologies that will drive economic change and promote social equity in the 21st century.

Climate change is a global problem. No single region or agency can solve the climate challenge on its own. But in the face of uncertainty at the national level, it is imperative that Bay Area residents, businesses and institutions step up to the challenge and provide leadership. Region-wide action may provide an example of metropolitan-scale solutions to improve air quality and protect the climate; an example that may be replicated throughout California, the United States and beyond.

To help accomplish the long-range vision described in this plan, the Air District will deploy all its tools and resources to continue reducing emissions of air pollutants and greenhouse gases (GHGs) in the Bay Area. But recognizing that climate change represents a profound and long-term challenge, the Air District will also step up to expand its role by fostering research and innovation, developing new partnerships, convening stakeholders, educating Bay Area residents about how they can reduce GHG emissions, and providing leadership as part of the overall regional effort to protect the climate.

Goals and Objectives

The 2017 Clean Air Plan, *Spare the Air, Cool the Climate* (2017 Plan), focuses on two closely-related goals: protecting public health and protecting the climate. Consistent with the GHG reduction targets adopted by the state of California, the plan lays the groundwork for a long-term effort to reduce Bay Area GHG emissions 40 percent below 1990 levels by 2030 and 80 percent below 1990 levels by 2050.

To help describe what it will take to achieve the ambitious GHG reduction target for 2050, the Plan offers a long-range vision of how the Bay Area could look and function in a year 2050 post-carbon economy, and describes a comprehensive control strategy that the Air District will implement over the next three to five years to protect public health and protect the climate, while setting the region on a pathway to achieve the 2050 vision.

The 2017 Plan updates the most recent Bay Area ozone plan, the *2010 Clean Air Plan,* pursuant to air quality planning requirements defined in the California Health & Safety Code.[1] To fulfill state ozone planning requirements, the 2017 control strategy includes all feasible measures to reduce emissions of ozone precursors—reactive organic gases (ROG) and nitrogen oxides (NO_x)—and reduce transport of ozone and its precursors to neighboring air basins. In addition, the Plan builds upon and enhances the Air District's efforts to reduce emissions of fine particulate matter and toxic air contaminants.

The Vision for 2050

By visualizing what the Bay Area may look like in a post-carbon year 2050—where we will live, how we will travel, what we will produce, and what we will consume—we can better discern the policies and actions that we, as a region, need to take in the near- to mid-term to embark on the transformation. The Plan describes a vision for a thriving region with clean air, a stable climate, a robust natural environment and a prosperous and sustainable economy. The vision for 2050 can be briefly summarized as follows.

Where We Live and Work: Buildings

By 2050 the buildings in which we live, work, learn, shop and socialize will be energy efficient, and they will be heated, cooled, and powered by renewable energy.

To eliminate the use of fossil fuels in buildings, we will need to:

- Maximize energy efficiency in both new and existing buildings. Stringent standards already apply to new buildings. However, efforts to retrofit existing commercial and residential buildings will need to be greatly expanded.
- Increase production of on-site renewable energy such as rooftop solar.
- Develop and deploy technologies for on-site energy storage.
- Switch from natural gas to clean electricity, or other renewable energy, for space and water heating, clothes drying, cooking, and other domestic uses.

To reduce emissions of particulate matter (PM) and black carbon, we will also need to eliminate wood burning.

How and Where We Travel: Transportation

By 2050 the transportation sector will be transformed. We will travel by a combination of electric vehicles, both shared and privately-owned; autonomous public transit fleets offering both fixed-route and flexible-route service; with a large share of trips by bicycling, walking and transit.

- New development will need to offer safe and convenient access to jobs, shopping and services by transit, bicycle and walking.
- The majority of trips will need to be made by walking, bicycling, riding transit or sharing vehicles.
- Nearly 90 percent of the motor vehicle fleet will need to be zero emission. Heavy-duty vehicles will need to be powered by electricity, or by renewable forms of diesel or other low-carbon liquid fuels.
- New technologies and services will reduce the need for personal vehicle ownership. Car-sharing services, transportation network companies, and autonomous electric-powered vehicles will greatly reduce emissions of air pollutants and greenhouse gases from transportation.

What We Produce: Sustainable Production

By 2050 the Bay Area economy will be powered by clean, renewable electricity. The region will be a leading incubator and producer of clean energy technologies, and Bay Area industry will lead the world in the carbon-efficiency of our products.

- A smart grid interconnecting renewable energy sources will be needed in order to provide nearly 100 percent renewable electricity.
- Bay Area industries will need to be powered by carbon-free electricity and biofuels.
- The carbon-intensity of products—the amount of carbon emissions associated with making a given product—manufactured in the region will need to be greatly reduced.
- The Bay Area will need to become a hub for the development and production of innovative renewable energy technologies, creating solid jobs requiring diverse education and skills.

What We Consume: "Conscientious Consumption"

By 2050, Bay Area residents will need to develop a low-carbon lifestyle. We will greatly reduce our personal GHG consumption (our "GHG footprint") by driving electric vehicles, living in zero net-energy homes, eating low-carbon foods, and purchasing goods and services with low carbon content. Waste will be greatly reduced, any waste *products will be re-used or recycled, and all organic waste will be composted and put to productive use.*

- The Air District and partner agencies will develop information campaigns to help Bay Area residents understand the active role they can play in reducing GHG emissions. This will include providing information on the factors that influence their GHG footprint and resources to help make effective choices to reduce their personal GHG footprint.
- Bay Area residents will need to reduce their consumption of carbon-intensive foods and adopt a low-carbon diet for at least some portion of their meals.
- Food waste will need to be greatly reduced and all organic matter will need to be diverted from the waste stream and put to productive use.

Pollutants Addressed

The 2017 Plan describes a multi-pollutant strategy to simultaneously reduce emissions and ambient concentrations of ozone, fine particulate matter, toxic air contaminants, as well as greenhouse gases that contribute to climate change. Each category of pollutant is briefly described below.

Ozone: Ozone (O_3), often called smog, is formed by photochemical reactions of precursor chemicals, known as ROG and NO_X, in the presence of sunlight. Exposure to ozone can damage the lungs and aggravate respiratory conditions such as asthma, bronchitis and emphysema. Motor vehicles and industrial sources are the largest sources of ozone precursors in the Bay Area.

Emissions of ozone precursors have been greatly reduced in recent decades. As a result, Bay Area ozone levels and population exposure to harmful levels of smog have decreased substantially. Despite this progress, the Bay Area does not yet fully attain state and national ozone standards. This is primarily due to the progressively tightened national ozone standard, but also to the amount of population and economic growth occurring within the Bay Area. Therefore, we need to further reduce emissions of ozone precursors. This is especially important because rising temperatures associated with climate change are expected to increase emissions of ozone precursors and smog formation.

Particulate matter: Fine particulate matter ($PM_{2.5}$), a diverse mixture of suspended particles and liquid droplets (aerosols), is the air pollutant most harmful to the health of Bay Area residents. Exposure to fine PM, on either a short-term or long-term basis, can cause a wide range of respiratory and cardiovascular health effects, including strokes, heart attacks and premature deaths. Combustion of fossil fuels and wood (primarily residential wood-burning) are the primary sources of $PM_{2.5}$ in the Bay Area. Emissions and ambient concentrations of PM have both been greatly reduced in recent years. As a result, the Bay Area currently meets national and state standards for both daily and annual average levels of $PM_{2.5}$.[2] Despite this progress, some Bay Area communities are still impacted by localized concentrations of PM. In addition, health studies find negative health impacts from exposure to PM even below the current standards. Therefore, we need to continue our efforts to further reduce PM emissions.

Toxic Air Contaminants: Toxic air contaminants (TACs) are a class of pollutants that includes hundreds of chemicals hazardous to human health. Long-term exposure to TACs may cause more severe health effects such as neurological damage, hormone disruption, developmental defects and cancer. Because TAC emissions are highly localized, exposure to TACs is a key criterion that the Air District uses to identify communities that are disproportionately impacted by air pollution. The average cancer risk from TACs in the Bay Area has been reduced by 80 percent since 1990. The Air District will continue working to reduce TACs with the goal of eliminating disparities in health risks from TACs among Bay Area communities.

Greenhouse Gases: The principal greenhouse gases that contribute to global warming and climate change include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), as well as black carbon and fluorinated gases (F-gases): hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). After increasing rapidly in past decades, GHG emissions throughout California and the Bay Area have leveled off. However, in order to prevent the most dangerous climate change scenarios, we must reduce GHG emissions greatly. It is especially important to rapidly reduce emissions of those GHGs with very high global warming potential, such as methane, black carbon, and F-gases, which we refer to as "super-GHGs" in this document. (The Air Resources Board refers to these compounds as short-lived climate pollutants or SLCPs.) To provide a roadmap, the 2017 Plan describes an ambitious strategy to reduce GHG emissions in order to protect the climate.

The 2017 Control Strategy

The 2017 Plan defines an integrated, multi-pollutant control strategy to reduce emissions of particulate matter, TACs, ozone precursors and greenhouse gases. The proposed control strategy is designed to complement efforts to improve air quality and protect the climate that are being implemented by partner agencies at the state, regional and local scale. The control strategy encompasses 85 individual control measures that describe specific actions to reduce emissions of air and climate pollutants from the full range of emission sources. The control measures are categorized based upon the economic sector framework used by the Air Resources Board for the AB 32 Scoping Plan Update. The sectors include:

Stationary (Industrial) Sources
Transportation
Energy
Buildings
Agriculture
Natural and Working Lands
Waste Management
Water
Super-GHG Pollutants

In addition to fostering consistency with climate planning efforts at the state level, the economic sector framework also ensures that the control strategy addresses all facets of the economy.

The proposed control strategy is based on four key priorities:

- Reduce emissions of criteria air pollutants and toxic air contaminants from all key sources.
- Reduce emissions of "super-GHGs" such as methane, black carbon and fluorinated gases.
- Decrease demand for fossil fuels (gasoline, diesel and natural gas).
    - Increase efficiency of our industrial processes, energy and transportation systems
    - Reduce demand for vehicle travel, and high-carbon goods and services.
- Decarbonize our energy system.
    - Make the electricity supply carbon-free.
    - Electrify the transportation and building sectors.

Key elements in the control strategy are briefly described below.

Stationary sources:

- Decrease emissions of GHGs and criteria air pollutants through a region-wide strategy to reduce combustion and improve combustion efficiency at industrial facilities, beginning with the three largest sources of emissions: oil refineries, power plants and cements plants.
- Reduce methane emissions from landfills, and from oil and natural gas production and distribution.
- Reduce emissions of toxic air contaminants by adopting more stringent thresholds and methods for evaluating toxic risks at existing and new facilities.

Transportation:

- Reduce motor vehicle travel by promoting transit, bicycling, walking and ridesharing.
- Implement pricing measures to reduce travel demand.

- Direct new development to areas that are well-served by transit, and conducive to bicycling and walking.
- Accelerate the widespread adoption of electric vehicles.
- Promote the use of clean fuels and low- or zero-carbon technologies in trucks and heavy-duty equipment.

Buildings and energy:

- Expand the production of low-carbon, renewable energy by promoting on-site technologies such as rooftop solar, wind and ground-source heat pumps.
- Support the expansion of community choice energy programs throughout the Bay Area.
- Promote energy and water efficiency in both new and existing buildings.
- Promote the switch from natural gas to electricity for space and water heating in Bay Area buildings.

The Air District's Tools and Resources

To implement the 2017 control strategy, the Air District will draw upon all the tools and resources at its disposal, including:

- *Rulemaking:* Use its regulatory and permitting authority to adopt and enforce rules to reduce emissions of air and climate pollutants.
- *Funding:* Provide funds and incentives through its grant and incentive programs and other sources.
- *Best Practices:* Develop and promote the use of best practices by public agencies and other entities by means of model ordinances, general plan, specific plan, CEQA and other planning guidance documents, informational campaigns, etc.

- *Informational resources:* Conduct marketing or media campaigns, disseminate educational materials, engage with community groups and other organizations.
- *Advocacy:* Support legislative action at the federal or state level and advocate for funding to support implementation of the measures in the 2017 control strategy.
- *Partnerships:* Work actively within the region and the state to develop partnerships that can enable business, local government and residents to work and learn together to develop viable air pollution and GHG reduction strategies.

What the 2017 Plan Will Accomplish

The 2017 Plan focuses on protecting public health and protecting the climate.

Protecting public health: The proposed control strategy will reduce emissions of the air pollutants that pose the greatest health risk to Bay Area residents. The strategy will decrease population exposure to PM and TACs in the communities that are most impacted by air pollution, and reinforce the Air District's commitment to protect public health in these communities, with a goal of eliminating disparities in exposure to air pollution between communities. The Plan will ensure that the Bay Area continues to meet fine PM standards, while continuing progress toward attaining state and national ozone standards.

The proposed control measures are estimated to reduce emissions of ROG by approximately 11 tons per day, NO_x by 9.3 tons per day, and $PM_{2.5}$ by 3.1 tons per day. These emission reductions are expected to decrease illness and premature mortality. The estimated dollar value of the avoided costs related to health care, lost productivity, and premature death is on the order of $736 million per year.[3]

Protecting the climate: The proposed control measures will reduce emissions of greenhouse gases by approximately 4.4 million metric tons of GHGs on a CO_2-equivalent basis per year by 2030, based on 100-year global warming potential factors and 5.6 MMT based on 20-year global warming potential factors, and set us on a course for deeper GHG reductions that will be needed to achieve the 2050 target. Using a value of $62 per metric ton of CO_2-equivalent to estimate the avoided social and economic costs related to the anticipated impacts of climate change, the GHG reductions from the 2017 Plan control strategy will have an estimated value of approximately $350 million per year (based on 20-year global warming potential).[4]

Moving Forward

The 2017 Plan provides a comprehensive strategy to improve air quality, protect public health, and protect the climate, utilizing all the tools and resources available to the Air District. In addition to reducing emissions of air pollutants and greenhouse gases in the Bay Area over the near term, the 2017 Plan is intended to set us on the pathway for the long-term transformation to a post-carbon future. To implement the Plan, the Air District will collaborate with government agencies, environmental and community groups and other non-profits, the business sector, academic institutions and Bay Area residents.

By taking aggressive action to protect the climate, we can ensure that the Bay Area continues to lead in the development of social and technological innovations that will transform our economy in the coming decades and create a sustainable Bay Area as described in the 2050 vision presented in Chapter 1.

We believe the 2017 Plan can inspire action elsewhere by providing an example of metropolitan-scale solutions to improve air quality and protect the climate that can be replicated throughout California, the nation and the world.

FOOTNOTES

[1] The 2017 Plan responds to planning requirements pursuant to state law only. The Plan does not address federal air quality planning requirements, nor is it part of a State Implementation Plan for federal air quality planning purposes.

[2] Although monitoring data shows that the Bay Area meets national and state standards for $PM_{2.5}$, the Bay Area is still formally designated as non-attainment for several $PM_{2.5}$ standards. In regard to the national standards, the non-attainment designation will continue to apply until the Air District submits, and the U.S. EPA approves, a re-designation request and a maintenance plan, as discussed in Chapter 2.

[3] See Appendix C for how the dollar value of estimated health benefits were quantified.

[4] The social cost of $62 per metric ton of CO_2e reduced is used per U.S. EPA guidance.

CHAPTER 1
PURPOSE AND VISION

We stand at a crossroads in human history. Rapid advances in science and technology over the past two centuries have brought unparalleled—albeit uneven—material prosperity and improved our quality of life. But our achievements and our prosperity rest upon a fragile foundation. Our material progress has imposed a heavy cost on the air we breathe, the water we drink, and the ecosystems and climate that sustain us.

Climate change, caused by human-produced emissions of carbon dioxide and other greenhouse gases, represents a profound threat to our health and well-being. If left unchecked, climate change will have major impacts on the region's natural systems, water supply, economy and infrastructure. A hotter climate will also degrade air quality, thus compromising the health of Bay Area residents. As atmospheric concentrations of greenhouse gases continue to increase, the negative impacts of climate change are expected to deepen and accelerate.

To protect public health and stabilize the climate, we must quickly reduce our dependence on fossil fuels and embark on the transition to a post-carbon economy.

Economic progress in the modern era has been powered by cheap and abundant energy from fossil fuels, the combustion of which is the primary source of air pollution and of the greenhouse gases that change the climate. To protect public health and stabilize the climate, we must move quickly to eliminate fossil fuel combustion and embark on the transition to a post-carbon economy. In fact, researchers have concluded that we need to leave three-quarters of remaining fossil fuels in the ground in order to avoid catastrophic impacts from climate change.[1] However, as long as there is a market for coal, oil and natural gas, there will always be strong economic incentive to exploit these fossil fuel reserves. Therefore, we can only stabilize the climate by slashing demand for fossil fuels.

The transition to a post-carbon economy presents a daunting challenge, but it also provides a tremendous opportunity that we must seize to ensure our continued viability and prosperity as a region. With its world-class academic institutions, innovative business sector, educated and progressive residents, and strong environmental ethos, the Bay Area is uniquely positioned to embrace this challenge and opportunity. By so doing, we can protect the environment and the climate that make the Bay Area a great place to live, while leading the way toward the innovative policies and technologies that will drive economic change and promote social equity in the 21st century.

Climate change is a global-scale problem. No single region or agency can solve the climate challenge on its own. But in the face of uncertainty and limited action at the national level, it is more imperative than ever that Bay Area residents, businesses and institutions step up to the challenge. To that end, the Air District will deploy the full range of its tools and resources to reduce emissions of air pollutants and greenhouse gases in the Bay Area, while providing an example of metropolitan-scale action to protect air quality and the climate that can be replicated throughout California, the United States and beyond.

After summarizing the goals and objectives for the 2017 Plan, this chapter offers a long-range vision as to how the Bay Area could look and function in a year 2050 post-carbon economy. The chapter concludes by introducing the proposed 2017 control strategy, a strategy which describes measures that the Air District will implement over the next three to five years to protect public health and protect the climate, while setting the region on a pathway to achieve the 2050 vision.

Goals and Objectives

Consistent with the mission of the Air District, the 2017 Plan focuses on two paramount goals:

Protect Air Quality and Health at the Regional and Local Scale:

- Attain all state and national air quality standards
- Eliminate disparities among Bay Area communities in cancer health risk from toxic air contaminants

Protect the Climate:

- Reduce Bay Area GHG emissions 40 percent below 1990 levels by 2030, and 80 percent below 1990 levels by 2050.[2]

These goals are complementary. Despite substantial progress in improving air quality, air pollution still has negative impacts on public health here and now. With the Bay Area projected to add

UPDATING THE BAY AREA'S STATE OZONE PLAN

Ground level ozone—often called "smog"—harms public health and ecosystems. As discussed in Chapter 2, Bay Area ozone levels have been greatly reduced in recent years, but the region still does not fully attain state and national ozone standards. The California Clean Air Act, as codified in the California Health & Safety Code, requires regional air districts that do not attain state ozone standards to prepare ozone plans. To that end, the 2017 Plan serves to update the most recent Bay Area ozone plan, the 2010 Clean Air Plan. The Health & Safety Code requires that ozone plans propose a control strategy to reduce emissions of ozone precursors—reactive organic gases (ROG) and nitrogen oxides (NO_x)—and reduce transport of ozone and its precursors to neighboring air basins. The control strategy must either reduce emissions 5 percent or more per year, or include "all feasible control measures". Because reducing emissions of ozone precursors by 5 percent per year is not achievable, the control strategy for the 2017 Plan is based on the "all feasible measures" approach. The Health & Safety Code ozone planning requirements are described in more detail in Appendix A.

two million new residents over the next several decades, it will be more important than ever to continue reducing air pollution and improving air quality. Climate change, which is already affecting the Bay Area, represents a profound threat to our health and well-being over the long-term. Since pollutants that impact the air and the climate are often emitted by the same sources, emission control programs will provide co-benefits in reducing both types of pollutants.

In pursuit of these goals, the 2017 Plan has several complementary objectives:

> *The Air District initiated its Community Air Risk Evaluation (CARE) program in 2004 to identify and assist communities and populations that are most impacted by air pollution.*

- Update the Bay Area ozone plan (i.e., the Bay Area 2010 Clean Air Plan) pursuant to the requirements of the California Health and Safety Code;
- Reduce population exposure to harmful air pollutants, especially in vulnerable communities and populations; and
- Protect the climate through a comprehensive regional climate protection strategy.

Protecting Impacted Communities and Promoting Social Equity

To protect public health and promote social equity, the 2017 Plan focuses on reducing population exposure to air pollutants throughout the region. The plan places a special emphasis on protecting communities and populations that are most vulnerable to the effects of air pollution, with a long-range goal to eliminate disparities in exposure to air pollution across communities. The Air District initiated its Community Air Risk Evaluation (CARE) program in 2004 to identify and assist communities and populations that are most impacted by air pollution. Communities with higher air pollution levels and worse health outcomes, for diseases affected by air pollution, are identified as impacted. The

Air District has worked to reduce health risks by targeting its regulatory and enforcement efforts in these communities, providing funding for projects to reduce emissions within these communities, and developing partnerships with local community groups, as described in Chapter 4. In implementing the 2017 Plan, the Air District will build upon these efforts with the goal of eliminating disparities among Bay Area communities in health risks from toxic air contaminants.

The Air District will also work to ensure that the transition to a post-carbon economy provides equitable outcomes for all Bay Area communities and that all socioeconomic groups share in the economic opportunities and environmental benefits of this transformation. For example, the Air District has been working to ensure that impacted communities in the Bay Area benefit from efforts to reduce GHG emissions and receive an equitable share of funding from programs such as the state's Greenhouse Gas Reduction Fund, as discussed on page 1-16.

Protecting the Climate

The Air District has been working for more than a decade to reduce GHG emissions and protect the climate, demonstrating leadership in showing how a regional air quality agency can take meaningful action to address climate change. With the 2017 Plan, the Air District is taking its climate protection program to a new level. There are compelling reasons, both practical and ethical, for the Air District to take aggressive action to reduce emissions of greenhouse gases and protect the climate.

Climate change is real: There is an overwhelming scientific consensus that the climate is changing due to human-produced emissions of carbon dioxide and other greenhouse gases. Every week brings new reports about the increasing speed and severity of climate change, and the widening range of its impacts.

Climate change will affect air quality and endanger public health: The two key goals of this Plan—protecting public health and protecting the climate—are closely related. Climate change will directly affect air quality, as described in Chapter 3. In addition, it will cause a wide range of effects on the environment and ecosystems that sustain us—including water supply, sea level and biological diversity—which will also impact public health. Therefore, it is essential to protect the climate in order to protect public health.

…the greenhouse gas footprint—the amount of GHGs embedded in the goods, services and activities that we consume in our daily lives—of the average Bay Area resident is much higher than the global average.

Vulnerable populations will suffer the most, both in the Bay Area and at the global scale: The negative public health effects from climate change will fall most heavily on the Bay Area communities and populations that are already most heavily impacted by air pollution. We must address climate change to protect our most vulnerable communities and promote social equity.

Climate change poses great risks to the Bay Area: Its coastal location and benign Mediterranean climate make the Bay Area a great place to live. But they also make the region highly vulnerable to the impacts of climate change, such as sea-level rise (flooding) and changes in precipitation patterns (drought, decreasing water supply). These vulnerabilities will endanger key transportation infrastructure (highways, airports, seaports) and power distribution systems, imposing significant economic costs on the region.

We are part of the problem: The Bay Area is relatively affluent. As a result, the greenhouse gas footprint—the amount of GHGs embedded in the goods, services and activities that we consume in our daily lives—of the average Bay Area resident is much higher than the global average. Since

CULTIVATING FUTURE CLIMATE LEADERS

Solving the climate crisis requires strong leadership, not just today but tomorrow, and in the years ahead. The Air District sponsors activities and supports local organizations that are training and developing the next generation of climate leaders.

YES Conference

The Air District's annual Youth for the Environment and Sustainability (YES) conference, co-sponsored by MTC, inspires and empowers Bay Area youth and their families to reduce greenhouse gas (GHG) emissions by changing their transportation habits. The 2017 conference will bring middle and high school students together to develop leadership skills, discuss solutions to the climate change crisis and launch youth-led actions that improve air quality and environmental health.

Cool the Earth

The Air District has provided multiple grants to the non-profit Cool the Earth to educate K–8 students on climate change and inspire them to take action at home. The program kicks off with a fun and educational assembly, then each child takes home a coupon book of actions families can take to reduce their carbon footprint. Every action completed is recorded on a banner displayed on campus and tracked online to stimulate friendly competition between classrooms and across schools. Cool the Earth operates in over 530 schools across the United States, reaching approximately 200,000 students.

EarthTeam

EarthTeam empowers high school students to become lifelong environmental stewards. EarthTeam's students develop leadership skills as they design and implement action projects and peer-to-peer education activities. In 2016, EarthTeam was awarded an Air District James Cary Smith Community Grant for *Sustainable Youth Zero Carbon School Internships* for thirty high school students in Oakland and Richmond. Through these internships, students educate their campuses and communities about air pollution, GHG emissions and the impacts of these emissions on human health.

ECO2School

ECO2School, a program of the Center for Climate Protection, inspires young people to take action for immediate GHG emission reductions while promoting long-term personal and community environmental action. A comprehensive Guidebook, developed with Air District funding, trains high school students to organize projects that support safe and healthy commutes. Since 2011, Sonoma County ECO2School programs have reduced nearly 50 tons of GHG emissions.

The YES Conference, Cool the Earth, EarthTeam and ECO2School are shining examples of how young people can actively engage in protecting the climate today, and become the leaders of tomorrow.

we emit a disproportionate amount of global GHG emissions, we bear a clear responsibility to take action to reduce these emissions. In a cruel irony, people and populations who are least responsible for contributing to this problem will be most vulnerable to the impacts of climate change. In addition, we have a moral obligation to act now in order to protect our children and future generations.

Bay Area residents support and expect tangible action to protect the climate: A recent poll found that a solid majority of Bay Area residents believe that climate change is a serious threat to California's future and that 75 percent of Bay Area residents want governmental action to protect the climate.[3]

Our actions can make a difference: Although climate change is already occurring, the course that it will take is not predetermined. By acting now, we can reduce global warming and mitigate the impacts of climate change, in the near and long term.

The Bay Area can provide leadership: The Bay Area has a long and rich tradition of environmental stewardship, technical innovation and policy leadership. Although we cannot solve the climate change challenge on our own, we can provide leadership. By fostering and incubating innovative policies, programs and technologies, we can provide an example and inspire action across the nation and around the world.

A Vision for 2050

Confronting climate change will require profound changes in the way we live, work, and travel. If we can see the goal, by visualizing what the Bay Area may look like in a post-carbon year 2050, we can better discern the policies and actions that we need to take in the near to mid-term to embark on the transformation. The 2050 vision for the Bay Area sketched below envisions a thriving region with clean air, a stable climate, a robust natural environment, and a prosperous and sustainable economy.

To achieve the deep emission reductions needed to protect public health and the climate, we must address fundamental causes and focus on the core activities we engage in—as a region and individually. These core activities include: where and how we live, how we travel, what we produce, and how and what we consume. Although we cannot predict the future, the section below attempts to describe how the Bay Area will need to look and to function in year 2050 in order to achieve our long-term climate protection and clean air goals.

We must ensure that the transition to a post-carbon economy provides equitable outcomes for all Bay Area communities and residents. Any costs or burdens should be shared equitably. But, more importantly, we must also ensure that all Bay Area residents share in the benefits and promise of the new energy economy, as manifested in cleaner air, improved public health, good jobs and an enhanced quality of life.

The buildings that serve as our homes, offices, schools, stores, and other institutions are a major source of greenhouse gas emissions and other air pollutants.

Where We Live and Work: Buildings

By 2050 the buildings in which we live, work, learn, shop and socialize will be energy efficient; they will be heated, cooled and powered by renewable energy.

The buildings that serve as our homes, offices, schools, stores and other institutions are a major source of greenhouse gas emissions and other air pollutants. This includes both direct emissions, such as when natural gas is burned in furnaces and water heaters, and indirect emissions when electricity is used for lighting, appliances, heating or cooling. Wood burning in buildings is a major source of harmful particulate matter and black carbon. Buildings also indirectly contribute to emissions from the transportation sector when they are located far away from services and transit options, and thus are accessible only by driving.

In order to reach our climate protection and clean air goals, we must greatly reduce both direct and indirect emissions from buildings by changing how our buildings function and how they are powered:

- Buildings will need to be energy efficient and powered, cooled, and heated by clean energy
- Wood burning will need to have been eliminated

Eliminate the Use of Fossil Fuels in Buildings

Greenhouse gas emissions from all buildings, both existing and new, will need to be near zero by 2050. In order to achieve this ambitious goal, a complete energy system approach to building construction and operation must be pursued, including:

- Maximize energy efficiency—California law (SB 350, 2015) requires a doubling of energy efficiency in all existing buildings in California by 2030. Most older buildings do not meet current energy standards, so retrofitting existing buildings to maximize their energy efficiency is an important first step. Lower income households spend a large portion of their income to power their homes. Increasing energy efficiency in existing buildings, particularly multi-family buildings, is a key strategy for increasing the disposable income and enhancing the well-being of low income households in the Bay Area.
- Ensure low- or zero-carbon electricity—Producing electricity from renewable energy or very low-carbon sources is requisite for large-scale fuel switching from natural gas to electricity. This will be accomplished in part by decreasing the carbon content of grid-delivered electricity (see more on this in “What We Produce” below), and also by increasing the portion of our energy needs that are met by on-site renewable energy such as rooftop solar.
- Develop energy storage technologies—Because of the intermittent nature of renewable power sources like solar and wind, developing advanced battery technology or other energy storage technologies that allows for significant onsite electricity storage is critical to decarbonizing the buildings sector.
- Switch from natural gas to electricity and renewable energy—We need to switch from natural gas to low-carbon electricity or renewable energy for space and water heating, clothes drying and cooking. In addition to grid-based electricity, these end uses can also be powered by onsite renewable energy such as ground source heat pumps, solar photovoltaic and solar thermal technologies. Biogas can be used as a replacement for natural gas in buildings and in commercial and industrial processes.

To achieve the 2050 vision, the entire building stock will need to be as low-carbon as possible. This is easier for new construction than for existing buildings, since it is less expensive to construct buildings with on-site renewable energy and cutting-edge energy efficiency technology than it is to retrofit existing buildings to the same energy performance level. Because it will be very difficult to achieve near-zero carbon emissions from existing buildings, all new construction should be zero-net carbon or carbon-negative. This vision is consistent with state goals that all new residential construction in California should be zero net energy by 2020, and all new commercial construction in California should be zero net energy by 2030.[4]

Eliminate Wood Burning

During the winter, smoke from residential wood burning is the leading source of fine particulate matter ($PM_{2.5}$), the air pollutant most harmful to public health in the Bay Area. Wood smoke is also a major source of black carbon, contributing to climate change. Residential wood-burning has been reduced by nearly 60 percent since the Air District adopted Rule 6-3 and implemented its mandatory winter Spare the Air program in 2008. However, to protect public health and the climate, we need to eliminate all wood-burning.

How and Where We Travel: Transportation

By 2050 the transportation sector will be transformed. We will travel by a combination of electric vehicles, both shared and privately-owned; autonomous, electric-powered public transit fleets offering both fixed-route and flexible-route service; with a large share of trips by bicycling, walking and transit.

Transportation is the largest source of greenhouse gases in the Bay Area, accounting for nearly 40 percent of all GHG emissions. In addition to direct tailpipe emissions from motor vehicles, transportation indirectly generates emissions from Bay Area oil refineries that produce the fuels that power our vehicles. To achieve the 2050 vision, we need to reduce motor vehicle travel and to eliminate combustion of gasoline and diesel in motor vehicles. This will require major changes to the motor vehicle fleet, fuels and fueling infrastructure, land use development patterns, and the transportation modes that we choose:

- New development will need to offer safe and convenient access to jobs, shopping, and services by transit, bicycle and walking
- The majority of trips will need to be made by walking, bicycling, riding transit or sharing vehicles
- Nearly 90 percent of the motor vehicle fleet will need to be zero emission
- All transportation fuels will need to come from renewable sources

The policies and actions set forth in the California Air Resources Board's (ARB) *Mobile Source Strategy* and *Plan Bay Area,* adopted by the Metropolitan Transportation Commission (MTC) and Association of Bay Area Governments (ABAG), provide a solid foundation for transforming the transportation sector. But strong efforts will be needed at the regional and local level to ensure that these plans achieve their goals for reducing motor vehicle use, directing new development to bike-able, walkable areas well served by transit, and accelerating the transition to zero-emission vehicles.

Locate New Development Near Transit, Pedestrian and Cycling Opportunities

The amount we drive varies depending upon where we live and work. In order to reduce future motor vehicle travel, we need to ensure that new development is directed to areas that are well served by transit and where jobs, shopping, schools, and services can be conveniently reached by biking or walking. *Plan Bay Area,* a regional blueprint

In order to reduce future motor vehicle travel, we need to ensure that new development is directed to areas that are well served by transit and where jobs, shopping, schools, and services can be conveniently reached by biking or walking.

for how the Bay Area could develop over the next 25 years, focuses 70 percent of all new housing in "priority development areas" near transit in order to reduce vehicle trips in favor of public transit, biking and walking.[5] Further progress will be needed to achieve long range goals. By 2050, all new development will need to occur in locations that offer safe and convenient transit, pedestrian and cycling opportunities in order to minimize the need for auto travel. In addition, we will need to retrofit existing neighborhoods to ensure that all Bay Area residents have safe access to cycling, walking and transit.

Reduce Motor Vehicle Travel

Plan Bay Area lays out a comprehensive strategy to reduce motor vehicle travel on a per capita basis by improving the region's public transit network; promoting bicycling, walking, and ridesharing; and directing new development to areas well served by transit. However, as regional population and employment grows over the next several decades, it is likely that we will need to strengthen these efforts. A mix of land use, parking, transit and transportation demand management strategies implemented by regional agencies and local communities, such as Safe Routes to School and Transit, "last-mile" connector services, parking pricing policies, and more are needed on a large scale.

Major change is already reshaping the transportation system, with bigger disruption looming on the horizon. New services, products, and technologies such as car-sharing, transportation network companies (e.g., Uber and Lyft), and self-driving vehicles are likely to transform the way we travel in the coming decades. How these developments will affect travel demand and vehicle emissions is not yet clear. However, it will be imperative for public agencies to guide these efforts so as to ensure that they benefit the environment as well as enhance personal mobility.

Commute trips account for a large share of motor vehicle travel (and traffic congestion) so reducing commute trips will be key to decreasing total travel demand. Demographic, social, and technological changes will affect how and where we work in 2050. Economic growth, plus the likelihood that people will work longer as they live longer, may increase the size of the Bay Area workforce. However, as advances in communication technologies enhance connectivity and lessen the need for direct contact in the workplace, Bay Area employers and employees are likely to embrace a more flexible work culture and structure. Commute travel in 2050 may decrease as more Bay Area residents work from home, or walk or bike to co-work spaces in their neighborhood, instead of driving to a more distant office on a daily basis.

Promote Zero-Emission Vehicles and Renewable Fuels

The state's *Mobile Source Strategy* provides an ambitious approach for reducing air pollutants and GHGs from cars and trucks by electrifying the fleet and promoting the use of renewable fuels, as well as advocating for more stringent federal emission limits on ships and locomotives. To achieve the 2050 GHG goal, the Air Resources Board projects that 87 percent of the light-duty vehicle fleet in California will need to be zero emission. The Air District's extensive grant and incentive program for plug-in electric and hydrogen fuel cell vehicles will help move the region toward this goal. Public agencies can lead the way in this effort by converting 90 percent of their fleets to zero-emission vehicles by 2050.

We will also need to apply the innovations and progress achieved to date in our light-duty fleet throughout the transportation system—to trucks, off-road vehicles and railroads. All rail lines, both passenger and freight, will need to be electrified by 2050. This shift toward electrification of the transportation sector will require significant public and private investment, as well as new technologies to improve battery efficiency and to develop renewable forms of diesel and other liquid fuels where still necessary.

What We Produce: Sustainable Production

By 2050 the Bay Area economy will be powered by clean, renewable electricity. The region will be a leading incubator and producer of clean energy technologies, and Bay Area industry will lead the world in the carbon-efficiency of our products.

The Bay Area is home to diverse industries that provide many thousands of jobs and produce vital goods that are consumed both within and outside the region. Emissions of air pollutants from industrial sources have been greatly reduced over the past several decades in response to the Air District's regulations, enforcement and permitting programs. But industrial and commercial facilities still account for a significant portion of the criteria air pollutants, toxic air contaminants, and greenhouse gases emitted in the Bay Area. In order to meet our aggressive emission reduction goals, these industries will need to maximize efficiencies, utilize the most effective low-carbon technologies and energy sources, and actively embrace the new energy economy. In 2050, the Bay Area industrial and energy landscape will need to include:

- A smart grid interconnecting renewable energy sources to provide nearly 100 percent renewable electricity
- Access to clean energy for people of all income levels
- Nearly complete fuel-switching from fossil fuels to electricity
- Oil companies/refineries transitioning to energy companies focusing on specialty fuels and renewable energy

Switch from Fossil Fuels to Electricity

All energy-intensive activities—including transportation, building heating and cooling, and industrial fuel usage—will need to be powered largely from carbon-free electricity in order to meet our climate protection and clean air goals. This will increase electricity demand, which will be partly offset by efficiency gains from energy conservation. In many cases, using electricity is more efficient than fossil fuel combustion for the same applications, and using renewable energy sources such as wind, water and solar power saves energy that would otherwise be expended on extracting, processing and transporting fossil fuels.

Oil Companies Will Transform to Clean Energy Companies

By 2050, Bay Area industries will need to be powered by renewable electricity wherever feasible with renewable fuels making up the difference, the carbon-intensity of products manufactured in the region will need to be greatly reduced, and a significant percentage of the light-duty vehicle fleet will be hybrid electric or fully battery-powered. In response to decreasing demand for gasoline and diesel, oil companies will need to reorient their focus to the production of renewable energy and biofuels, while perhaps continuing to provide hard-to-replace or specialty fuels (e.g., jet fuel). This transition can already be observed at some of the world's largest oil companies. For example, Shell has created a New Energies division to focus on biofuels, hydrogen, wind and solar.

A transition of the oil companies may have serious implications for the Bay Area economy. To meet California's 2050 climate goals, demand for traditional transportation fuels will need to be dramatically reduced. California's refineries will likely need to shift production to a renewable fuel portfolio and/or steadily decrease, and in some cases even cease, production. It will be critical for government and industry leaders to devise a transition plan for the workforce and for the communities that rely on these facilities, so that they may benefit from the transition to a clean energy economy.

Foster the Development of New Energy Providers

The Bay Area will become a hub for the development and production of innovative renewable energy technologies, creating solid jobs requiring diverse education and skills, and helping to reduce carbon dioxide emissions worldwide by exporting these technologies and products across the nation and the globe.

100 Percent Renewable Power Supply

Studies have found that achieving high levels of renewable-based electricity (80–100 percent) by 2050 is economically and technologically feasible for the U.S. and California.[6] Achieving a stable power supply with 100 percent renewable resources by 2050 will require technologies such as demand-response management (a "smart grid" to integrate diverse sources of renewable energy), electricity storage (batteries), or using excess electricity for hydrogen production. Some of these technologies are not yet mature enough to support a transition to 100 percent renewable energy today. However, the Bay Area could have carbon-free electricity by 2050 if we pursue research and investment in new technologies, in combination with supportive policy measures such as carbon pricing (see the carbon-pricing textbox on page 1-14).

Smart Grid

The development of a "smart grid" will allow for efficient integration of new low-carbon power sources. A smart grid is a network that uses digital communication technology to detect and react to changes in usage. A smart grid may help reduce energy demand by allowing for "real-time" pricing based upon the relationship between electricity supply and demand.

> *The decisions we make as individual consumers—about which goods and services we purchase, how and where we travel, and what foods we eat —have a great impact on our "GHG footprint", both at the household and regional scale.*

Increased Access to Clean Energy

Transitioning away from fossil fuel-based energy will reduce exposure to harmful air pollutants associated with power generation and oil refining. Access to clean energy will need to be available to all Bay Area residents, not just those who can afford to buy an electric car or put solar panels on their roofs. Programs like community choice energy and utility-sponsored clean energy offerings are proliferating in the Bay Area and will play a major role in helping the region achieve a 100 percent clean energy supply by 2050. The programs can also build the local economy by developing local sources of renewable energy, creating local jobs and stimulating local investment.

Supporting Jobs in a Clean Energy Economy

As we shift our energy and industrial production away from fossil fuels, labor in these sectors will also need to transform. Jobs in a sustainable economy will require people with different educational backgrounds and skills. This presents an opportunity for the Bay Area, and California, to train and employ individuals in well-paying jobs that have positive impacts in their communities.

What We Consume: Conscientious Consumption

By 2050 Bay Area residents will need to develop a low-carbon lifestyle. We will greatly reduce our personal GHG consumption (our "GHG footprint") by driving electric vehicles, living in zero net-energy homes, eating low-carbon foods, and purchasing goods and services with low carbon content. Waste will be greatly reduced, any waste products will be re-used or recycled, and all organic waste will be composted and put to productive use.

Bay Area residents must play a critical role in achieving our air quality and GHG reduction targets. The decisions we make as individual consumers—about which goods and services we purchase, how and where we travel, and what foods we eat—have a great impact on our "GHG footprint", both at the household and regional scale.[7]

The Air District has developed a consumption-based GHG inventory (see Chapter 3) to help people understand the most effective choices they can make to reduce their carbon footprint.[8] The production and consumption of food provides a good example of how we can take simple steps as "conscientious consumers" to reduce GHG emissions on a daily basis. Large amounts of GHGs are emitted in the production, processing, and distribution of the food that we eat. Therefore, we need to consider the full GHG impacts of food production when choosing what we eat. By 2050:

The USDA estimates that in 2010 in the United States total food losses—edible food that is not consumed—amounted to 31 percent of the available food supply.

- Bay Area residents will need to reduce their consumption of carbon-intensive foods and adopt a low-carbon diet for at least some portion of their meals
- Food waste will need to be reduced by 75 percent
- All organic matter will need to be diverted from the waste stream and put to productive use

Low-GHG Diet

Reducing the energy and GHG intensity of diets begins at the point of food production, at Bay Area farms, dairies, etc. We can reduce emissions of carbon dioxide and other pollutants from the agriculture sector by replacing diesel-fueled equipment (e.g., pumps, tractors, trucks) with cleaner and more efficient alternatives, such as electricity and biofuels.

Methane is another significant GHG generated at many Bay Area farms, produced from both manure management and enteric fermentation (digestion in ruminant animals, such as cows and sheep). Given methane's high global warming potential,[9] it is especially critical that the methane from manure be recycled by establishing biogas recovery systems that capture and re-use biomethane on all Bay Area dairies by 2050. These systems not only reduce methane emissions, but also generate renewable energy for use onsite, or for sale to generate revenue or recover costs.

Factors that contribute to the GHG-intensity of food production include the energy inputs involved in rearing farm animals and the methane output from those animals, as described above. The use of fertilizers, as well as energy used for water pumping and irrigation, also contribute to GHG emissions from agriculture. Studies have found that GHG emissions at the global scale would be greatly reduced if most people were to adopt a vegetarian or vegan diet.[10]

Reduce Food Waste

Food waste occurs at all steps of the production, distribution, and consumption cycle. The USDA estimates that in 2010 in the United States total food losses—edible food that is not consumed —amounted to 31 percent of the available food supply.[11] Building upon ongoing waste reduction efforts, including the national goal established by U.S. EPA and the U.S. Department of Agriculture to reduce food waste 50 percent by 2030, it is reasonable that by 2050 much higher percentages of waste reduction could be achieved. Reducing food waste will require a multi-pronged approach: reducing waste in food production, at supermarkets, in restaurants and institutions (schools, hospitals, prisons), and in the home, as well as diverting excess edible food to food banks and shelters. Agencies like Cal-Recycle at the state level and StopWaste.org in the Bay Area are launching efforts aimed at food waste reduction, creating a solid foundation to build upon.

Putting Organic Materials to Productive Use

In 2050, any and all food waste that cannot be put to edible use will need to be composted or otherwise put to productive use. In addition to preventing methane emissions at landfills, composted waste will be available for use as a soil amendment at a local or larger scale. Many farms also generate vegetative material as a by-product of food production. In current practices, some of this material is left in place to decay, some is sent to landfills, and some is burned—resulting in GHG emissions. This waste material can be redirected to create compost for use as a soil amendment in agricultural and rangelands, augmenting the carbon sequestration abilities of these lands.

Achieving the Vision

The text above outlines an ambitious and optimistic vision for achieving a transformation to a post-carbon Bay Area in 2050. In addition to improving air quality and reducing emissions of greenhouse gases, this vision would provide a wide range of co-benefits in terms of economic development, enhanced mobility, improved diet and health, etc. The Air District and its partner agencies cannot achieve this vision on their own, of course. A transformation of this magnitude will require a concerted effort by all Bay Area institutions—including the business community, the financial sector, educational institutions—and by Bay Area residents.

Government: Government agencies, including the Air District, should play a key role by establishing targets, defining the legal and policy framework, and helping to support and fund the development of new technologies and the infrastructure needed to support the vision. Collaboration among government agencies, each playing an appropriate role commensurate with its authority and expertise, will be essential. One important function that government could perform would be to set a price on carbon by implementing a carbon tax or fee (as described in the text box below). Government also must work to ensure that the transition to a carbon-free future promotes social equity.

Educational institutions: Schools and universities will have a primary role in educating our citizens—particularly younger generations—on the causes and impacts of climate change, so they may have the motivation and knowledge to become part of the solution. Schools and universities will also need to engage in scientific and technical research, collaborate with the private sector to drive technological innovation, and provide the Bay Area workforce with the training and skills that will be required by emerging industries.

Business and finance: The transformation to a post-carbon economy will require major technological innovation, large-scale investments to bring new technologies and products to market,

PUTTING A PRICE ON CARBON

Pricing is a powerful tool in our market-based economy. Most economists agree that implementing a broad-based price on carbon would be the most efficient way to reduce GHG emissions. A carbon tax or fee can be structured to reflect the amount of GHG emissions embedded in the production of the goods and services we consume.

A carbon fee can encourage producers to reduce the carbon content of their products, while also encouraging consumers to make low-carbon choices. A well-designed carbon-pricing system can also promote social equity. A carbon fee could have a progressive impact from a tax-policy standpoint, since the average household GHG footprint is highly correlated with household income; e.g., low-income households generally have a relatively small carbon footprint. The revenues from a carbon tax could be used to fully offset costs for low-income households, as well as to fund clean energy or clean vehicle projects in low-income communities.

In addition to using the power of the market to reduce GHG emissions, carbon pricing can provide a significant revenue stream to fund projects and programs that will reduce GHG emissions in the near term, as well as research and development of new technologies needed to accelerate the replacement of fossil fuels. Putting a price on carbon could also help to stimulate investment in clean technologies by reducing volatility in the price of fossil fuels, thus providing a more stable climate for investment in alternative fuels and new energy technologies.

The state of California has implemented a carbon pricing mechanism, known as the “Cap-and-Trade” program, which is designed to reduce CO_2 emissions from key sources. The impact of Cap-and-Trade on Bay Area GHG emissions is discussed in Chapter 4. In its December 2016 Discussion Draft 2030 Target Scoping Plan Update, the Air Resources Board discusses the potential effectiveness of several scenarios, including Cap-and-Trade and a carbon tax, to help achieve the state’s 2030 GHG reduction targets. As ARB continues to investigate various carbon pricing mechanisms, the Air District will closely follow, and seek to build upon, resulting state pricing initiatives.

and marketing to consumers. Investment must be directed toward renewable energy, energy efficiency technologies, and zero-emission vehicles to achieve the 2050 vision.

Bay Area residents: The choices that we make in terms of where we live, how we travel, what we eat, and what goods and services we consume all have a direct effect on our individual GHG footprint, as discussed in the 2050 vision above. To achieve the transformation to a low-carbon economy, Bay Area residents will have to embrace new technologies, new neighborhood designs, new ways of traveling, and consider the GHG impacts of the choices that we make as consumers.

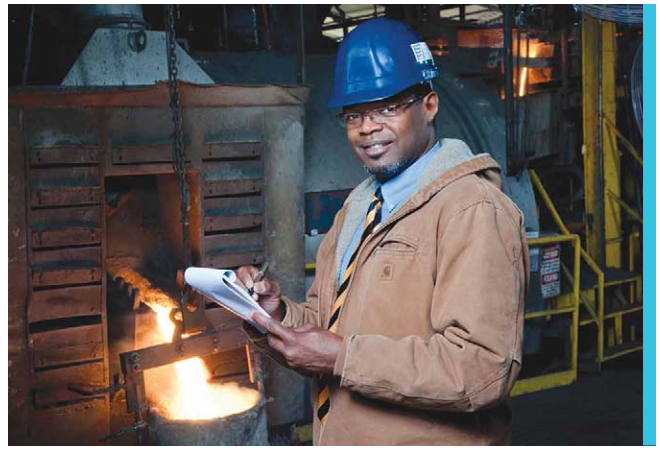
Meeting the Challenge

The transformation needed to achieve the 2050 vision of a post-carbon economy provides a great opportunity to protect our quality of life and expand the Bay Area economy. But it also represents a formidable challenge. We have made great progress in improving air quality over the past several decades, even while the Bay Area’s population and economy have grown significantly. However, the foundation of our recent progress—cleaner fuels and pollution control devices on tailpipes and smokestacks—did not require fundamental changes in our energy sources or economy. Reducing greenhouse gas emissions is a bigger challenge, requiring fundamental solutions to reduce demand for fossil fuels and develop new energy sources. As we move forward to implement the 2050 vision, we need to ensure that our response to this challenge benefits all Bay Area communities, particularly disadvantaged communities.

Fossil fuels offer high-energy density at a low cost to the consumer—however, their true costs or full impact they have on the environment, public health and the climate, are not incorporated into the consumer price. And, as recent political developments at the national scale demonstrate, there is enormous economic and political power vested in the current energy system. Climate leadership from California and the Bay Area is thus more important than ever. Several of the key challenges we face in critical sectors include:

New energy technologies: Despite great progress in recent years in developing new energy technologies and in driving down their production and installation costs, we still need big breakthroughs in the production and storage of energy from renewable sources to advance to a post-carbon energy system. The development of new energy technologies requires significant capital investment and time. Government-sponsored research can play a critical role in incubating new technologies; however, attracting private sector financing to move from basic R&D to commercial scale production is a challenge. Government agencies, such as the Air District, may be able to play a catalytic role by funding joint research with industry and implementing pilot projects that demonstrate new technologies at scale. To that end, the Air District is creating a Technology Implementation Office (TIO). The TIO will establish the Air District as a catalyst for innovation in the field of greenhouse gas emissions reduction, focusing on zero emissions vehicles, smart/connected technologies, and zero emissions energy generation and efficiency technologies.

Vehicle technologies: California and the Bay Area lead the way in developing and deploying new vehicle technologies, such as plug-in hybrid, battery electric and fuel cell vehicles. Even so, gasoline and diesel vehicles are likely to account for most



of the light-duty fleet over the next two decades, making it ever more critical that fuel economy standards continue to improve and Bay Area consumers purchase the most fuel-efficient vehicles possible. There has been impressive progress in the number of plug-in hybrid and battery electric vehicles on the road, and in the increasing range of battery EVs. However, we need to expand the appeal of electric vehicles to achieve greater penetration in the mainstream market. New technologies such as automated vehicles will transform our communication and transportation systems, but we need to ensure that these innovations use clean power and are deployed so as to reduce overall travel demand and GHG emissions from the transportation sector.

Energy efficiency in buildings: Reducing GHG emissions by improving energy efficiency in the buildings sector will be essential to achieve the 2050 GHG reduction target. The most difficult challenge will be finding a way to greatly increase energy retrofits in existing buildings, given the long lifespan and low replacement rate of buildings, the significant cost, and the sheer number of existing buildings in need of retrofit.

Housing and land use: Housing, transportation, and air quality are key issues that impact the Bay Area economy and quality of life. Directing new housing and job growth to urban core areas, and other developed areas that are well served by transit and bicycle and pedestrian facilities, can help to address all these issues. However, infill development is challenging, so local communities and regional agencies will need to collaborate to ensure that land use and development decisions benefit existing communities, while also helping to resolve housing, transportation and environmental challenges at the regional scale.

The Air District's Role

Achieving the 2050 vision will require a concerted effort on the part of all segments of society and all levels of government. The Air District cannot realize this vision on its own. However, the District can play a key part in this transformation by actively pursuing several important roles.

Leader: To provide leadership, the Air District will perform several roles, as described below, to ensure that the Bay Area is in the forefront of the effort to protect public health and the climate, here in the region as well as in the national and global arena.

Regulator: The Air District will use its full regulatory, permitting, and enforcement authorities to adopt and amend rules to reduce GHG emissions pursuant to its powers as defined in the California Health & Safety Code. This may include adopting "backstop" measures to ensure that anticipated emission reductions from programs such as the statewide Cap-and-Trade are fully achieved.

Partner: The Air District will serve as a partner to the state to ensure that measures identified in the AB 32 Scoping Plan are fully and successfully implemented in the Bay Area. In addition, the Air District will work closely with local government agencies in the Bay Area (cities, counties, schools, special districts, etc.) to support their climate protection efforts by facilitating information exchange, sharing best practices and developing model ordinances.

Health steward: The Air District will continue to focus on protecting public health in communities that are most impacted by air pollution through its regulatory and permitting programs, air-quality monitoring, funding, and other programs, with a goal of eliminating disparities in health risks among Bay Area communities.

PARTNERSHIPS AND COLLABORATIONS

While the Air District can play a prominent, and even a leadership role in guiding the Bay Area to a post-carbon society, it cannot do so alone. Partnerships and collaborations are critical elements to the success of this journey. The Air District looks forward to building upon existing partnerships with its sister regional agencies (through the Bay Area Regional Collaborative), local governments and public health agencies, state agencies, businesses and their networks, academic and research institutions, the technology industry, neighborhood groups, and the vast array of community organizations that have long been working on sustainable development issues and programs. In order to leverage resources and maximize the diverse expertise available in the Bay Area, the Air District will build upon these partnerships and seek out new collaborations. By aligning goals, leveraging resources, sharing information and working together, we can build the collaborative infrastructure necessary to move the region toward the 2050 vision.

ADVOCATING TO ENSURE THAT BAY AREA IMPACTED COMMUNITIES QUALIFY FOR CLIMATE FUNDING

The Air District is working to ensure that the effort to reduce GHG emissions and protect the climate will promote social equity and benefit all Bay Area residents, especially in the communities most impacted by air pollution. Therefore, the Air District seeks to ensure that impacted communities in the Bay Area receive sufficient and equitable resources related to climate protection. For example, the Air District supports the intent of California law which requires that at least 25 percent of the funds from the state's Greenhouse Gas Reduction Fund (GGRF) be distributed for projects within disadvantaged communities throughout California. However, the tool that the state is currently using to identify disadvantaged communities (CalEnviroScreen) fails to include key Bay Area communities that the Air District has defined as impacted communities via its Community Air Risk Evaluation (CARE) program. To address this issue, the Air District has been engaging with the legislature, appropriate state agencies, regional agency partners, and community groups to advocate for revisions needed to ensure that all Bay Area impacted communities are eligible for GGRF revenues and receive an equitable share of funds through other state programs that are adopting disadvantaged community funding criteria.

Educator: The Air District will serve as an information source and educator. In this role, the District will monitor Bay Area atmospheric concentrations of key GHGs, and refine its GHG emissions inventory; provide information and guidance to local cities and counties to inform their climate action efforts; and educate Bay Area residents about effective steps that they can take to reduce their GHG footprint.

Funder: Over the past five years, the Air District has provided nearly $250 million in funding through its grant programs for clean transportation projects in the Bay Area, thus reducing emissions and expanding markets for emerging technologies. The Air District will continue to provide funding to accelerate the deployment of advanced technologies that improve energy efficiency, reduce demand for fossil fuels, increase the production of renewable energy, and promote low or zero-emission motor vehicles. In addition, the Air District will implement a new $4.5 million climate protection grant program to facilitate implementation of control measures in this Plan at the local level. As noted above, the Air District is creating a Technology Implementation Office to catalyze the development and commercialization of new energy and vehicle technologies needed to achieve the transition to a post-carbon economy. Over the period 2017 through 2024, the Air District expects to provide approximately $288 million for additional projects to reduce emissions of air pollutants and GHGs in the Bay Area through grant programs that it directly administers. In addition, the region may receive a significant amount of funding from the California Cap-and-Trade Program, assuming that the program is extended beyond 2020. Cap-and-Trade funds could provide significant capital to spur the innovation and growth in clean technology needed to achieve the 2050 vision for a post-carbon Bay Area.

Advocate: The Air District will play an advocacy role by encouraging partner agencies to pursue ambitious GHG reduction programs, encouraging the Bay Area business community to develop and adopt transformative technologies, and supporting legislation to ensure that the Air District and its partner agencies have the necessary tools and authority to achieve the 2050 GHG reduction targets.

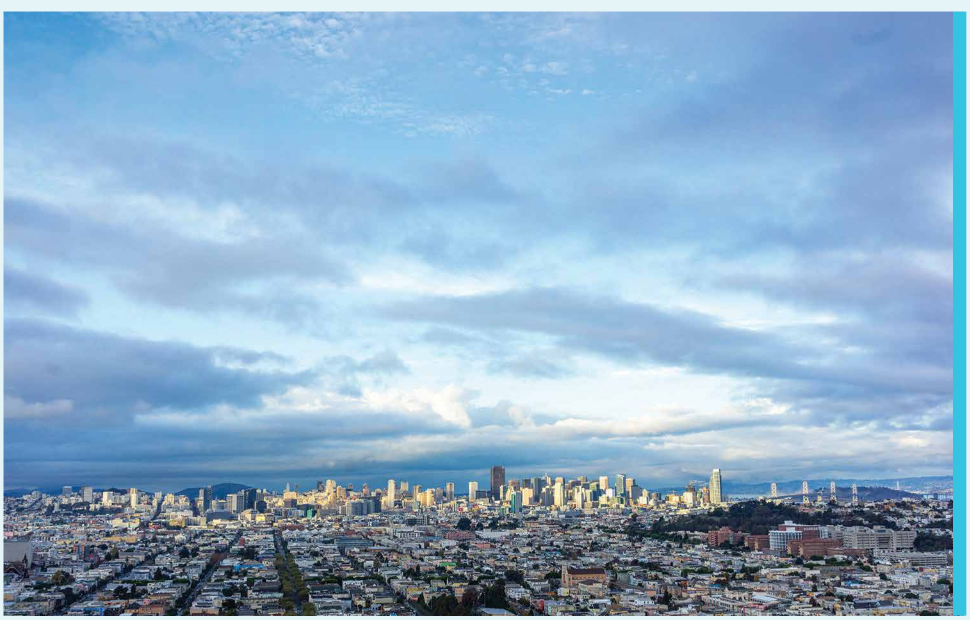
CONTROL STRATEGY BASED ON A MULTI-POLLUTANT APPROACH

The Air District took a major step forward in its air quality planning by employing an integrated, multi-pollutant approach for the Bay Area 2010 Clean Air Plan that focused on reducing emissions of the air pollutants that are most harmful to public health. The control strategy in the 2017 Plan again uses a multi-pollutant approach to reduce emissions of the most important air pollutants and climate pollutants:

- Ground-level ozone and ozone precursors: ROG and NO_x
- Particulate matter: both directly-emitted PM and secondary PM
- Key air toxics, such as diesel PM and benzene, and
- Key greenhouse gases

There is a sound scientific rationale for multi-pollutant planning. Air pollutants often share common emission sources, and in many cases, common mitigation solutions. In addition, people inhale a combination of air pollutants in the same breath, and the combined effect of exposure to multiple pollutants may have a greater impact on health than exposure to an individual pollutant.

Multi-pollutant planning can maximize reductions across all air pollutants and climate pollutants, while minimizing any potential emission trade-offs. By analyzing air pollutants on the basis of their relative harm to public health, as well as their potency in heating the climate, multi-pollutant planning also provides a means to maximize public health and climate protection benefits. In addition, multi-pollutant planning can help to ensure that our efforts to improve air quality focus on reducing the most harmful air pollution in the communities that are most impacted by air pollution.



Key Priorities

The 2017 Plan defines an integrated, multi-pollutant control strategy to improve air quality, protect public health, and protect the climate by reducing emissions of criteria air pollutants, toxic air contaminants, and GHGs. The 2017 control strategy is described in Chapter 5. Detailed descriptions of the 85 specific control measures included in the strategy are provided in Volume 2 of this Plan.[12]

To protect public health and protect the climate, the proposed control strategy is based upon four key priorities:

- Reduce emissions of criteria air pollutants and toxic air contaminants from all key sources
- Reduce emissions of "super-GHGs" such as methane, black carbon and fluorinated gases
- Decrease demand for fossil fuels
    - Increase efficiency of our industrial processes, energy and transportation systems
    - Reduce demand for vehicle travel, and high-carbon goods and services
- Decarbonize our energy system
    - Make the electricity supply carbon-free
    - Electrify the transportation and building sectors

Reduce Criteria Air Pollutants and TACs

The control strategy includes a wide range of measures to reduce the most harmful air pollutants, including ozone precursors (ROG and NO_x), fine particulate matter ($PM_{2.5}$) and TACs. Measures are proposed to reduce emissions of PM and PM precursors (e.g., ammonia) from stationary sources and wood burning, and to strengthen the Air District's thresholds for TACs. The control strategy also includes a suite of measures to reduce emissions from the five Bay Area oil refineries.

Reduce Super-GHGs

Certain climate pollutants, such as methane, black carbon and fluorinated gases, are especially potent and play an important role in heating the climate in the near term. Throughout this Plan, we refer to these climate pollutants as "super-GHGs" to reflect their powerful ability to contribute to global warming.[13] Reducing emissions of super-GHGs can make an immediate beneficial impact on climate change, as explained in Chapter 3. The Air District will continue to reduce black carbon through wood smoke and diesel engine rules and programs. The control strategy also includes a region-wide methane reduction strategy that will focus on reducing emissions of methane from key Bay Area sources such as landfills, natural gas production and distribution, agriculture (animal husbandry) and wastewater.

The Air District will continue to reduce black carbon through wood smoke and diesel engine rules and programs.

By creating not only a sustainable vision, but a model for how that vision can be achieved, the Bay Area will contribute on the global stage to solving the planet's most pressing challenge.

Decrease Demand for Fossil Fuels

The most direct and cost-effective way to reduce CO_2 emissions is to decrease demand for fossil fuels by improving the energy efficiency in buildings, motor vehicles, and industrial processes. To that end, the control strategy includes a basin-wide combustion strategy to reduce energy use in industry; measures to promote energy efficiency in new and existing buildings, and measures to reduce transportation emissions by decreasing motor vehicle travel and improving the fuel efficiency of the vehicle fleet.

Decarbonize the Energy System

To protect and stabilize the climate over the long-haul, we must learn to live without fossil fuels. The proposed control strategy includes many measures to accelerate the critical transition to a cleaner, "decarbonized" energy system. This requires a two-pronged effort to reduce the carbon intensity of electricity, in combination with switching from natural gas to electricity to power, heat and cool our buildings, and replacing gasoline and diesel-powered vehicles with zero-emission cars and trucks powered by clean electricity or other renewable fuels.

Call to Action

The transition to a post-carbon economy will require concerted action from all sectors of society and a commitment to ensure that our response to this challenge benefits all Bay Area communities, particularly disadvantaged communities. Its diversity of resources makes the Bay Area an unparalleled incubator for the innovation in new technologies and public policies needed to drive this transition. Engaging these diverse resources to work towards a common goal will be essential to the successful implementation of the 2017 Plan.

The Air District, with limited authorities and resources, cannot achieve this transition alone. However, by creating a model for how a major metropolitan region can transition to a post-carbon economy, by harnessing its vast array of resources and through collaboration, the impact of the Bay Area's vision and accomplishments will reach far beyond its regional borders. By creating not only a sustainable vision, but a model for how that vision can be achieved, the Bay Area will contribute on the global stage to solving the planet's most pressing challenge.

FOOTNOTES

[1] Christophe McGlade & Paul Ekins, *The Geographical Distribution of Fossil Fuels Unused When Limiting Global Warming to 2º C.* Nature, 8 Jan. 2015. http://www.nature.com/nature/journal/v517/n7533/full/nature14016.html

[2] The Air District's 2030 GHG target is consistent with the state of California's GHG 2030 reduction target, per SB 32 (Pavley, 2016). The Air District's 2050 target is consistent with the state's 2050 GHG reduction target per Executive Order S-3-05.

[3] See the July 2015 survey performed by the Public Policy Institute of California: http://www.ppic.org/main/publication_show.asp?i=1172

[4] See: http://www.californiaznehomes.com/about

[5] For information on *Plan Bay Area,* see: http://www.planbayarea.org/

[6] Hand, M.M. et al. (2012) Renewable Electricity Futures Study. eds. 4 vols. NREL/TP-6A20-52409. Golden, CO: National Renewable Energy Laboratory. Available at: http://www.nrel.gov/analysis/re_futures/

[7] See the UC Berkeley "Cool Climate" household GHG calculator: http://coolclimate.berkeley.edu/calculator

[8] See the Bay Area consumption-based GHG inventory: http://www.baaqmd.gov/research-and-data/emission-inventory/consumption-based-ghg-emissions-inventory

[9] Global warming potential (GWP) is a measure of how much heat a specific greenhouse gas traps in the atmosphere relative to CO_2. As discussed in Chapter 3, reducing emissions of methane and other high-GWP gases must be a crucial element of a comprehensive strategy to protect the climate.

[10] Climate Central, 2016, Healthy Diet May Reduce Gas, Greenhouse Gas That Is: http://www.climatecentral.org/news/diet-may-reduce-gas-greenhouse-gas-that-is-20160, March 21, 2016

[11] USDA, Economic Research Service, Food Availability (Per Capita) Data System—Loss-Adjusted Food Availability Documentation: https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/, accessed April 7, 2017

[12] Volume 2 of the 2017 Plan

[13] The Air Resources Board refers to these compounds as "short-lived climate pollutants" or SLCPs.

CHAPTER 2

AIR POLLUTION AND PUBLIC HEALTH

The Air District is committed to reducing air pollutants throughout the region, with special emphasis on reducing human exposure to the most harmful pollutants, and reducing health impacts in the Bay Area communities and populations that are most heavily impacted by air pollution.

The 2017 Plan addresses ozone, particulate matter (PM), and toxic air contaminants (TACs), the air pollutants of greatest concern for the purpose of protecting public health. This chapter briefly describes how air pollution impacts public health, the Bay Area's air quality status in relation to state and national standards, and key tools and analytical methods used in air quality planning. In addition, this chapter provides a profile of each of these three key pollutants, their primary health effects, the major sources of emissions, and trends in emissions and concentrations for each pollutant. The final section of this chapter summarizes progress achieved in recent decades in providing cleaner air for Bay Area residents.

Climate pollutants, and the impacts of climate change on air quality, the environment, and public health, are discussed in Chapter 3.

How Air Pollution Impacts Public Health

There is a vast body of literature that documents the negative impact of air pollution on public health. Researchers use a variety of methods, including epidemiological studies and clinical studies, to analyze the health effects of specific air pollutants and the biological mechanisms or pathways as to how pollutants harm the body. On-going research continually improves our understanding of the range of health effects. The respiratory effects of exposure to air pollution such as disease or damage to lungs in the form of asthma, bronchitis and emphysema, have been documented for decades. However, as the science advances, researchers are finding new evidence that links air pollution to a much wider variety of health effects, including cardiovascular disease (heart attacks and strokes), diabetes and dementia.

The major air quality improvements achieved over the past several decades have greatly benefited public health in the Bay Area as described in Appendix C. Nonetheless, air pollution still has negative impacts on public health. Vulnerable populations, such as children, pregnant women, seniors, and people with existing cardiovascular or respiratory conditions, are most at risk.

The relationship between air pollution and public health can be expressed as:

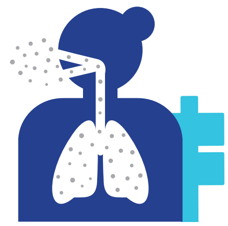
Emissions: Many different sources emit a wide variety of air pollutants, including PM, TACs, and precursor chemicals that react in the atmosphere to form ozone. Emission sources include stationary sources including factories, refineries, foundries, gas stations, and dry cleaners and mobile sources such as cars, trucks, locomotives, marine vessels, and farm and construction equipment. Identifying the key emission sources and developing strategies to reduce emissions of harmful pollutants, or their chemical precursors, is the first step in developing measures to reduce air pollution and improve air quality. The Air District develops emissions inventories to characterize and quantify emissions of key pollutants by source category.

Ambient Concentrations: This term refers to the level of pollutants that are measured in the air. The relationship between emissions and ambient concentrations is complex and depends upon many factors, *Individual exposure to air pollution varies greatly depending upon where people live, work and play.*

including meteorological conditions (temperature, wind speed and direction, and vertical mixing) the ratio of precursor pollutants (e.g., the ROG to NO_x ratio, in the case of ozone), and regional topography. Some pollutants such as ozone are regional in scale. In the case of PM and toxic air contaminants, however, ambient concentrations can vary greatly within a small geographical area. The Air District uses its monitoring network to measure air pollutant concentrations and performs photochemical modeling to better understand the relationship between emissions and ambient concentrations.

Population Exposure: Population exposure refers to the amount of pollution that a given individual or population is exposed to, and the frequency and duration of that exposure. From the public health perspective, the key issue is not how much pollution is present in the air, but rather how many people are actually exposed to the pollution. Individual exposure to air pollution varies greatly depending upon where people live, work and play. Total population exposure is greater in urban areas due to higher population density.

Dosage: Dosage refers to the actual amount of pollution that an individual takes into the body. The dosage from a given level of exposure will vary by individual depending upon age, activity, and metabolic rate. For example, when people are exercising, especially children, they receive higher dosages from a given amount of exposure because they are breathing deeper and faster. Activity patterns and lifestyle, such as how much time people are outside, or how much time they spend driving on busy roadways, vary greatly from person to person. Dosage occurs primarily through respiration (breathing), but can also occur through ingestion or by absorption through the skin.



Health Effects: Air pollution can cause or contribute to a wide range of health effects and illnesses, depending upon individual exposure and tolerance to air pollution. Just as individual exposure differs, so does the ability of our bodies to tolerate exposure to pollutants. The Air District is especially concerned about reducing population exposure for people who are most vulnerable to air pollution, including children, pregnant women, seniors, and people with existing cardiovascular or respiratory conditions.

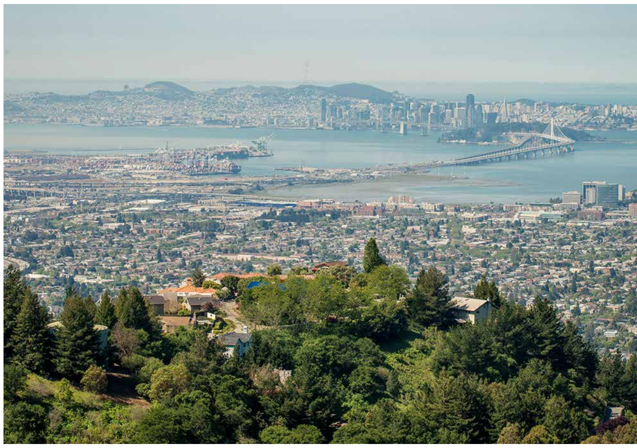
Exposure to air pollution can cause a wide range of health effects, including short-term (acute) effects and long-term (chronic) effects, including asthma, bronchitis, cancer, heart attacks and strokes, as summarized in Table 2-1.

Appendix C provides an analysis of the health burden that air pollution imposes on Bay Area residents, based on key health endpoints related to both morbidity (illness) and premature deaths, and estimates the economic cost to the region. Appendix C also analyzes how improved air quality has reduced the health burden from air pollution in recent decades, and estimates the dollar value of the benefit in terms of reduced health care costs, improved productivity, and increased average lifespan. One of the key findings is that the vast majority—more than 90 percent—of premature deaths associated with air pollution are related to cardiovascular effects, such as strokes and heart attacks, from exposure to fine particulate matter ($PM_{2.5}$).

The discussion above addresses only direct health effects related to ozone, PM and TACs. In addition, climate change will have a wide range of potential impacts on air quality and public health as discussed in Chapter 3.

Table 2-1. Air Pollutants and Their Impacts

Pollutant	Constituents/ Precursors	Key Anthropogenic Sources	Scale of Impact	Peak Levels	Health Impacts	Other Impacts
Ozone	ROG	• Mobile sources • Evaporation of petroleum and solvents • Consumer products	Regional and beyond	Summer	• Aggravated asthma • Acute bronchitis • Chronic bronchitis • Respiratory symptoms • Decreased lung function • Heart attacks • Premature mortality	• Property damage: Tires, paints, building surfaces • Damage to crops • Nitrogen deposition to land and waterways
	NO_x	• Mobile sources • Other combustion				
$PM_{2.5}$	Direct emissions from combustion	• Wood burning • Diesel engines • Gasoline engines • Burning natural gas • Commercial cooking	Local and Regional	Winter	• Aggravated asthma • Respiratory symptoms • Increased blood pressure • Decreased lung function • Heart disease • Stroke • Premature mortality	• Regional haze • Acid deposition • Water pollution
	ROG	See ROG above				
	NO_x	See NO_x above				
	Ammonia (NH_3)	• Landfills • Livestock • Wastewater treatment • Refineries				
	SO_2	• Petroleum refining • Ships				
Toxic Air Contaminants	Diesel PM Benzene 1,3 Butadiene Formaldehyde Acetaldehyde	• Diesel engines • Gasoline engines • Construction equipment • Ships and boats	Local	Year-round	• Acute non-cancer • Chronic non-cancer • Lung cancer • Leukemia • Premature mortality	• Water pollution
Greenhouse Gases	Carbon dioxide (CO_2) Methane (CH_4) Nitrous oxide (N_2O) Hydrofluorocarbon Perfluorocarbon Sulfur hexafluoride Black carbon	• Fossil fuel combustion • Production of fossil fuels (e.g., oil refining) • Mobile sources • Electricity generation	Global	Year-round	• Potentially increased ozone levels • Disease vectors • Effects from prolonged heat waves	• Climate change • Rising sea levels • Acidification of oceans • Species extinction • Drought • Wildfires



Ambient concentrations of all six of the criteria pollutants have been greatly reduced in the Bay Area over the past four decades.

Air Quality Standards and Bay Area Attainment Status

The federal Clean Air Act of 1970 directed U.S. EPA to establish national ambient air quality standards (NAAQS) at a level to provide an adequate margin of safety to protect public health for six air pollutants: ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, lead and particulate matter.[1] These six pollutants are commonly referred to as "criteria pollutants."[2] U.S. EPA is required to review and potentially revise the NAAQS every five years in light of new scientific evidence. After considering recommendations from an independent committee of experts—the Clean Air Science Advisory Committee—U.S. EPA staff presents a range of values for the standard, from which the U.S. EPA administrator selects the final standard.

The state of California also establishes air quality standards, referred to as "state standards" in the 2017 Plan. State standards are determined by the California Air Resources Board (ARB), based on technical input from the Office of Environmental Health Hazard Assessment (OEHHA). In many cases, state standards are more stringent than national standards.

Air quality standards for criteria pollutants are generally defined in terms of ambient concentrations of a pollutant in the atmosphere. Standards are expressed either in terms of a *parts per million* ratio (the state and national 8-hour ozone standard is 0.070 parts per million) or a *mass per volume* basis (the national 24-hour $PM_{2.5}$ standard is 35 $\mu g/m^3$ or micrograms per cubic meter).

Air quality standards may be established for different time intervals ranging from hourly averaged measurements to annual averages. There are multiple standards that apply to some pollutants, such as ozone and PM. Determining whether an air basin attains a given standard requires comparing monitored pollutant values, such as an hourly peak or annual average, with the standard. For purposes of determining whether an air basin attains a given air quality standard, a metric called the *design value* is calculated for each monitoring station. The way the design value is calculated depends upon how the standard is defined; i.e., the "form of the standard." An air basin (e.g., the Bay Area) generally meets the standard only if the design value at each monitoring site within its monitoring network does not exceed the standard.

Ambient concentrations of all six of the criteria pollutants have been greatly reduced in the Bay Area over the past four decades. The Air District attains national and state standards for four of the six criteria pollutants: lead, carbon monoxide, sulfur dioxide and nitrogen dioxide. In fact, as shown by the design values in Table 2-2, Bay Area concentrations are well below current standards for these four pollutants. However, while the region has achieved reductions in ozone and PM, the Air District does not yet attain all state and national standards for ozone and PM.

Table 2-2 summarizes current national and state standards, Air District attainment status, and Bay Area design values for the six criteria pollutants.

Table 2-2. Standards for Criteria Pollutants, Attainment Status and Design Values[a]

Pollutant	Averaging Time	California Standard	Attainment Status	National Standard	Attainment Status*	Design Value[b] (2015)
Ozone	1-hour	0.09 ppm	N			0.10 (Calif)
Ozone	8-hour	0.070 ppm	N	0.070 ppm—3-year avg. of 4th highest value	N[c]	0.073 ppm
CO	1-hour	20 ppm	A	35 ppm—not to be exceeded > once per year	A	3.8 ppm
CO	8-hour	9 ppm	A	9 ppm—not to be exceeded > once per year	A	2.0 ppm
$PM_{2.5}$	24-hour			35 µg/m^3—3-year average of 98th percentile	N[d]	30 µg/m^3
$PM_{2.5}$ [e]	Annual	12 µg/m^3—3-year max	N	12 µg/m^3—3-year average	A	11.4 µg/m^3
PM_{10}	24-hour	50 µg/m^3	N	150 µg/m^3 [f]	U	58 µg/m^3
PM_{10}	Annual	20 µg/m^3	N			22 µg/m^3 (Calif)
SO_2 [g]	1-hour	0.25 ppm	A	75 ppb—3-year 99th percentile	U	14 ppb
SO_2	24-hour	0.04 ppm	A	0.14 ppm—not to be exceeded > once per year	A	< 0.01 ppm
NO_2	Annual	0.030 ppm	A	0.053 ppm	A	0.018 ppm
NO_2	1-hour	0.18 ppm	A	100 ppb—3-year average of 98th percentile	U	57 ppb
Lead	3-month rolling avg.			0.15 µg/m^3	A	< 0.01 µg/m^3

* A = Attainment N = Non-Attainment U = Unclassified

[a] The design value is a statistic based on the monitored concentrations that can be compared with the corresponding standard. The standard is violated if the design value exceeds the standard. Design values are computed on a site-by-site basis. Air District design value is the highest design value at any individual monitoring site.

[b] Design values relative to the NAAQS are shown unless indicated as (California).

[c] U.S. EPA lowered the national 8-hour ozone standard from 0.075 to 0.070 PPM (or 70 ppb) in October 2015.

[d] U.S. EPA tightened the national 24-hour $PM_{2.5}$ standard from 65 to 35 µg/m^3 in 2006. On January 9, 2013, U.S. EPA issued a final rule to determine that the Air District attains the 24-hour $PM_{2.5}$ national standard. This U.S. EPA rule suspends key SIP requirements as long as monitoring data continues to show that the Air District attains the standard. Despite this U.S. EPA action, the Air District will continue to be designated as non-attainment for the national 24-hour $PM_{2.5}$ standard until the Air District submits a redesignation request and a maintenance plan to U.S. EPA, and U.S. EPA approves the proposed redesignation.

[e] On January 15, 2013, U.S. EPA revised the annual $PM_{2.5}$ standard from 15 µg/m^3 to 12 µg/m^3.

[f] The national 24-hour PM_{10} standard allows one exceedance per year over 3 years with every-day sampling. Because PM_{10} is sampled on a 1-in-6-day schedule, this means that, in practice, any exceedance would violate the standard.

[g] On June 2, 2010, a new 1-hour SO2 NAAQS was established and the existing 24-hour and annual primary standards were revoked. U.S. EPA has yet to determine whether or not the Bay Area has attained the 1-hour SO_2 standard. Their determination is likely to occur end of 2017.

The Air District's air monitoring program operates a network of 34 air monitoring stations to measure air quality levels in the Bay Area.

Technical and Analytical Tools

Sound air quality planning requires a solid technical foundation. The Air District uses a variety of tools and analytical techniques to measure and characterize emissions and ambient concentrations of air pollutants, and to estimate the effects of air pollution on the health of Bay Area residents. Key tools include the air quality monitoring network, emissions inventories, photochemical modeling, and the multi-pollutant evaluation method (MPEM). These tools are described briefly below.

Air Quality Monitoring Network

The Air District's air monitoring program operates a network of 34 air monitoring stations to measure air quality levels in the Bay Area. The monitoring network, which complies with all state and national requirements, is designed to: (1) Provide the data required to determine the Air District's attainment status for national and state ambient air quality standards, (2) provide air quality data to the public in a timely manner, and (3) support air pollution research and modeling studies. The monitoring network is evaluated and updated on a regular basis in response to changes in monitoring requirements, shifts in population and other factors. The Air District revises its *Air Monitoring Network Plan*[3] annually to describe changes and improvements to the monitoring network.

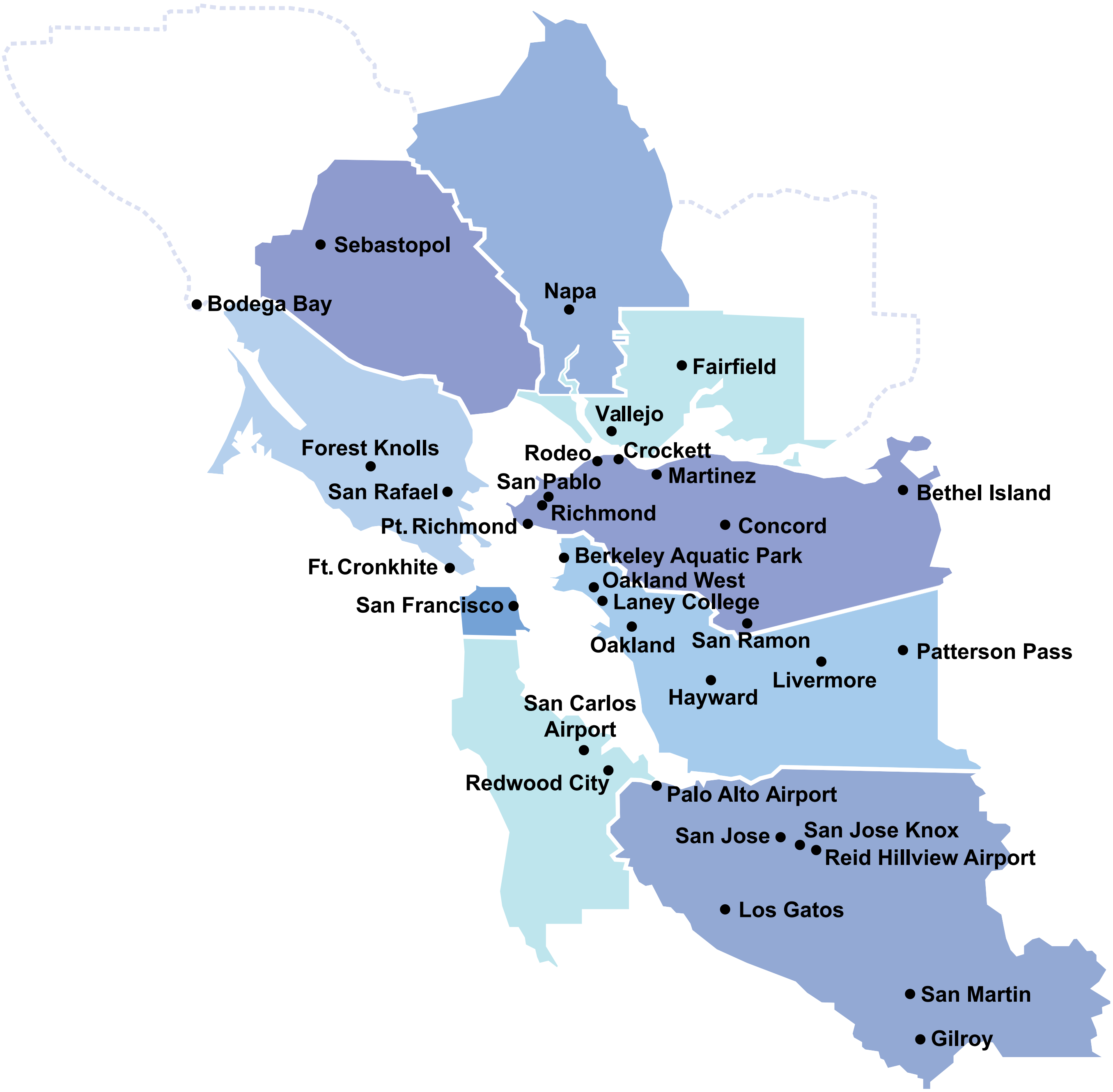
The Air District has been working to enhance its monitoring capabilities in relation to localized concentrations of air pollutants as well as greenhouse gases. The monitoring network now includes three sites to measure near-roadway emissions of NO_2, CO, $PM_{2.5}$, black carbon, and ultra-fine PM (UFPM): Aquatic Park in Berkeley (Hwy 80); Laney College in Oakland (Hwy 880); and San Jose–Knox (Hwy 101/280). A fourth near-roadway site in Dublin (Hwy 580) is currently in development. The Air District has also installed ultra-fine PM particle counters in Livermore, Redwood City, San Pablo and Sebastopol. The Air District is also developing a monitoring network to measure ambient concentrations of CO_2, methane and other GHGs, as described in Chapter 3.

Table 2-3 shows the monitoring stations operated by the Air District in 2016 and the pollutants monitored at each site. The location of monitoring sites is shown in Figure 2-1.

Table 2-3. Bay Area Monitoring Stations and Pollutants Monitored in 2016

Site	Station Name	Pollutants Monitored
1	Bethel Island	O_3, NO_x, SO_2, CO, PM_{10}, Toxics, GHG
2	Berkeley Aquatic Park	NO_x, CO, $PM_{2.5}$, Toxics, Black Carbon (BC), Ultrafine PM (UFPM)
3	Bodega Bay	GHG (background site)
4	Concord	O_3, NO_x, SO_2, CO, PM_{10}, $PM_{2.5}$, Toxics
5	Crockett	SO_2, Toxics
6	Fairfield	O_3
7	Forest Knolls	BC
8	Fort Cronkhite	Toxics
9	Gilroy	O_3, $PM_{2.5}$
10	Hayward	O_3
11	Laney College	NO_x, CO, $PM_{2.5}$, Toxics, BC, UFPM
12	Livermore	O_3, NO_x, HC, $PM_{2.5}$, Toxics, BC, UFPM, GHG
13	Los Gatos	O_3
14	Martinez	SO_2, Toxics
15	Napa	O_3, NO_x, CO, PM_{10}, $PM_{2.5}$, Toxics
16	Oakland	O_3, NO_x, CO, $PM_{2.5}$, Toxics
17	Oakland West	O_3, NO_x, SO_2, CO, $PM_{2.5}$, Toxics, BC
18	Palo Alto Airport	Lead
19	Patterson Pass	NO_x, O_3
20	Point Richmond	Hydrogen sulfide (H_2S)
21	Redwood City	O_3, NO_x, CO, $PM_{2.5C}$, Toxics, UFPM
22	Reid-Hillview Airport	Lead
23	Richmond 7th	SO_2, H_2S, Toxics
24	Rodeo	H_2S
25	San Carlos Airport II	Lead
26	San Francisco	O_3, NO_x, CO, PM_{10}, $PM_{2.5}$, Toxics
27	San Jose	O_3, NO_x, SO_2, CO, PM_{10}, $PM_{2.5}$, Toxics, Lead
28	San Jose Knox Ave	NO_x, CO, $PM_{2.5}$, Toxics, BC, UFPM
29	San Martin	O_3, GHG
30	San Pablo	O_3, NO_x, SO_2, CO, PM_{10}, $PM_{2.5}$, Toxics, UFPM
31	San Rafael	O_3, NO_x, CO, PM_{10}, $PM_{2.5}$, Toxics
32	San Ramon	O_3, NO_x
33	Sebastopol	O_3, NO_x, CO, $PM_{2.5}$, Toxics, UFPM
34	Vallejo	O_3, NO_x, SO_2, CO, $PM_{2.5}$, Toxics

Figure 2-1. **2016 Air Monitoring Network**



Air quality modeling is an important tool for analyzing the formation, transport, and dispersal of air pollutants, and for estimating how exposure to air pollution affects the health of Bay Area residents.

Emissions Inventories

Emissions inventories are essential tools for air quality planning. Inventories identify source categories and provide estimates of emissions from each "anthropogenic" source.[4] Emissions inventories are used to perform air quality modeling, to identify source categories where there may be opportunities for additional emission reductions, and to estimate potential emission reductions for control measures under consideration.

The Air District develops and maintains emissions inventories for a variety of pollutants including ROG, NO_x, $PM_{2.5}$ and PM_{10}.[5] The inventories provide detailed estimates of emissions from a wide variety of sources. The Air District has also developed a TAC inventory, as well as an ammonia inventory, since ammonia is a key precursor to secondary formation of PM. Emissions inventories are periodically revised to reflect changes in emission factors, such as turnover in the vehicle fleet, economic and demographic trends, and regulatory activity such as more stringent limits on emissions sources.

Air Quality Modeling

Air quality modeling is an important tool for analyzing the formation, transport, and dispersal of air pollutants, and for estimating how exposure to air pollution affects the health of Bay Area residents. Modeling is also useful for predicting how an increase or decrease in emissions will affect ambient concentrations of a given pollutant. The Air District has robust in-house modeling capabilities. The Air District applies air quality models to simulate ozone, PM, TACs and other air pollutants which can be used to inform the efficacy of potential control measures, support rule development, and upgrade the Multi-Pollutant Evaluation Method described below. Appendix D provides a summary of the Air District's recent air quality modeling projects and the results of those efforts.

Multi-Pollutant Evaluation Method

Reducing emissions of criteria air pollutants, TACs and GHGs will provide a variety of social and economic benefits. The Air District developed a multi-pollutant evaluation method (MPEM) as an analytical tool for the multi-pollutant Bay Area 2010 Clean Air Plan. The MPEM provides a means to quantify the estimated benefits of individual control measures and the control strategy as a whole in protecting public health, extending the average lifespan of Bay Area residents and protecting the climate. This information can be used to compare the estimated costs and benefits of individual control measures, to help prioritize implementation of control measures in the 2017 Plan, and to estimate the magnitude of benefits to the region from the control strategy as a whole. MPEM input values have been updated for use of the method in the 2017 Plan. A more detailed description of the MPEM is provided in Appendix C.

Profiles of Key Pollutants

Brief profiles of the air pollutants that have the greatest direct impact on public health—ozone, particulate matte, and toxic air contaminants—are provided below.

Ozone

Ozone (O_3), often called smog, is harmful to public health at high concentrations near ground level.[6] Ozone can damage the tissues of the lungs and respiratory tract. High concentrations of ozone irritate the nose, throat, and respiratory system and constrict the airways. Ozone also can aggravate other respiratory conditions such as asthma, bronchitis and emphysema, causing increased

hospital admissions. Repeated exposure to high ozone levels can make people more susceptible to respiratory infection and lung inflammation and permanently damage lung tissue. Ozone can also have negative cardiovascular impacts, including chronic hardening of the arteries and acute triggering of heart attacks. Children are most at risk as they tend to be active and outdoors in the summer when ozone levels are highest. Seniors and people with respiratory illnesses are also especially sensitive to ozone's effects. Even healthy adults can be affected by working or exercising outdoors during high ozone levels.

In addition to negative health effects, ozone also has negative ecosystem and economic impacts. Ozone damages leaf tissue in trees and other plants, and reduces yields of agricultural crops.[7] This reduces the ability of trees and plants to photosynthesize and produce their own food. Ozone can also cause substantial damage to a variety of materials such as rubber, plastics, fabrics, paint, and metals. Exposure to ozone progressively damages both the functional and aesthetic qualities of materials and products, and shortens their life spans. Damage from ozone exposure can result in significant economic losses as a result of the increased costs of maintenance, upkeep, and replacement of these materials.

Ozone Standards and Bay Area Attainment Status

The state of California has two ozone standards: a one-hour ozone standard of 0.090 parts per million (ppm) and an 8-hour standard of 0.070 ppm. The Bay Area is classified as non-attainment for both of these state ozone standards. The national 8-hour ozone standard was revised downward to 0.070 ppm in 2015.[8] U.S. EPA is expected to complete the process to designate the attainment status for each air basin under the revised standard in fall 2017. Based on current monitoring data, it is likely that the Air District will be designated as non-attainment at that time. Any action by the Air District in response to such a designation will depend upon the region's classification (i.e., the severity of non-attainment) and further guidance from U.S. EPA.

Although the region does not yet attain state and national ozone standards, Bay Area ozone levels have been greatly reduced over the past 30 years. The reduction in ozone levels has been documented in relation to several indicators, including:

- The number of days per year that ozone levels exceed state or national standard;
- The "expected peak day concentration" (see Appendix E); and
- Population exposure to unhealthy levels of ozone (see Appendix E).

Ozone concentrations are a function of the quantity and spatial distribution of ozone precursor (ROG and NO_x) emissions, the ratio of ROG to NO_x, meteorological conditions (temperature, wind speed and direction, etc.), and other factors. Several factors make it difficult to predict when the Bay Area will attain state and national ambient ozone standards:

- Emissions of ozone precursors are projected to continue decreasing in response to existing Air District and ARB regulations and programs. However, it is difficult to predict future emissions with precision.
- Normal fluctuations in weather cause ozone levels to vary from year-to-year.
- Higher temperatures related to climate change may cause increased ozone formation in future years, as discussed in Chapter 3.

In order for the Bay Area to fully attain state and national standards, the region must continue efforts to further reduce emissions of ozone precursors, including the proposed control measures that will reduce emissions of ROG and NO_x, as described in the control strategy summary in Chapter 5. Nonetheless, it should be emphasized that great progress has been made in reducing ozone concentrations in recent decades. Peak concentrations of ozone have been significantly reduced[9] and population exposure to unhealthy levels of ozone has decreased dramatically. For example, per capita exposure to ozone levels above the state 1-hour ozone standard (90 parts per billion) has been reduced by 99 percent over the past 30 years, as discussed in Appendix E.

Ozone Dynamics

Ozone is not emitted directly from pollution sources. Instead, ozone is formed in the atmosphere in the presence of sunlight through complex chemical reactions between two types of precursor chemicals: reactive organic gases (ROG) and nitrogen oxides (NO_x). As the air temperature rises, ground-level ozone forms at an accelerated rate. Ozone levels are usually highest on hot, windless summer afternoons, especially in inland valleys. Exceedances of state or national ozone standards in the Bay Area only occur on hot, relatively stagnant days. Because weather conditions have a strong impact on ozone formation, ozone levels can vary significantly from day-to-day or from one summer to the next.

Climate change may increase ozone levels in future years. Longer and more severe heat waves expected as a result of climate change may cause more ozone formation, resulting in more frequent exceedances of ozone standards. As discussed in Chapter 3, climate change could erode decades of progress in reducing ozone levels.

Ozone is a regional pollutant. Emissions of ROG and NO_x throughout the Bay Area contribute to ozone formation in downwind areas. Therefore, reductions in emissions of ROG and NO_x are needed throughout the region in order to decrease ozone levels.

Longer and more severe heat waves expected as a result of climate change may cause more ozone formation, resulting in more frequent exceedances of ozone standards.

The ROG to NO_x ratio strongly affects the ozone formation rate. The Air District's ozone modeling indicates that the Bay Area is "ROG-limited" for ozone formation. This suggests that reducing ROG emissions will be more productive in reducing ozone, at least in the near term. However, modeling also indicates that large reductions in NO_x emissions will be needed over the long term to achieve the reduction in ozone concentrations required to attain state and national ozone standards which have become progressively more stringent in recent decades. Additional discussion of ozone dynamics is provided in Appendix E, and results of the Air District's ozone modeling are provided in Appendix D.

Key Sources of Ozone Precursors

There are literally millions of discrete sources of ozone precursor emissions in the Bay Area, both man-made and natural. Emissions produced by human activity are called "anthropogenic." Emissions produced by natural sources, such as plants and animals, are called "biogenic." In the Bay Area, emissions from anthropogenic sources are greater than from biogenic sources. The main sources of ROG emissions in the Bay Area are motor vehicles and other mobile sources, as well as evaporation of petroleum and solvents, as shown in Figure 2-2. The main sources of NO_x emissions in the region are motor vehicles and other mobile sources, as well as combustion at industrial and other facilities, as shown in Figure 2-3.

Figure 2-2. 2015 Annual Average ROG Emissions by Source (259 tons/day)

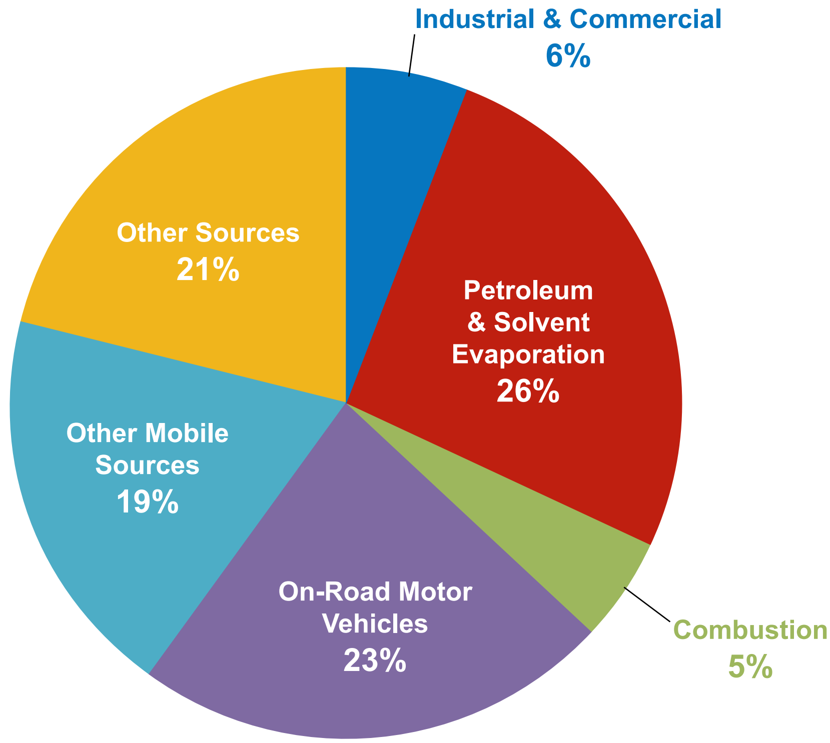
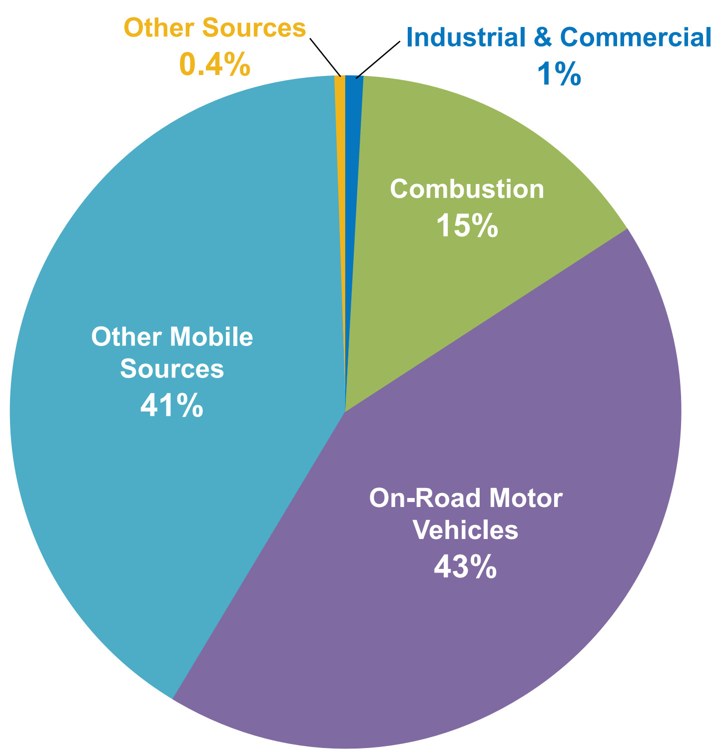


Figure 2-3. 2015 Annual Average NO_x Emissions by Source (298 tons/day)



Trends in Emissions of Ozone Precursors

Emissions of ROG and NO_x have both been greatly reduced in recent decades in response to aggressive ARB and Air District regulations. ROG emissions declined from approximately 830 tons per day (tpd) in 1990 to approximately 259 tpd in 2015, a reduction of 67 percent. NO_x emissions declined from approximately 790 tpd in 1990 to approximately 300 tpd in 2015, a reduction of over 60 percent. Looking forward, emissions of ROG and NO_x in the Bay Area are currently projected to flatten out, with nominal increases in future years as shown in Figures 2–4 and 2–5. However, these projections only reflect the impact of adopted regulations that were in place as of December 31, 2012. Future emissions of ROG and NO_x will likely decrease in response to the control strategy described in this Plan, as well as potential action by ARB to further tighten motor vehicle emission standards.

Figure 2-4. **Annual Average ROG Emissions Trend, 1990–2030**

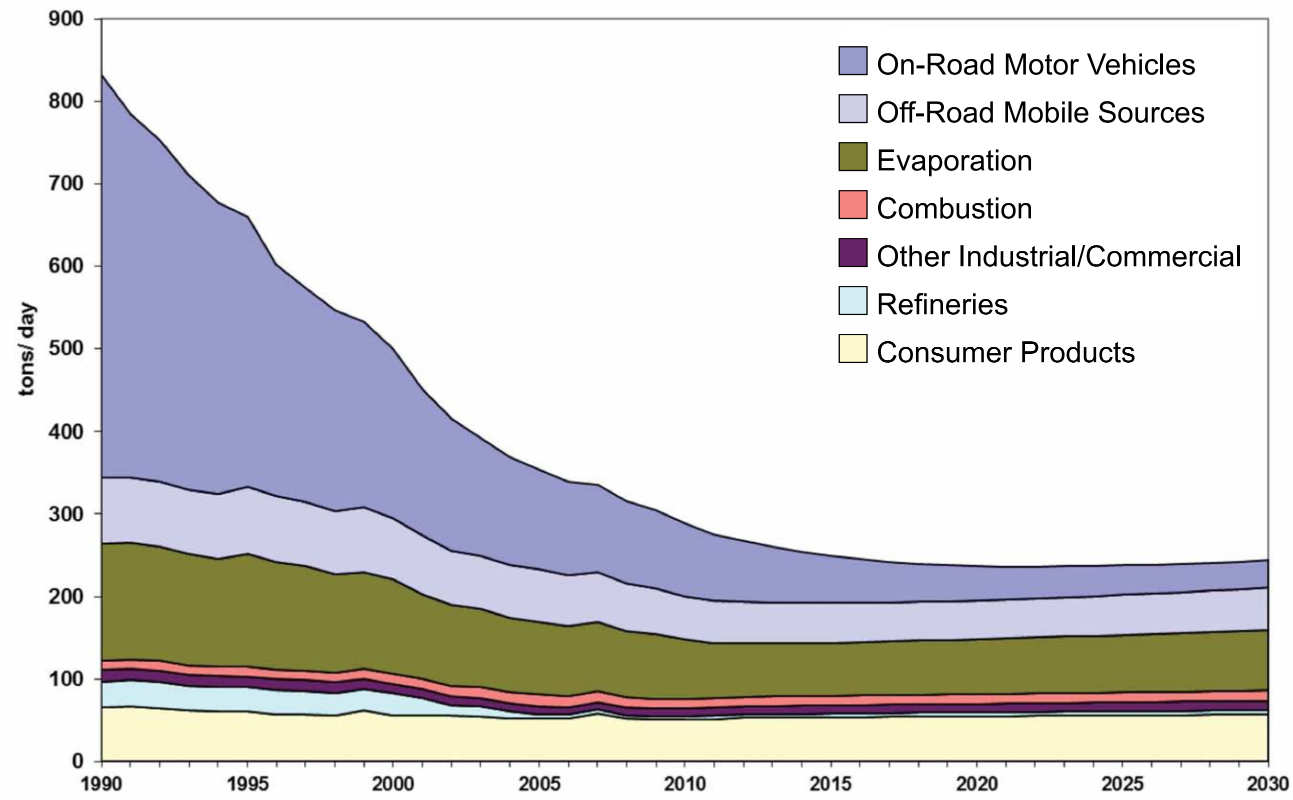
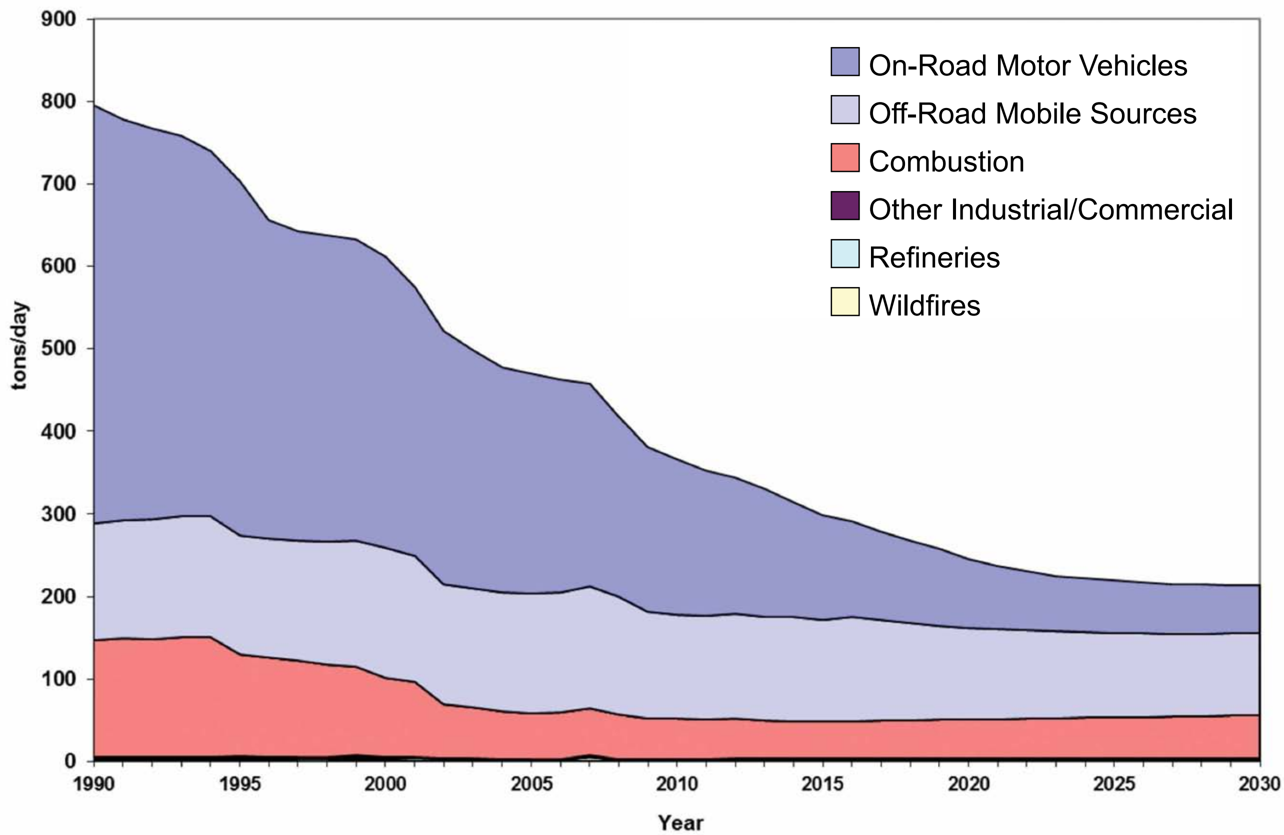


Figure 2-5. **Annual Average NO_x Emissions Trend, 1990–2030**



The reduction in emissions of ozone precursors has resulted in substantial decrease in ozone concentrations and exposure of Bay Area residents to unhealthy ozone levels, as discussed in the "Progress in Improving Air Quality and Protecting Public Health" section below.

Particulate Matter

Particulate matter is a diverse mixture of suspended particles and liquid droplets (aerosols). PM includes elements such as carbon and metals; compounds such as nitrates, organics, and sulfates; and complex mixtures such as diesel exhaust, wood smoke and soil. Unlike the other criteria pollutants which are individual chemical compounds, PM includes all particles that are suspended in the air. PM is both directly emitted (referred to as direct PM or primary PM) and also formed in the atmosphere through reactions among different pollutants (referred to as indirect or secondary PM).

PM is generally characterized on the basis of particle size. Ultra-fine PM includes particles less than one micron in diameter. Fine PM ($PM_{2.5}$) consists of particles 2.5 microns or less in diameter. PM_{10} consists of particles 10 microns or less in diameter. Total suspended particulates (TSP) includes suspended particles of any size.

Compelling evidence suggests that fine PM is the air pollutant most harmful to the health of Bay Area residents, as discussed below as well as in the health burden analysis presented in Appendix C. In view of the impact of PM on public health, the Air District issued a detailed report titled *Understanding Particulate Matter: Protecting Public Health in the San Francisco Bay Area* in November 2012.[10] Readers are encouraged to review that report for an in-depth discussion of the effects of PM on public health, ecosystems, and the climate; population exposure to PM; PM emissions sources in the Bay Area; and the Air District's PM control program.

Researchers continue to study the relative risk associated with the many types and sources of particles that comprise PM. The evidence that is currently available suggests that all types of fine particles are harmful, irrespective of size, source, or chemical composition. In general, however, smaller particles have more adverse health effects because they can penetrate more deeply into the lungs, bloodstream, organs and cells.

A large and growing body of scientific evidence indicates that both short-term and long-term exposure to fine particles can cause a wide range of health effects, including aggravated asthma and bronchitis; hospital visits for respiratory and cardiovascular symptoms; and strokes and heart attacks, some of which result in premature deaths. The evidence shows that reducing PM emissions can reduce mortality and increase average life span. For example, a study of nationwide scope found that reducing fine PM results in significant and measurable improvements in human health and life expectancy.[11]

Although epidemiological evidence demonstrates a strong correlation between elevated PM levels and negative public health effects, scientists are still working to understand the precise biological mechanisms through which PM damages our health. Research suggests that PM may harm our bodies by a combination of 1) increasing blood pressure, and 2) triggering a response which causes inflammation that can stiffen and damage blood vessels.[12] Studies also indicate that exposure to PM may damage cells or tissue via oxidative stress[13] and contribute to diabetes.[14] Oxidative stress refers to the body's inability to protect itself against elevated levels of free radicals (e.g., hydroxyl, nitric acid) or non-radicals (e.g., hydrogen peroxide, lipid peroxide), thereby causing tissue damage. A Danish study found that participants who rode bicycles in traffic in Copenhagen, and were therefore exposed to elevated levels of PM and ultrafine PM, sustained damage to their DNA.[15]

In addition to its negative health effects, PM is also a prime cause of regional haze. PM emissions also impact the climate. PM aerosols that scatter sunlight can help to reduce or mask the warming effect of solar radiation. However, black carbon (soot), a component of PM, has been determined to be a potent agent of climate change, as discussed in Chapter 3. Therefore, reducing emissions of black carbon from sources such as diesel engines and wood burning can help to both protect public health and protect the climate.

The evidence shows that reducing PM emissions can reduce mortality and increase average life span.

PM Standards and Bay Area Attainment Status

There are national and state ambient air quality standards for both $PM_{2.5}$ and PM_{10}. The 24-hour standards are intended to prevent short-term (acute) health effects; the annual average standards address long-term (chronic) health effects. In response to new evidence about the health effects of PM, national and state PM standards have been tightened since 2000. However, researchers have not yet been able to identify a clear threshold below which there are no health effects from exposure to fine PM. This suggests that $PM_{2.5}$ standards may be further tightened in the future.

The Bay Area's attainment status relative to national and state PM standards is shown in Table 2-2. The Bay Area attains the national 24-hour PM_{10} standard and the national annual $PM_{2.5}$ standard. On January 9, 2013, U.S. EPA issued a final rule confirming that monitoring data shows that the Bay Area currently meets the 24-hour $PM_{2.5}$ national standard. This U.S. EPA action suspends key State Implementation Plan (SIP) requirements as long as monitoring data continues to show that the Air District meets the standard. However, despite this U.S. EPA action, the Air District will continue to be formally designated as non-attainment

Consecutive stagnant and clear winter days are typically prerequisites for development of $PM_{2.5}$ episodes.

for the national 24-hour $PM_{2.5}$ standard until the Air District submits and U.S. EPA approves a redesignation request including a maintenance plan.

In 2002, the state of California adopted an annual $PM_{2.5}$ standard, but the state has yet to adopt a short-term 24-hour $PM_{2.5}$ standard. Monitoring data for the 2014 through 2016 period indicates that the Bay Area currently meets the state annual $PM_{2.5}$ standard. However, the Bay Area has not yet attained the state annual and 24-hour standards for PM_{10}.

PM Dynamics

PM chemistry and formation is complex and variable. PM concentrations vary considerably in composition and in spatial distribution both on a day-to-day basis and on a seasonal basis in response to changes in weather and emissions. The Bay Area generally experiences its highest PM concentrations in the winter. Exceedances of the 24-hour national $PM_{2.5}$ standard almost always occur between November and February. High $PM_{2.5}$ episodes are typically regional in scale, impacting multiple Bay Area locations. During other seasons, by contrast, Bay Area $PM_{2.5}$ tends to be low due to the area's natural ventilation system. Thus, on an annual average basis, the Bay Area's $PM_{2.5}$ levels are among the lowest measured in major U.S. metropolitan areas. During summer and fall, Bay Area PM levels occasionally spike in response to wildfires that occur either within the region or in adjacent regions.

Consecutive stagnant and clear winter days are typically prerequisites for development of $PM_{2.5}$ episodes. The lower levels of solar radiation (sunlight) in the winter lead to stronger temperature inversions. These inversions are conducive to the buildup of PM in ambient air near ground level, especially ultrafine particles, which can remain airborne for a number of days. Winter is also when the most residential wood burning occurs; in some parts of the Bay Area, wood smoke accounts for the majority of airborne $PM_{2.5}$ during high PM episodes.

Secondary $PM_{2.5}$ levels are likewise elevated during the winter months. Cool weather is conducive to the formation of ammonium nitrate. Ammonium nitrate is the main type of secondary $PM_{2.5}$ in winter months, contributing an average of about 35 percent of total $PM_{2.5}$ under peak PM conditions. This semi-volatile $PM_{2.5}$ component is stable in its solid form only during the cooler winter months. Although the contribution of ammonium sulfate is relatively low (averaging 1-2 $\mu g/m^3$) it accounts for approximately 10 percent of total $PM_{2.5}$ on an annual average basis.

PM Emissions Sources

Combustion of fossil fuels and biomass, primarily wood, from various sources are the primary contributors of directly-emitted Bay Area $PM_{2.5}$ in all seasons, as shown in Figure 2-6. Biomass combustion emissions are about 3–4 times higher in winter than during the other seasons, and its contribution to peak $PM_{2.5}$ is also greater in winter, as confirmed by isotopic carbon (C^{14}) analysis. The increased winter biomass combustion emissions reflect increased residential wood burning during the winter season. Residential wood burning can degrade local air quality, especially in communities such as the San Geronimo Valley in Marin County, where wood smoke is trapped by local topography. Therefore, to address the health impacts of wood burning at both the local and regional scale and to avoid exceedances of PM standards, the Air District adopted and continues to strengthen its winter "Spare the Air" wood smoke control program and Regulation 6, Rule 3: Wood Burning Devices, as described in Chapter 4.

Figure 2-6. **Direct $PM_{2.5}$ Emissions by Source, Annual Average, 2015 (47 tons/day)**

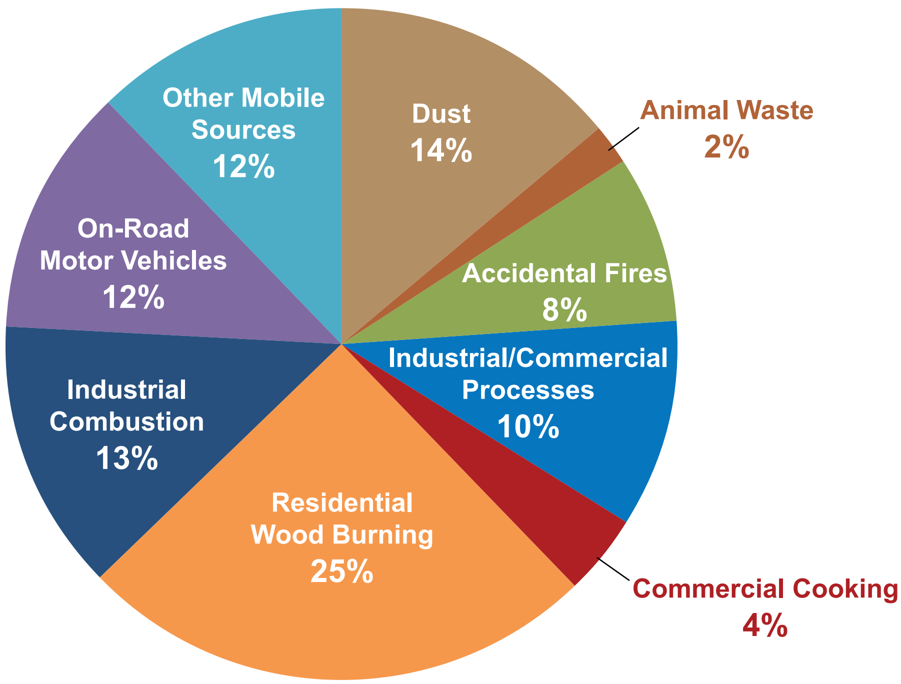


Figure 2-7. **Direct PM_{10} Emissions by Source, Annual Average, 2015 (109 tons/day)**

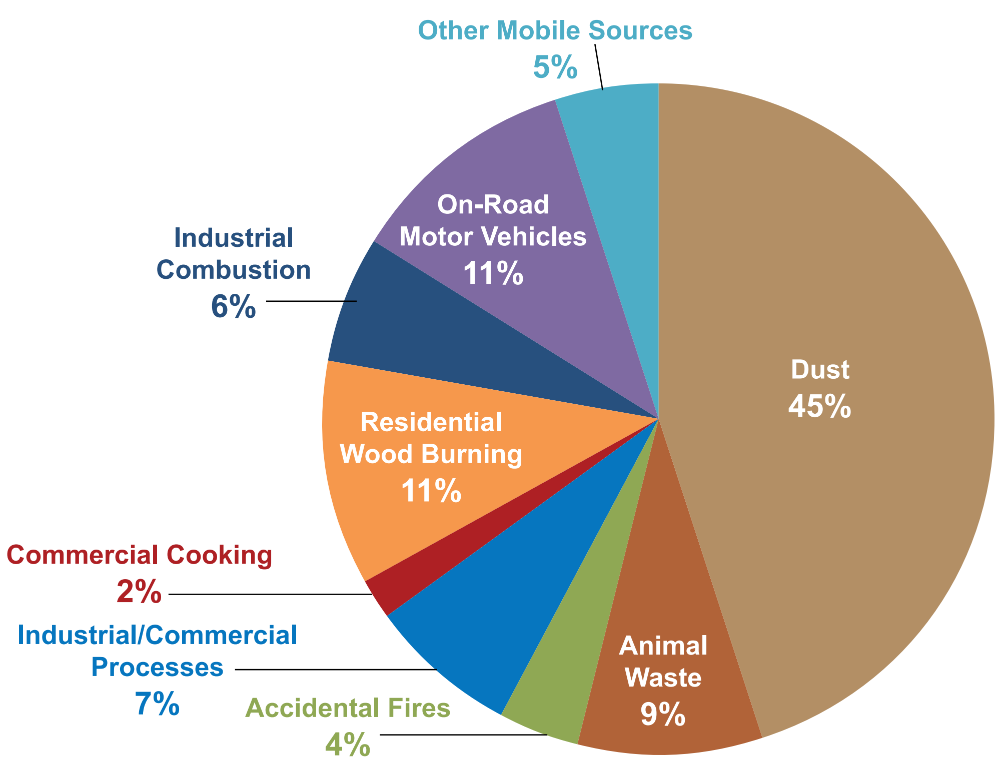


Figure 2-7 shows key sources of directly-emitted PM_{10} in the Bay Area. Whereas dust contributes only modestly to Bay Area $PM_{2.5}$ concentrations, it accounts for a significant portion of PM_{10}, as shown by comparing Figure 2-6 with Figure 2-7.

The reduction in directly-emitted PM, as well as emissions of precursors to secondary PM, has resulted in substantial decrease in PM concentrations and exposure of Bay Area residents to unhealthy PM levels, as discussed in the "Progress in Improving Air Quality and Protecting Public Health" section below.

Source Contributions to Ambient PM Concentrations

Ambient $PM_{2.5}$ derives both from direct emissions and secondary compounds created in the atmosphere. Determining the relative contributions of various sources of direct $PM_{2.5}$ emissions and $PM_{2.5}$ precursors to total PM concentrations is complex. To estimate the overall contribution of various sources, the Air District combines emissions inventory data with the results of chemical mass balance (CMB) analysis, the latter providing information on the relative contributions from source categories contributing to primary and secondary PM.

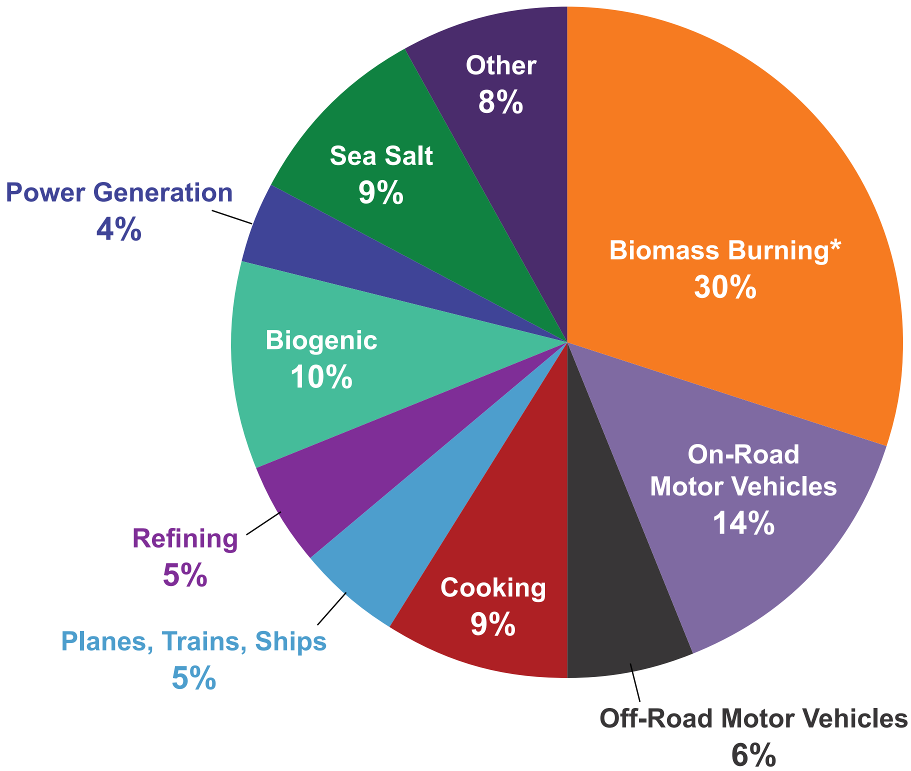
In analyzing PM sources there may be discrepancies between the estimated PM emissions inventory and ambient PM concentrations estimated from CMB analysis. For example, the emissions inventory lists road and windblown dust as significant sources, whereas chemical mass balance analysis shows such dust to be a very small contributor on ambient filters. There are several likely reasons, a primary one being that what gets emitted does not necessarily stay airborne to be sampled. Thus, larger $PM_{2.5}$ particles—those nearly 2.5 microns in diameter such as the bulk of geological dust—tend to settle out relatively quickly, whereas smaller particles—those less than 1 micron in diameter including combustion-related $PM_{2.5}$—can stay airborne for days.

...most Bay Area anthropogenic $PM_{2.5}$ derives from combustion – either wood (biomass) burning, or combustion of fossil fuels.

In addition to directly emitted PM, emissions of PM precursors such as NO_x, ammonia and sulfur dioxide contribute to the formation of secondary PM. Combustion of fossil fuels produces NO_x, which combines with ammonia in the atmosphere to form ammonium nitrate and sulfur dioxide (SO_2), which combines with ammonia to form ammonium sulfate. These secondary compounds constitute one-third of Bay Area $PM_{2.5}$ concentrations on an annual basis and approximately 40–45 percent during winter peak periods.

Figure 2-8 shows estimated contributions to both primary and secondary annual-average $PM_{2.5}$ concentrations by source. The contributions in Figure 2-8 differ from those in Figure 2-6 in a number of respects: Sea salt constitutes about 9 percent of Bay Area $PM_{2.5}$, but is not included in the emissions inventory. Emissions of NO_x from motor vehicles contribute significantly to secondary $PM_{2.5}$, namely ammonium nitrate. Because of this, the overall contribution of motor vehicles to $PM_{2.5}$ concentrations is considerably larger than their direct emissions alone. Similarly, refineries emit significant amounts of SO_2, so that their contribution to ammonium sulfate is significant. Also, animals, fertilizers and landfills emit ammonia, which contributes to the formation of ammonium nitrate and sulfate. Nevertheless, most Bay Area anthropogenic $PM_{2.5}$ derives from combustion—either wood (biomass) burning, or combustion of fossil fuels.

Figure 2-8. Contributions to Annual $PM_{2.5}$ Concentrations in the Bay Area, 2011–2013



* These estimates derive from combining the source category contribution estimates from 4 sites: Livermore, San Jose, Vallejo, and West Oakland for 2009–2011, with detailed emissions estimates from the Air District's emissions inventory.

Toxic Air Contaminants

Toxic air contaminants are a class of pollutants that includes hundreds of individual airborne chemical species hazardous to human health. Many TACs are commonly present in urban environments. Reducing emissions of TACs and population exposure to these pollutants is a key priority for the Air District.

TACs can cause or contribute to a wide range of health effects. Acute (short-term) health effects may include eye and throat irritation. Chronic (long-term) exposure to TACs may cause more severe effects such as neurological damage, hormone disruption, developmental defects and cancer. ARB has identified roughly 200 TACs, including diesel particulate matter (diesel PM) and environmental tobacco smoke.

Unlike criteria pollutants which are subject to ambient air quality standards, TACs are primarily regulated at the individual emissions source level based on risk assessment. Human outdoor exposure risk associated with an individual air toxic species is calculated as its ground-level concentration multiplied by an established unit risk factor for that air toxic species. Total risk due to TACs is the sum of the individual risks associated with each air toxic species.

Occupational health studies have shown diesel PM to be a lung carcinogen as well as a respiratory irritant.[16] Benzene, present in gasoline vapors and also a byproduct of combustion, has been classified as a human carcinogen and is associated with leukemia. 1,3-butadiene, produced from motor vehicle exhaust and other combustion sources, has also been associated with leukemia. Reducing 1,3-butadiene also has a co-benefit in reducing the air toxic acrolein.[17]

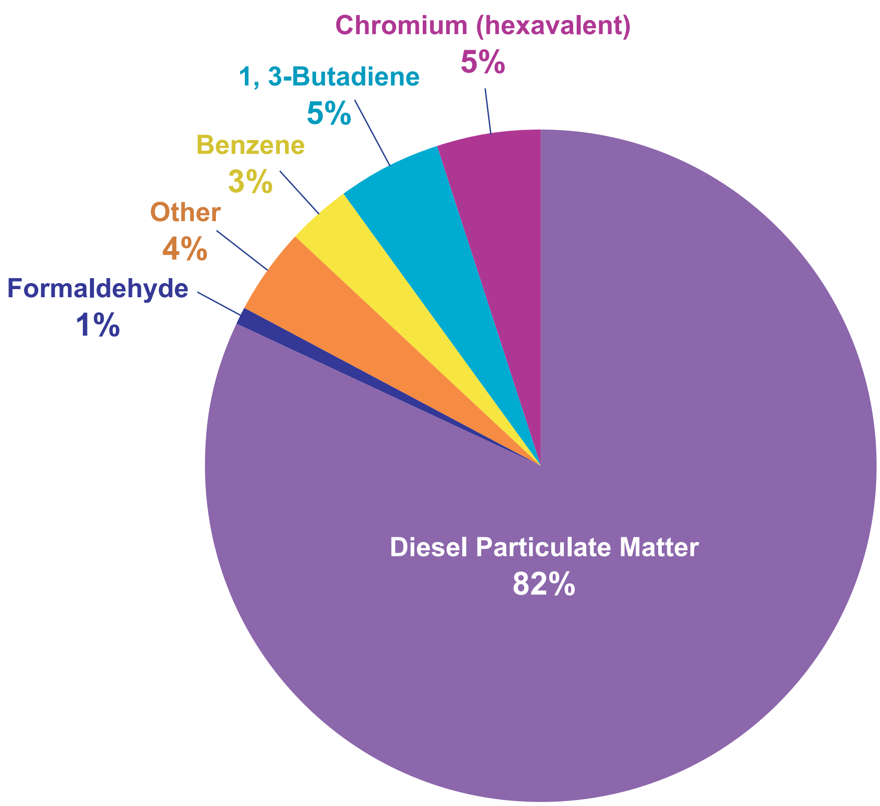
Acetaldehyde and formaldehyde are emitted from fuel combustion and other sources. They are also formed photochemically in the atmosphere from other compounds. Both compounds have been found to cause nasal cancers in animal studies and are also associated with skin and respiratory irritation. Human studies for carcinogenic effects of acetaldehyde are sparse, but in combination with animal studies, sufficient to support classification as a probable human carcinogen. Formaldehyde has been associated with nasal sinus cancer and nasopharyngeal cancer, and possibly with leukemia.

TAC Emissions Sources

Through its Community Air Risk Evaluation (CARE) program, the Air District compiled estimates of TAC emissions within the Bay Area for all major source categories including oil refineries, power plants, landfills, dry-cleaners, gasoline stations, on-road vehicles, off-road vehicles and equipment, ships and trains.

The Air District's cancer-risk weighted emissions inventory, developed based upon CalEPA's Office of Environmental Health Hazard Assessment (OEHHA) health risk estimates, shows that a small subset of TACs account for approximately 95 percent of the total cancer risk from air pollutants in the Bay Area, and that diesel PM in itself greatly dominates the cancer risk from TACs, as shown in Figure 2-9.

Figure 2-9. Cancer-Risk Weighted Emission Estimates by TAC, 2015



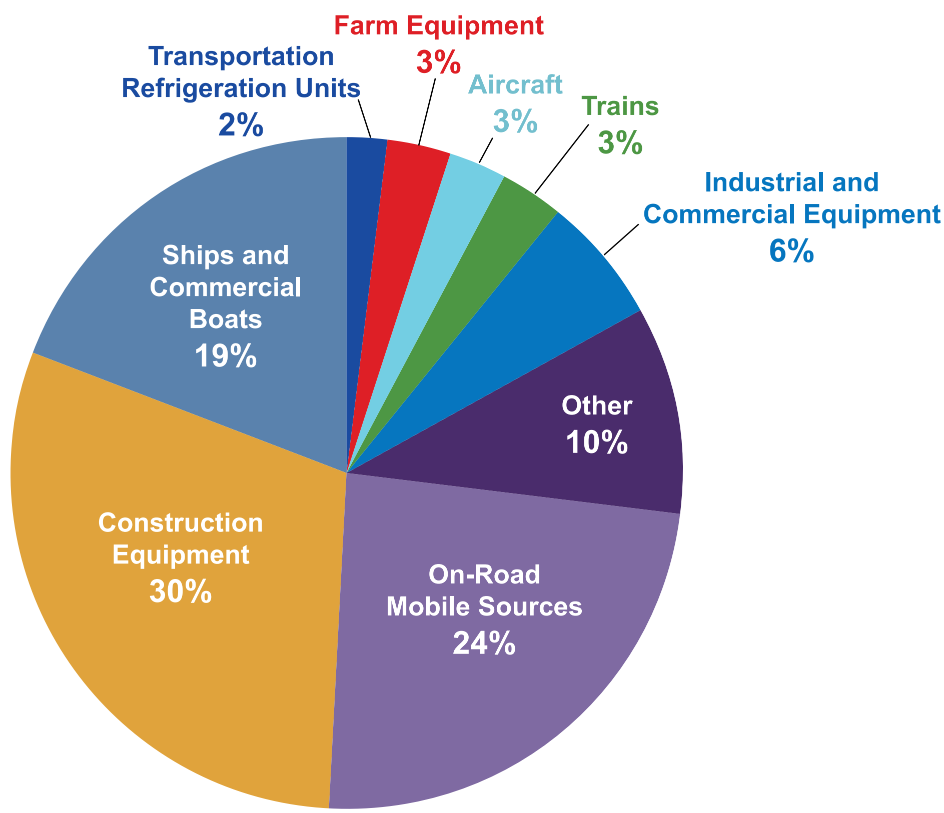
When TAC emissions are weighted based upon their cancer risk, mobile sources of diesel emissions account for most of the cancer risk associated with TACs in the Bay Area. On-road mobile sources and construction equipment together account for 60 percent of the total cancer-risk weighted emissions as shown in Figure 2-10.

Cancer-risk weighted TAC emissions data are based on an inventory of TAC emissions developed for 2005 and revised and projected to reflect conditions in 2015. The projection to 2015 accounted for growth in population, travel, and business, based on socioeconomic forecasts. It also accounted for anticipated reductions in toxic emissions due to regulations, including state regulations for diesel exhaust emissions from on-road and off-road vehicles.[18]

Progress in Improving Air Quality and Protecting Public Health

We have made substantial progress in improving Bay Area air quality over the past several decades, even as the region's population, the amount of motor vehicle travel, and economic output have all grown substantially. As a result, the exposure of Bay Area residents to air pollution has been greatly reduced. This section summarizes the progress in reducing ambient concentrations of ozone, particulate matter, and toxic air contaminants and reducing population exposure to these pollutants.

Figure 2-10. Cancer-Risk Weighted TAC Emissions by Emission Source Category, 2015



Progress in Improving Air Quality

Ozone

The Bay Area has made steady progress in reducing ozone levels and decreasing the number of days that Bay Area ozone levels exceed standards. Most importantly, we have reduced the population exposure of Bay Area residents to elevated ozone levels that have the greatest health impact.

The California Health and Safety Code requires the Air District to assess Bay Area progress toward attainment of the state ozone standards during the most recent triennial period. Figure 2-11 shows the annual number of days that the 1-hour ozone standard was exceeded at any Bay Area monitoring station between 1986 and 2015. The number of days per year when the region exceeds the state 1-hour ozone standard has been decreasing steadily over the past 30 years. However, the data show large fluctuations in the number of exceedance days from year to year. For example, from 1996 to 1997 the number of exceedances dropped from 45 to 10, and then rose to 29 in 1998. Most of this short-term fluctuation from one year to the next is due to variation in weather patterns. Averaging the data across several years reduces the weather-related short-term variation. The 3-year rolling average in Figure 2-11 shows a relatively steady downward trend in exceedances, from an average of 20 or more exceedance days in most years prior to 2000 to fewer than 10 days in the past decade.

Figure 2-12 shows Bay Area trends relative to the current state 8-hour ozone standard of 0.070 ppm. The trend for the 8-hour standard is similar to the trend for the 1-hour standard shown below.

Figure 2-11. Annual Bay Area Days Exceeding 0.09 ppm State 1-hour Ozone Standard, 1986–2015

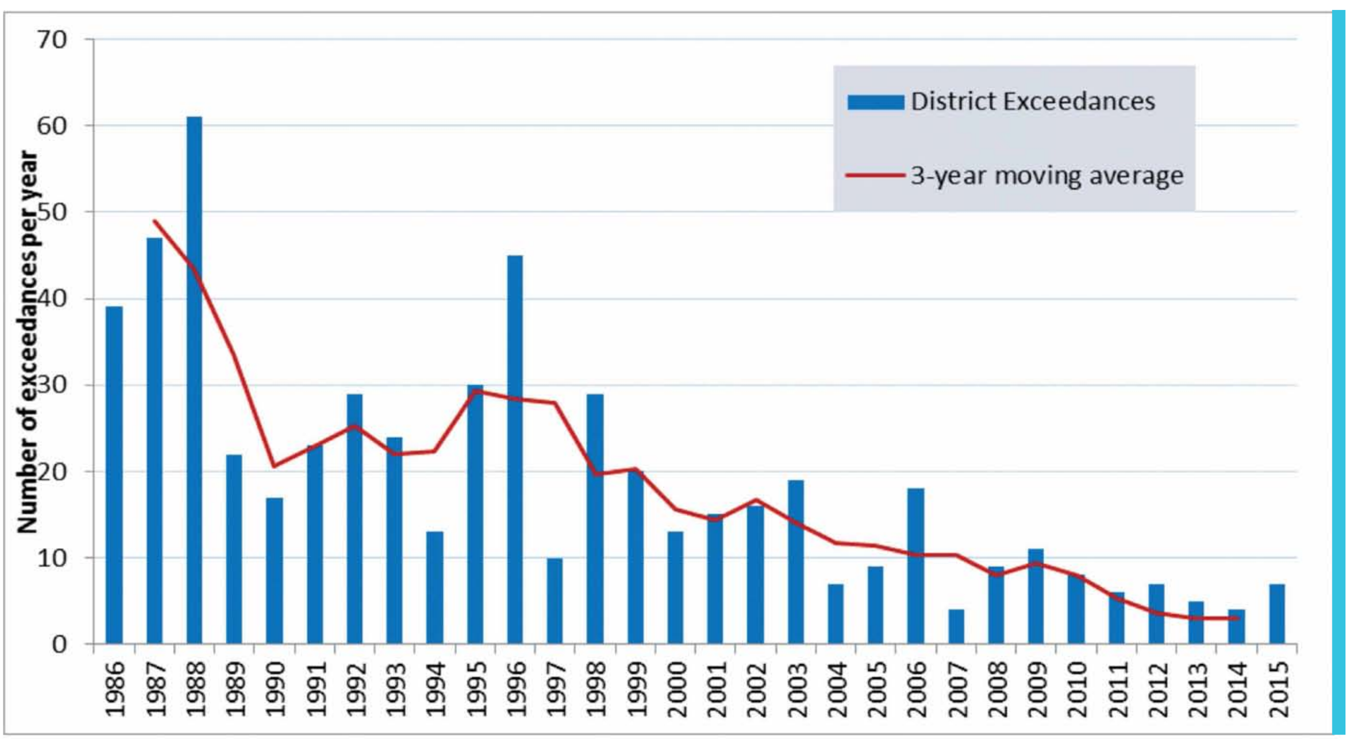
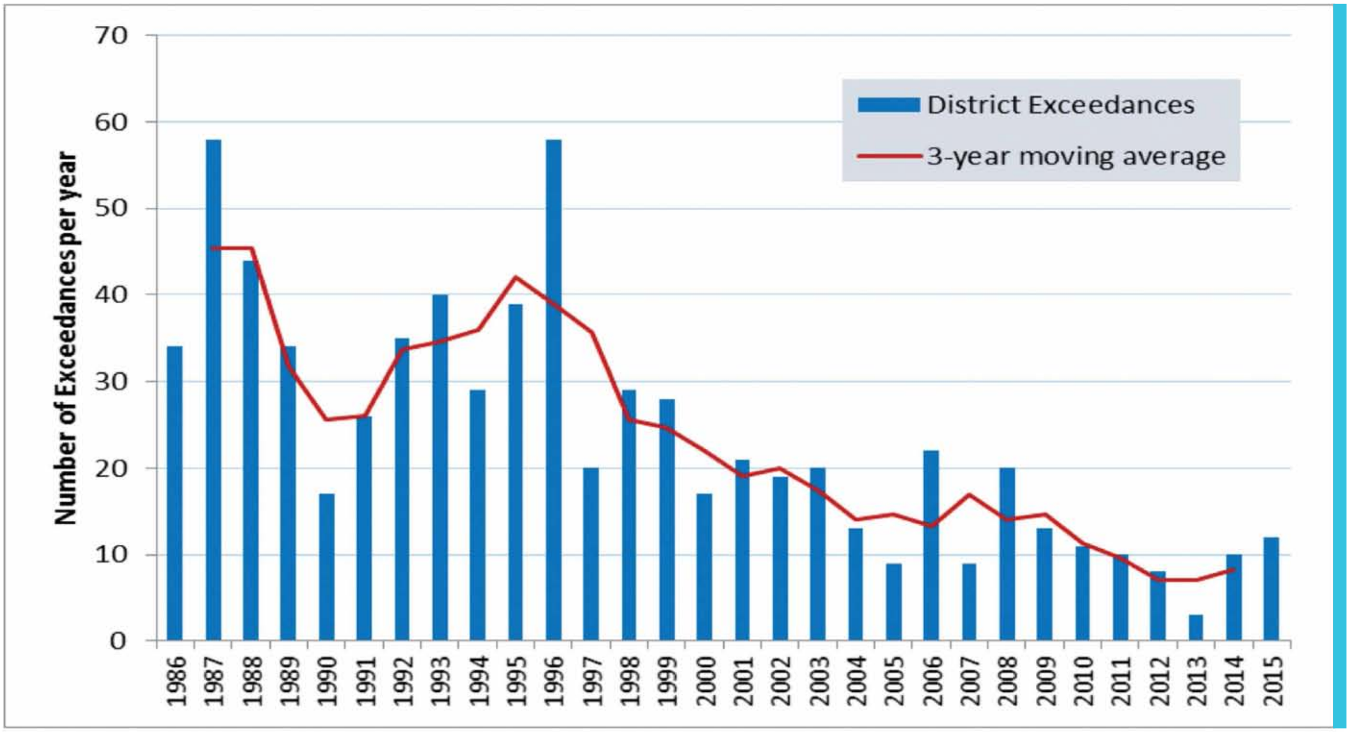


Figure 2-12. **Annual Bay Area Days Exceeding 0.07 ppm State 8-hour Ozone Standard, 1986–2015**



Additional indicators can be used to assess ozone levels and population exposure to ozone. ARB guidance requires the calculation of the following three indicators to assess the extent and rate of improvement in ozone within an air basin:

- **Expected Peak Day Concentration**
- **Population-weighted exposure to ozone:** This indicator measures human exposure to unhealthy levels of ozone.
- **Area-weighted exposure to ozone:** This indicator measures how much the overall ecosystem is subject to unhealthy levels of ozone.

The Air District has made substantial progress in relation to all three indicators in recent decades, as described in Appendix E. Expected Peak Day Concentration decreased 25 percent in relation to the state 1-hour ozone standard between 1986–1988 and 2012–2014 and 23 percent in relation to the state 8-hour ozone standard during the same time period.

Population exposure to unhealthy ozone levels declined dramatically. In 1986–1988, the average Bay Area resident was exposed to unhealthy ozone concentrations 213 hours per year. Exposure to unhealthy ozone levels (ozone exceeding the state one-hour standard of 95 parts per billion) has been reduced to less than one hour per year during the 2012–2014 period, an overall reduction of 99.8 percent.

Particulate Matter

The Bay Area has achieved significant reductions in ambient concentrations of both $PM_{2.5}$ and PM_{10} in recent years through efforts to decrease emissions from key emissions sources, such as motor vehicles and wood burning. Figure 2-13 shows trends relative to the national and state PM standards.

PM_{10} levels have been greatly reduced since 1990. Peak concentrations have declined by 60 percent and annual average values have declined by 50 percent. $PM_{2.5}$ has only been measured since 1999, so long-term quantitative trend analysis is currently limited. However, concentrations of $PM_{2.5}$ have been reduced since 1999 in relation to both the annual standard and the 24-hour standard. Bay Area 24-hour $PM_{2.5}$ levels have been cut in half since 1999.

Monitoring data shows that the Bay Area currently meets the national standards for both annual and 24-hour $PM_{2.5}$ levels. However, because the health effects of PM are serious and far-reaching, and no safe threshold of exposure to PM has yet been identified, it is important that we continue efforts to further reduce PM emissions and concentrations.

Toxic Air Contaminants

The Bay Area has benefited from dramatic reductions in public exposure to toxic air contaminants. Based on ambient air quality monitoring, and using OEHHA cancer risk factors,[19] the estimated lifetime cancer risk for Bay Area residents, over a 70-year lifespan from all TACs combined, declined from 4,100 cases per million in 1990 to 690 cases per million people in 2014, as shown in Figure 2-14. This represents an 83 percent decrease between 1990 and 2014.

The cancer risk related to diesel PM, which accounts for most of the cancer risk from TACs, has declined substantially over the past 15–20 years as a result of ARB regulations and Air District programs to reduce emissions from diesel engines. However, diesel PM still accounts for roughly 60 percent of the total cancer risk related to TACs.[20]

Figure 2-13. Bay Area PM Trends Relative to National and California Standards

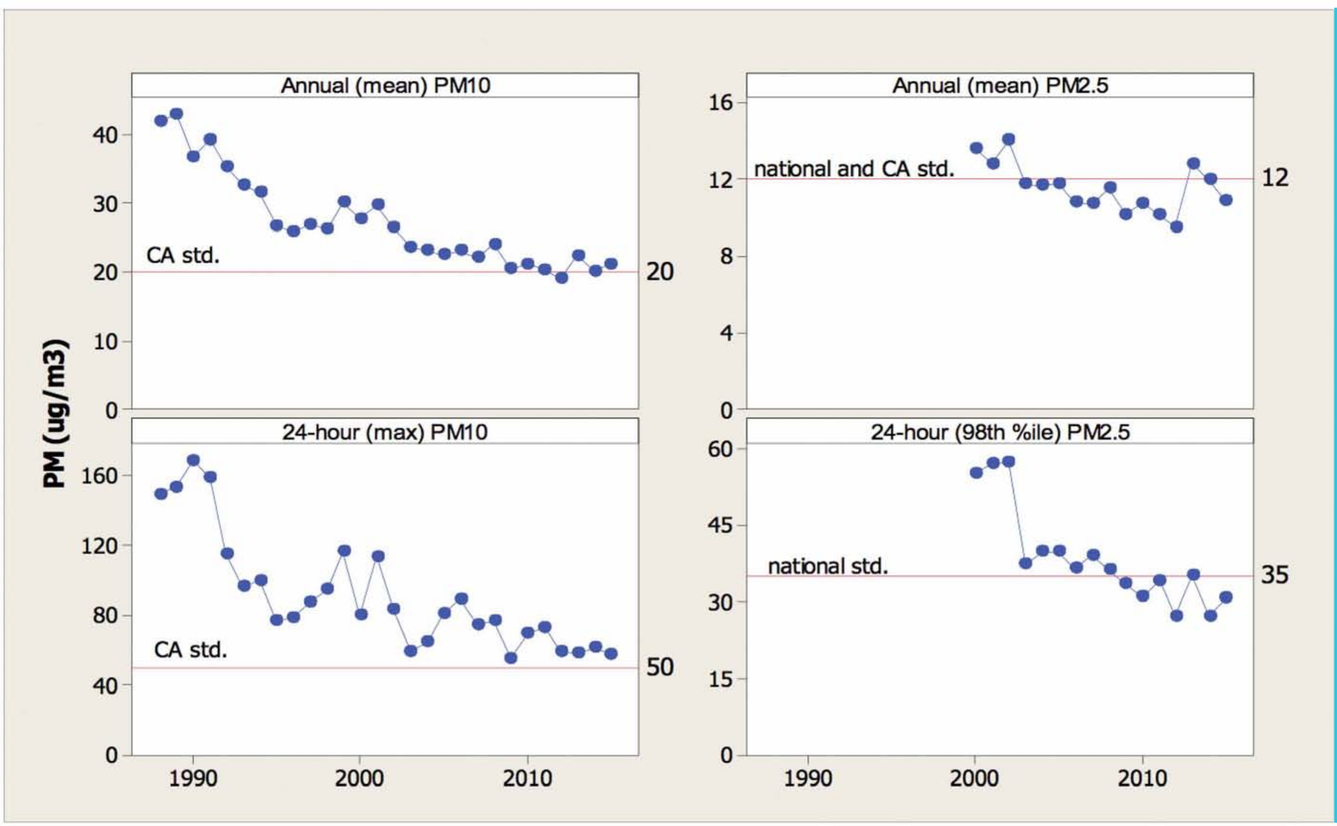
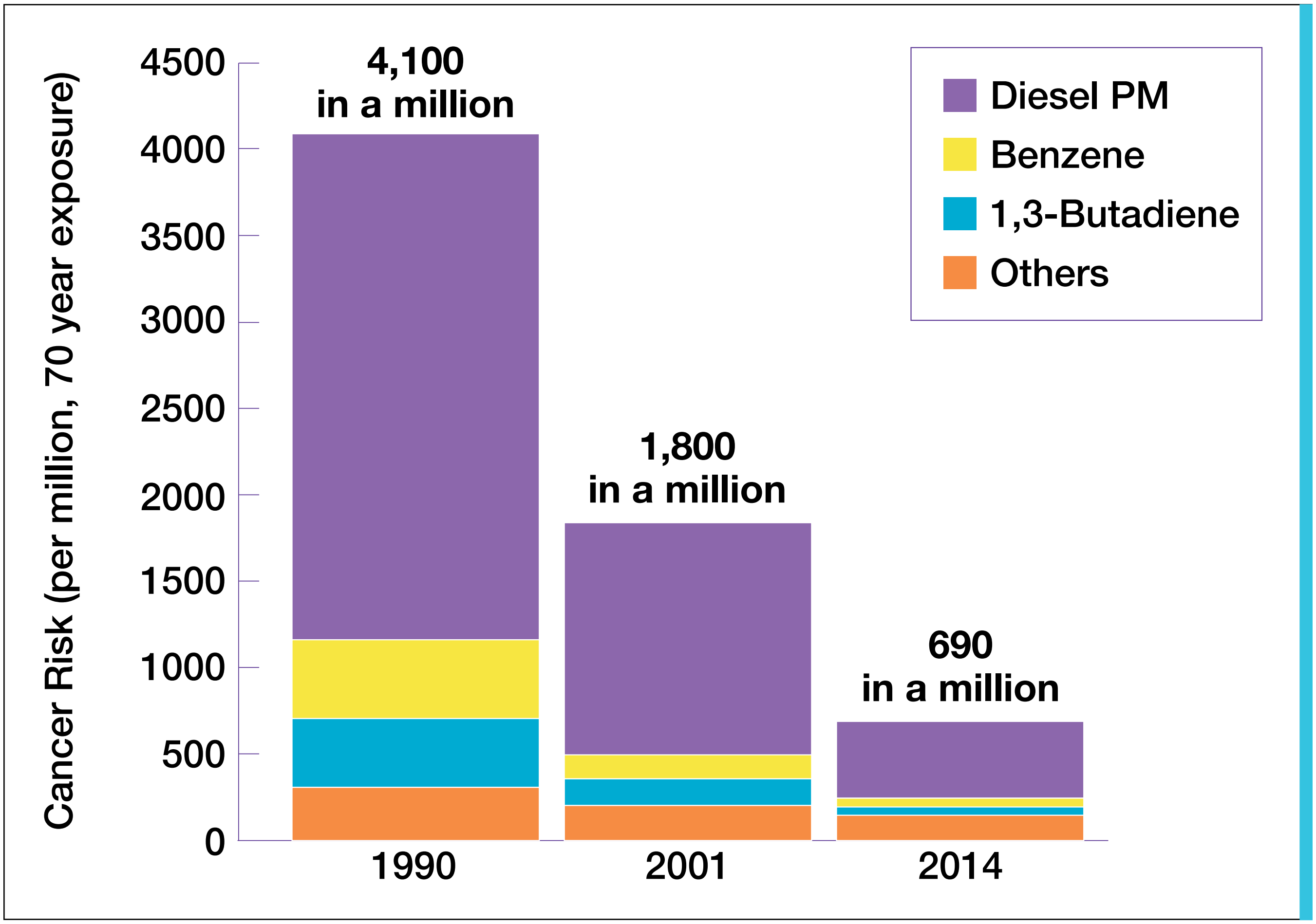


Figure 2-14. **Cancer-Risk Weighted Toxics Trends**

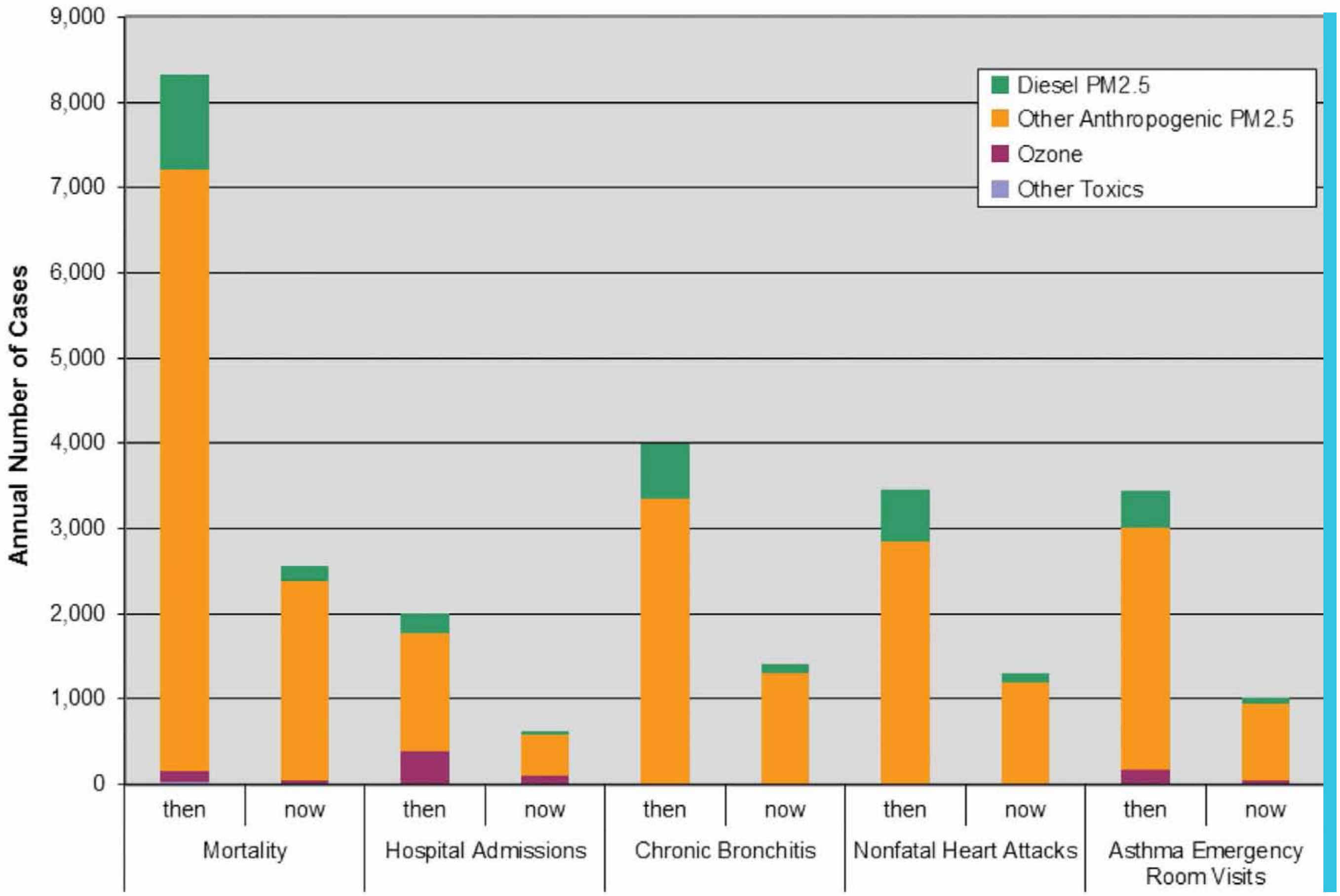


Progress in Protecting Public Health

The Air District is committed to protecting the health of all Bay Area residents, with a special focus on improving air quality in the Bay Area communities most impacted by air pollution. We have made significant progress in reducing air pollution and population exposure to ozone, PM and TACs as described above. Better air quality has improved public health and extended the average life expectancy of Bay Area residents.

Figure 2-15 shows that the estimated incidence of key health impacts from exposure to air pollution, such as premature mortality, heart attacks, cancer, and hospital visits for respiratory and cardiovascular problems, have been greatly reduced among Bay Area residents over the past 3–4 decades. The graph also shows that, despite major progress in reducing particulate emissions, $PM_{2.5}$ is still the most harmful air pollutant to Bay Area residents. In Figure 2-15 the bar labeled "then" shows estimated health effects for population exposure to the earliest data available—1970 for ozone, and the late 1980s for toxics and PM. The bar labeled "now" shows estimated health effects for population exposure to Bay Area air pollution levels in 2015.

Figure 2-15. **Progress in Protecting Public Health**



In addition to enhancing our quality of life, the improvement in air quality has provided economic benefits, valued in hundreds of millions of dollars per year, by reducing health care costs, improving productivity, and reducing lost work days and school days. Appendix C provides additional information regarding the estimated health and economic value of cleaner air.

FOOTNOTES

[1] There are no national or state ambient air quality standards for toxic air contaminants (with the exception of lead) or for greenhouse gases, such as carbon dioxide.

[2] The term “criteria pollutant” refers to the fact that, in setting the NAAQS, U.S. EPA develops a “Criteria Document” that summarizes the scientific evidence on the sources, concentrations, atmospheric dynamics, and health effects of a pollutant.

[3] http://www.baaqmd.gov/~/media/files/technical-services/2014_network_plan.pdf?la=en

[4] In addition to anthropogenic sources, there are also natural or “biogenic” sources of some pollutants. For example, some species of trees and vegetation emit volatile organic compounds (VOC) that contribute to formation of ozone in the atmosphere.

[5] The emissions inventories are available at http://www.baaqmd.gov/research-and-data/emission-inventory.

[6] While ground-level ozone is a harmful air pollutant, ozone in the upper atmosphere is beneficial because it blocks the sun’s harmful ultraviolet rays. The 2017 Clean Air Plan addresses ground-level ozone only.

[7] The need to reduce damage to orchards in the Santa Clara Valley was a major factor in the creation of the Air District in 1955, when agriculture was a much larger part of the economy in the South Bay.

[8] The state and national 8-hour standards are currently set at the same numerical value (0.070 ppm). However, attaining the state standard is more difficult because a region is considered to violate the state standard if the standard is exceeded even once at any monitoring site. By contrast, the determination as to whether a region attains the national standard is determined based upon the 3-year average of the annual 4th-highest daily maximum concentration at the monitoring site with the highest ozone levels.

[9] As discussed in Appendix E, for the state 1-hour ozone standard, the expected peak day concentration decreased an average of 0.9 percent per year across all Bay Area sites between 1986–1988 and 2012–2014, for a total reduction of 25 percent over that period. For the state 8-hour ozone standard, the expected peak day concentration decreased an average, of 0.8 percent per year over that period, with an overall reduction of 23 percent over that period. During the period from 2008 through 2013, the reduction was 1.6 percent per year in 1-hour ozone and 0.5 percent per year in 8-hour ozone, indicating that progress has continued in recent years.

[10] Additional information on PM health effects can be found in the November 2012 BAAQMD report entitled *Understanding Particulate Matter*. http://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/Plans/PM%20Planning/ParticulatesMatter_Nov%207.ashx?la=en

[11] Pope, C. Arden III et al. “Fine Particulate Air Pollution and Life Expectancy in the United States.” New England Journal of Medicine, January 22, 2009. Volume 360:376-386. No. 4.

[12] Robert Brook et al. “Insights into the Mechanism and Mediators of the Effects of Air Pollution Exposure on Blood Pressure and Vascular Function in Healthy Humans.” Hypertension: Journal of the American Heart Association, July 29, 2009.

[13] *Oxidative stress-induced DNA damage by particulate air pollution,* Risom, L, et al. December 30 2005.

[14] O’Donnell et al. *Particulate Matter and Acute Ischemic Stroke,* Epidemiology, Volume 22, Number 3, May 2011.

[15] *Personal Exposure to Ultrafine Particles and Oxidative DNA Damage,* Vinzents, Peter S., et al. May 31 2005. (It should be noted that drivers and pedestrians may well be subject to similar effects from exposure to PM from motor vehicles.)

[16] “Health Risk Assessment for Diesel Exhaust,” Chapter 6.2. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, May 1998.

[17] Acrolein, which is emitted directly in combustion processes and chemically produced from 1,3-butadiene in the atmosphere, has been associated with both chronic and acute health effects, including respiratory aliments, decreased respiratory function and eye irritation.

[18] More details of 2015 TAC emissions estimates are provided in an online report: Preparation of future-year emissions inventories of toxic air contaminants for the San Francisco Bay Area, April 23, 2010, Sonoma Technology, Inc., Contract No. 2009-127. http://www.baaqmd.gov/plans-and-climate/community-air-risk-evaluation-care-program/documents.

[19] On March 6, 2015, OEHHA adopted a revised Air Toxics Hot Spots Program Guidance Manual for the Preparation of Health Risk Assessments to replace the 2003 Air Toxic Hot Spots Guidance Manual. OEHHA’s 2015 HRA Guidelines reflect both children’s greater sensitivity to toxic air contaminants and more refined data related to childhood and adult exposure to air toxics. OEHHA’s 2015 HRA Guidelines affect how risk assessments are

conducted. On July 23, 2015, California Air Resources Board (CARB) adopted the CARB/CAPCOA Risk Management Guidance for Stationary Sources of Air Toxics. This document provides guidance on managing potential cancer and non-cancer health risks from sources subject to Air Toxics New Source Review Permitting and Air Toxics Hot Spots Programs. This document includes additional recommendations that affect how risk is calculated for certain types of risk assessments. The cancer risk estimates shown in Figure 2-13 are higher than the estimates provided in documents such as the Bay Area 2010 Clean Air Plan and the April 2014 CARE report entitled *Improving Air Quality and Health in Bay Area Communities.* It should be emphasized that the higher risk estimates shown in Figure 2-13 are due solely to changes in the methodology used to estimate cancer risk, and not to any actual increase in TAC emissions or population exposure to TACs.

[20] Unlike most other TACs, diesel PM cannot be measured directly because no accepted measurement method currently exists. Therefore, the concentration estimates for diesel PM have been made using elemental carbon measurements.

CHAPTER 3
GREENHOUSE GASES AND CLIMATE CHANGE IMPACTS

This chapter provides a foundation for the regional climate protection strategy described in Chapter 5 by discussing (1) the impacts of global warming and climate change on the Bay Area, including air quality and public health; (2) the greenhouse gases (GHGs) addressed in this Plan; and (3) why it is important to reduce emissions of "super-GHGs" such as methane, black carbon and fluorinated gases, in addition to carbon dioxide. This chapter also provides Bay Area GHG emissions inventory data and projected GHG emission trends, and summarizes the findings of the Bay Area consumption-based GHG emissions inventory that the Air District developed in collaboration with the UC Berkeley *Cool Climate Network.*

The Climate is Changing

The earth is getting hotter. Although the global climate has varied over the long-range geologic time scale, there is a strong scientific consensus that the rapidity of the heating across the planet in recent decades is highly unusual, and that this rapid heating is primarily caused by emissions of greenhouse gases (GHGs) from human activities. Atmospheric concentrations of carbon dioxide, the main GHG, have been increasing rapidly in recent decades. Atmospheric CO_2 averaged about 280 parts per million (ppm) before the start of the Industrial Revolution in the 1760s. CO_2 levels then began to rise gradually, reaching 320 ppm in 1950. In recent years, however, the build-up of CO_2 in the atmosphere has accelerated rapidly. Average CO_2 concentrations surpassed 400 ppm in 2013 and are now approaching 405 ppm. This represents an increase of nearly 45 percent over pre-industrial levels.

Climate change will have profound impacts on the natural and the man-made systems that sustain us, affecting the environment, public health, and the economy at both the local and global scale.

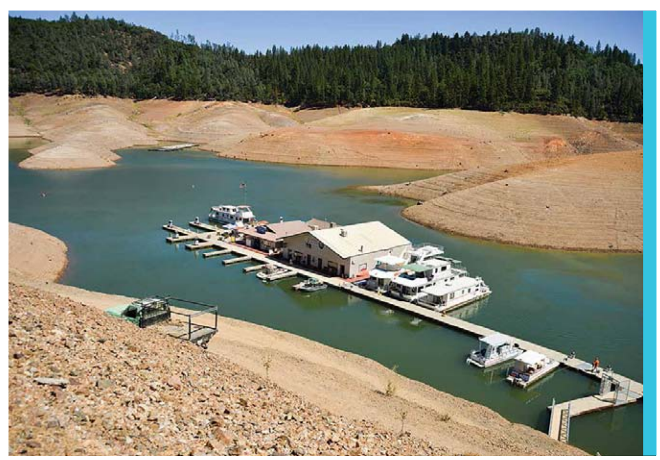
Even if we could somehow reduce GHG emissions to zero today, temperatures will continue to rise in future years due to the build-up of GHGs that have already accumulated in the atmosphere and the oceans. Moreover, as future emissions increase the level of carbon dioxide and other GHGs in the atmosphere and the biosphere, global warming and the impacts of climate change are projected to steadily worsen over the next few decades.

Climate change will have profound impacts on the natural and the man-made systems that sustain us, affecting the environment, public health, and the economy at the local, regional and global scales. At the regional scale, a hotter climate is expected to complicate the Air District's efforts to improve air quality and protect public health in the Bay Area as discussed below. Climate change will also have major impacts on the region's natural systems, water supply, economy and infrastructure.

But climate change provides an opportunity as well as a challenge. Even though we cannot fully prevent it, we can still take action to minimize climate change and manage its impacts. This will require aggressive action, both in the Bay Area and on a worldwide basis, to reduce emissions of GHGs and to prepare for the impacts of climate change. By rising to this challenge, we can protect the environment and quality of life that makes the Bay Area a great place to live, and also ensure that our region leads the way in developing the innovative policies and technologies that will drive social and economic development in the 21st century.

The regional climate protection strategy described in Chapter 5 of the 2017 Plan focuses on reducing emissions of GHGs and laying the groundwork to attain ambitious GHG reduction targets for 2030 and 2050. A concerted effort to reduce emissions of fast-acting super-GHGs, such as methane and black carbon, in the near-term can help to lessen the amount of atmospheric and oceanic heating that we experience by mid-century.[1] Over the longer term, reductions in super-GHGs must be combined with policies to dramatically decrease emissions of carbon dioxide by eliminating combustion of fossil fuels and transitioning to clean, renewable energy. The speed at which fossil fuel combustion can be eliminated, and the success or failure of large-scale efforts to remove CO_2 from the biosphere, will ultimately determine whether the impacts of climate change in the Bay Area and around the globe will be moderate, severe or catastrophic.

To protect the Bay Area, the effort to reduce GHG emissions in the region must be coupled with a coordinated adaptation and resilience program to strengthen the Bay Area's ability to cope with the impacts of climate change, such as heat waves, drought, flooding, and other extreme events, with a special focus on protecting more vulnerable populations, as discussed below.[2]



Climate Change Impacts on the Bay Area and California

The impacts of climate change—including warmer temperatures, more extreme weather, more variable precipitation patterns, and sea level rise—are clearly felt today in the Bay

Area and California. Scientists are recording an increasing number of climate-related impacts that touch all aspects of California life—including human health, natural systems, infrastructure and agriculture—as the planet gets hotter.

This section focuses on the climate change impacts that will most directly affect the Bay Area and California. However, the changes in our region must be viewed in the context of a global shift that is occurring on every continent as temperatures rise. The severity and the speed of global warming and its impacts on climate are not uniformly distributed. In particular, due to several processes described in the text box below, the polar regions in both hemispheres are experiencing much more rapid warming than temperate and tropical regions.[3] Melting of ice caps in areas like Greenland and the West Antarctic Peninsula, in combination with the fact that water expands as it gets warmer, cause the sea level to rise, threatening coastal areas around the world. In addition to direct impacts at the regional scale that are described below, the Bay Area will also be affected by changes in climate across the planet through impacts on our food, water, energy, and industrial networks; international migration patterns; and potential global instability related to climate change.

CLIMATE FEEDBACK LOOPS

In addition to increasing average global temperatures, the build-up of GHGs in the atmosphere and the oceans also affects the earth in various ways that can further increase the rate of climate change. Examples of these climate feedback loops include:

Increase in water vapor: Water vapor in the atmosphere acts as a potent greenhouse gas. Higher temperatures caused by man-made emissions of GHGs cause more evaporation, thus increasing the amount of water vapor in the atmosphere. This increase in water vapor, in turn, causes more warming, which leads to more evaporation, in a feedback loop.

Melting of ice and snow: Because ice and snow are white, they reflect sunlight, and thus help to cool the earth. But as the earth gets hotter, ice and snow have been melting on a massive scale in polar regions, and glaciers have been retreating across the globe. The loss of ice and snow uncovers darker land and water underneath, resulting in increased absorption of solar radiation, thus increasing global warming which leads to more melting and then more heating.

Melting of permafrost: Permafrost in arctic regions holds enormous quantities of locked-in methane, a potent greenhouse gas. When permafrost melts in response to higher temperatures, the release of the previously locked methane leads to more global warming, which in turn leads to more melting of permafrost and release of additional methane, resulting in a cyclical effect.

Warming of oceans: The oceans act as a huge reservoir, storing carbon dioxide, thus dampening the process of global warming. Oceans have stored roughly half the CO_2 emitted since the beginning of the Industrial Revolution. But increased levels of CO_2 in ocean waters are causing acidification, which seriously imperils aquatic ecosystems such as coral reefs. In addition, as oceans become warmer and more acidic, their ability to take on more CO_2 is reduced. As the ability of oceans to store CO_2 diminishes, the concentration of CO_2 in the atmosphere will rise more rapidly, and in turn accelerate global warming.

To avoid these effects that accelerate climate change, we need to act quickly and aggressively to reduce GHG emissions, especially methane and super-GHGs.

In the last 5 years, California has experienced some of the most extreme climate events in its recorded history—a severe 4-year drought, a dramatic reduction in the Sierra Nevada winter snowpack, five of the state's 20 largest forest fires since 1932 (when accurate record-keeping began),[4] and two years back-to-back of the hottest average temperatures.[5]

Temperatures Are Already Rising

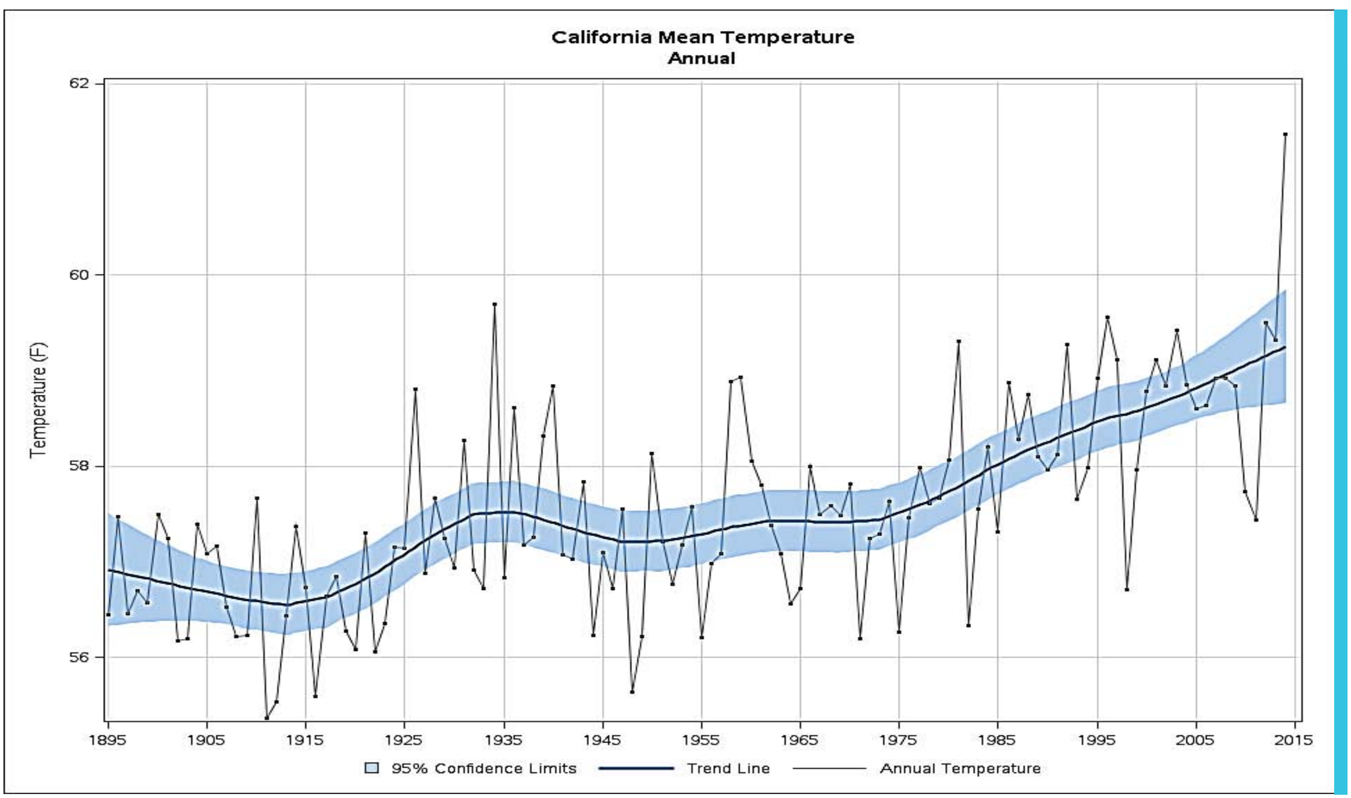
California's annual average temperature has increased about 1.5° F in the last 100 years as shown in Figure 3-1.[6] This may sound like a small amount, but a temperature change of this magnitude over one century—a mere blip on the geologic time scale—is highly unusual in the Earth's recent history. Furthermore, even relatively small changes in temperature can cause enormous changes in the environment. For example, at the end of the last Ice Age, when the northeastern United States was covered by more than 3,000 feet of ice, average temperatures were only 9° F degrees cooler than today.[7]

Increased heat affects daytime and nighttime temperatures. Statewide, nighttime temperatures are rising faster than daytime temperatures,[8] resulting in increasingly hot, humid nights rather than just hot days.[9] Higher nighttime temperatures do not allow people to cool down before the next wave of daytime heat, so they become more susceptible to heat-related illness. 2014 was the hottest year on record in California, and 2015 was the second hottest.[10] The winter average minimum temperature of 2014–15 for the Sierra Nevada region was 32.1° F, the first time this value was above water's freezing point in 120 years of recordkeeping.[11]

The Bay Area has experienced similar trends. Averaged across the region, mean annual temperature has increased nearly 1° F in the last 30 years over the previous 30-year period.[12]

Over the period from April 2015 through April 2016, all nine Bay Area counties were 1–3° F above their historical average temperatures.[13]

Figure 3-1. California Annual Average Temperatures



Source: National Climatic Data Center, www.ncdc.noaa.gov

Stanford scientists recently reported that atmospheric patterns associated with droughts in California have occurred more frequently in recent decades.

The trend of record-breaking temperatures at the regional and global scale has continued in 2016. April 2016 was the warmest April on record globally, and is the 12th consecutive month that a monthly global record temperature has been broken, the longest such streak in 137 years of record-keeping.[14]

Temperatures Are Projected to Rise Substantially and More Extreme Hot Days Will Occur

By 2050, Bay Area annual average temperatures are projected to increase by an additional 2.7° F, without additional actions to reduce GHG emissions.[15] Post-2050 projections show a wide range of substantial increases, between 3.6° F and 10.8° F, depending upon how much we can cut emissions.[16] Most importantly, the number of very hot days and severe heat waves are projected to increase significantly across the region by mid-century. Currently, the Bay Area averages 12 days per year with temperatures of 95° F or more. If global GHG emissions continue on their current path, the Bay Area will likely experience 16 to 20 such days in the near term, 20 to 29 days by mid-century, and 32 to 65 days—more than two months—each year by century's end.[17]

More Precipitation Extremes and More Rain, Less Snow Are Predicted

California and the Bay Area are seeing more precipitation extremes. Extremes are increasing at both ends of the water spectrum in the Sierra Nevada where, over the last 35 years, the region has experienced some of the wettest and the driest years in more than 100 years of record keeping.[18] Stanford scientists recently reported that atmospheric patterns associated with droughts in California have occurred more frequently in recent decades. The scientists also reported that California is having fewer 'average' years, and instead are seeing more extremes of both wet and dry years.[19]

In the Sierra Nevada, the source of much of the Bay Area's water supply, warmer temperatures in recent decades have resulted in more precipitation falling as rain instead of snow.[20] This poses a growing challenge for our water storage and distribution systems and results in drier, longer fire seasons as there is less water 'banked' in snowmelt to last through the summer months.[21] While it is unclear whether California will have more total precipitation or less, projections indicate that the "more rain/less snow" trend in the Sierra Nevada is likely to continue and accelerate. As a result, the Sierra snowpack is projected to decrease very significantly by mid-century.[22]

A recent NASA study has found that a mega-drought of three decades would be "extremely likely" in the second half of the 21st century in the Southwest and California if emissions continue at the current pace.[23] Even if precipitation for the Bay Area does not decline in future years, higher temperatures will produce water deficits, decrease soil moisture, dry out vegetation, and increase evaporation from reservoirs.[24]

Sea Level is Already Rising and is Projected to Rise Substantially in Coming Decades

Sea level at the Golden Gate Bridge has risen 8 inches over the last 100 years.[25] The frequency of extreme high-water events (e.g., above the 99.99th percentile) has increased 20 times since 1915. This has important implications for coastal flooding, erosion and related damages, such as maintenance of shipping channels and clearance under bridges.[26]

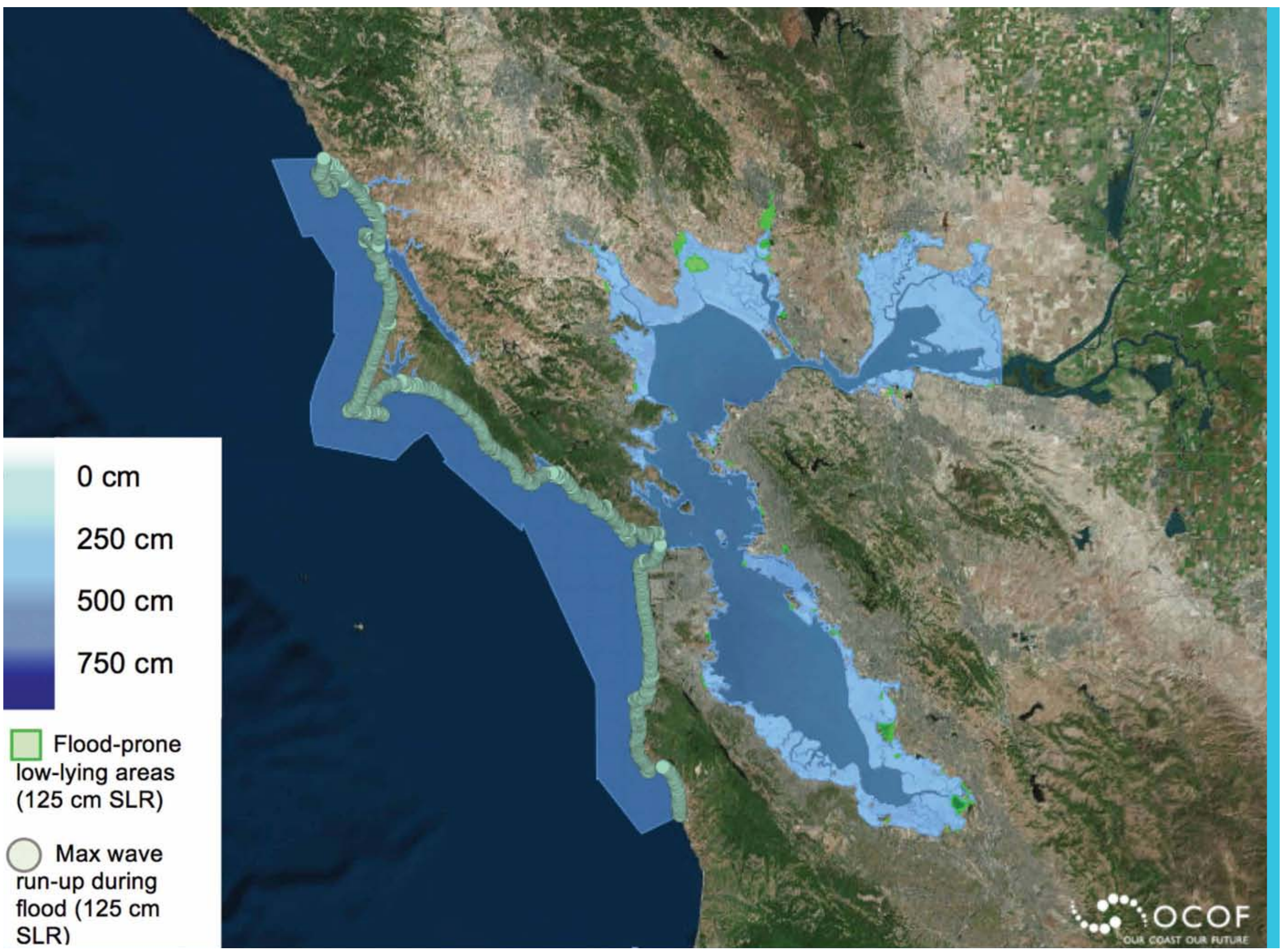
The National Research Council projects an additional 2-12 inches locally by 2030 (2000 baseline), 5–24 inches by 2050, and 17–66 inches by 2100. The likely projections are 6 inches by 2030, 11 inches by 2050, and 36 inches by 2100.[27] However, there are great uncertainties concerning these projections, linked to the melting of the massive Greenland and Antarctica ice sheets. New research shows that the West Antarctica ice sheet alone has the potential to contribute more than 3 feet of sea-level rise by 2100, another foot per decade in the mid-22nd century, and nearly 50 feet by 2500, if emissions continue unabated.[28] Sea-level rise is a critical Bay Area concern as four of the top seven California counties, in terms of population at risk, are in our region—San Mateo #1, Alameda #4, Marin #6, and Santa Clara #7.[29] Figure 3-2 shows flooding (light blue) from 4 feet of sea-level rise when combined with a moderate (once per year) storm.

Extreme Storms Are Expected to Increase

Climate change is expected to alter the frequency and severity of extreme storm events. "Atmospheric river" storm events, which bring 35–45 percent of California's precipitation, are expected to increase in frequency and intensity later this century.[30]

The 2015 Bay Area Council Institute study entitled *Surviving the Storm* found that an extreme storm (100 to 200-year storm, 12 inches of rain, high creek/river flows and maximum tide levels) in today's Bay Area—even without any further sea-level rise—could result in $10.4 billion in damages to structures, and building contents, in addition

Figure 3-2. Bay Area Flooding from 4-Foot Sea-Level Rise



Source: Our Coast, Our Future, Point Blue website http://data.prbo.org/apps/ocof/index.php?page=flood-map to causing transportation delays and electricity interruption. The hardest-hit counties would be Santa Clara ($6.1 billion), Marin ($1.2 billion), and San Mateo ($1.1 billion).[31]

Inundation from sea-level rise and flooding from extreme storms could seriously damage key Bay Area infrastructure, such as freeways, airports, seaports and sewage treatment plants, resulting in severe economic impacts to the region. An extreme storm in the Sacramento-San Joaquin River Delta, coupled with sea-level rise, would pose extensive risk to Bay Area natural gas supplies. Since California currently imports 90 percent of its natural gas, the state is highly vulnerable to climate-related disruptions elsewhere. In addition, Bay Area water supplies could be threatened by flooding through the Delta during severe storms, while sea-level rise and storm surges could damage the Delta's already-fragile levee system.

Climate Change is Affecting Bay Area Air Quality and Public Health

Climate change will impact public health in many ways, both directly and indirectly, potentially exacerbating a variety of existing health problems. The California Department of Public Health recognizes that addressing climate change provides one of the greatest opportunities to improve public health and reduce health inequities, especially for vulnerable populations.[32]

Safeguarding California 2014, the state's adaptation strategy, identifies extreme heat and poor air quality (due to wildfire smoke, ozone, allergens, etc.) as the two most "immediate and concerning impacts" to vulnerable populations including the poor, the elderly, and communities without adequate resources to respond. The report states that longer and more severe heat waves are intensifying occurrences of chronic disease and heat-related illness and will increase morbidity during hot summer months. Higher temperatures promote the formation of air pollutants, increasing concentrations of pollutants such as ozone or secondary aerosols (particulate matter). The report also states that these increases could negate much of the progress achieved through air pollution control measures. At the same time, an increase in the frequency and intensity of wildfires is exposing more California and Bay Area residents, in both rural and urban areas, to particulate matter and other pollutants in wood smoke.[33]

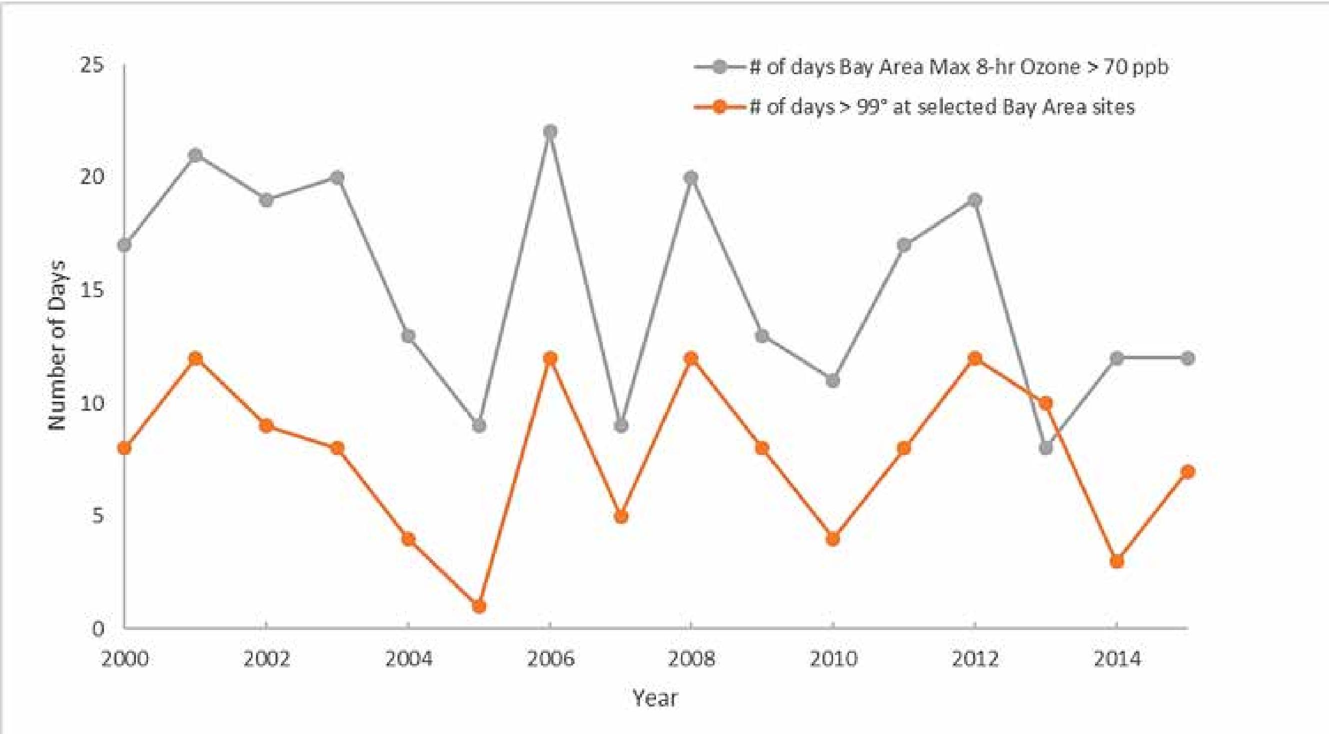
Higher Temperatures Produce More High Ozone Days

As shown in Figure 3-3, Air District data shows that the number of days with high ozone levels correlates very closely with years when the Bay Area experiences more extreme-heat days.

Higher temperatures can increase ozone levels in several ways: by increasing the rate of photochemical reactions in the atmosphere that produce ozone; by increasing biogenic emissions (i.e., emissions from trees and vegetation) of reactive organic gases (ROG); and by increasing anthropogenic emissions of ROG, due to more evaporation of volatile compounds from storage tanks, gas tanks, etc.[34] Higher ozone levels due to climate change may increase health impacts such as acute respiratory symptoms, hospital visits, lost school days, and even premature death.[35]

The Air District performed photochemical modeling to estimate the impacts of a 3.6° F (2° Celsius) increase in Bay Area temperatures on regional ozone levels, focusing on effects of potential increases in photochemical reactions and in biogenic emissions. The modeling found that increased photochemical reactions due to an increase in average temperature of 3.6° F would by itself (without any increase in biogenic emissions) increase the Bay Area maximum ozone by 4 parts per billion

Figure 3-3. **High Heat Days and Ozone Exceedances**



(ppb) annually. An increase in biogenic emissions due to a temperature increase of 3.6° F would by itself (without any increase in photochemical reactions) also increase the Bay Area maximum ozone by 4 ppb. Increased photochemical reactions resulting from a 3.6° F temperature increase, in combination with the expected increase of the biogenic emissions due to the temperature increase, would increase the Bay Area maximum ozone by 8 ppb. This suggests that the potential increase in ozone levels due to climate change between now and 2050 may offset years of hard-won progress in reducing ozone levels in the Bay Area.[36]

Higher Temperatures Produce More Pollution from Power Plants and Vehicles

Higher temperatures can also increase emissions of ozone precursors and other air pollutants. For example, higher temperatures increase the use of air conditioners in buildings and cars, which in turn requires more combustion of fossil fuels to generate electricity and to power motor vehicles. The increase in fossil fuel combustion results in higher emissions of ozone precursors, particulate matter, toxic air contaminants and greenhouse gases.[37]

Changes in Air Mixing and Flow Can Increase Pollution Levels

Climate change can affect patterns of air mixing and airflow that transport pollutants. Projections of more frequent hot and stagnant air increase the likelihood of more frequent poor air quality days.[38] Similarly, drought and low-wind conditions in wintertime can increase particulate matter (PM) levels, leading to greater population exposure to PM. During the severe drought winters of 2013–14 and 2014–15, the Air District issued 30 and 15 winter Spare the Air alerts, respectively, substantially above the average of 9 per year for the previous five years.

Higher Temperatures and Drought Are Fueling Wildfires

Climate change creates weather conditions in the Bay Area and across California—drought, higher temperatures and winds—that can increase the frequency and severity of wildfires and also lengthen the wildfire season. Large wildfire activity in western U.S. forests increased suddenly and markedly in the mid-1980s.[39] Wildfires can cause dramatic short-term spikes in pollution levels, and

Large wildfire activity in western U.S. forests increased suddenly and markedly in the mid-1980s.

greatly increase population exposure to particulate matter and other harmful pollutants. Wildfires emit massive quantities of fine particles such as black carbon, as well as other air pollutants, such as carbon monoxide, NO_x and air toxics. These pollutants contribute to a wide range of respiratory and cardiovascular health effects (described in Chapter 2). Smoke from wildfires can cause a variety of acute health effects, including irritation of the eyes and the respiratory tract, reduced lung function, bronchitis, exacerbation of asthma and premature death. Most of the particles from wildfires are in the very fine size range, the types of particles that can most effectively penetrate deep into the lungs. The outbreak of wildfires that swept across California in late June 2008 caused ambient concentrations of ozone and PM to soar to unprecedented levels.[40] Analysis found that the PM released by the June 2008 fires was also much more toxic than the PM more typically present in the California atmosphere.[41] In addition, large-scale wildfires release substantial quantities of climate pollutants, including carbon dioxide, black carbon (a component of PM) and methane.

Climate Change Will Have Non-Air Quality Impacts on Public Health

In addition to increasing air quality-related health problems for Bay Area residents, climate change will have a wide range of other negative impacts on public health, significantly adding to the region's overall individual and community health burden.

Heat-Related Illnesses and Death Will Increase

More hot days and nights will increase heat-related illnesses and heat-related deaths in the Bay Area. Researchers have observed significant connections between heat and several disease-

specific types of hospital admissions.[42] During the 2006 California heat wave, a greater increase in emergency room visits and hospitalizations for heat-related illnesses occurred in the normally cooler coastal counties.[43] Populations in cooler areas are less accustomed to heat. They are generally less aware of what they can do to reduce heat exposure, their homes and offices are often not designed or equipped for warmer conditions, and their communities may not have emergency heat plans.[44] Although the use of air conditioners increases emissions of air and climate pollutants, it can significantly reduce the health risk related to higher temperatures, especially among the elderly. However, many Bay Area homes and apartments, particularly those in lower income neighborhoods, lack proper ventilation or air conditioning.[45]

Urban Heat Island Impacts Will Grow

Higher temperatures from a changing climate will create more urban heat islands (UHIs)—areas with extensive pavement, roofs and other hard surfaces—that exacerbate the impact of heat waves and degrade air quality. Sensitive populations, such as children, the elderly, and those with existing health conditions, are at particular risk to respiratory difficulties, heat exhaustion, non-fatal heat stroke and heat-related mortality.[46]

The UHI effect on higher *nighttime* temperatures limits the ability of people to cool down and recover before the heat of the next day, thereby adding to the risk of illness and fatalities. Cities on average have temperatures that are 1.8–5.4° F hotter

The UHI effect on higher nighttime temperatures limits the ability of people to cool down and recover before the heat of the next day...

during the day than rural areas, and as high as 22° F hotter at night, due to heat that is stored in paved surfaces and the built environment and released after sundown.[47]

The Air District's Advisory Council studied the impacts of UHIs and issued a report in June 2015 which summarized relevant information and provided recommendations on potential UHI mitigation measures relating to cool roofs, cool paving, and urban tree-planting.[48] Key recommendations from this report include the following:

- Additional research is needed to determine where (in which climate zones) UHI mitigations measures should be focused and which measures would be most effective.
- The Air District should provide technical support to local governments to incorporate air quality criteria into their street tree-selection processes, including carbon sequestration capacity, VOC emissions, and potential for PM capture.
- The Air District should collaborate with local governments in warmer climates to incorporate cool roof requirements into their local building codes. The Air District should communicate benefits of urban cooling measures as part of geographically-targeted public education campaigns.

The Advisory Council's recommendations provide the basis for proposed control measure BL-4 in the building sector.

Higher Temperatures Will Increase Vector-Borne Diseases

Climate change will affect transmission and infection patterns of vector-borne diseases. Higher temperatures cause changes in the geographic distribution of mosquitoes and ticks that carry diseases such West Nile virus, Lyme, dengue, Zika and malaria. West Nile virus has been found in several Bay Area counties since 2012.[49] The types of mosquitoes that can carry Zika and dengue have been identified in the last few years for the first time in San Mateo County.[50]

Other Potential Impacts on Public Health

Higher temperatures will produce more plant pollen and lengthen allergy seasons,[51] aggravating asthma and other respiratory and cardiovascular diseases.[52] Toxic materials stored in flood zones can contaminate housing, parks and other areas during flood events.[53] Flooding can also lead to growth of harmful molds. And if the Bay Area experiences extreme weather events related to climate change, this could result in mental health impacts, including post-traumatic stress disorder (PTSD), depression and general anxiety.[54]

Potential Impacts to Systems on Which Our Health Depends

In addition to direct impacts on health, extreme weather events related to climate change may disrupt critical infrastructure—such as power, water, transportation and communications—that are essential to medical and emergency services. Extreme weather (e.g., drought, heat, storms) in local and distant food-producing areas could increase prices, produce shortages of important basic food items and disrupt distribution systems. Biodiversity and ecosystem degradation could also affect public health. Disruptions to natural ecosystems could increase the population of rodents and other vectors that pose health risks. In addition, an influx of climate refugees from regions and countries severely impacted by climate change could place an increased burden on Bay Area housing, social services and other systems.

The most intense urban heat island effects are often seen in neighborhoods where dense land use and paved surfaces are predominant...

Vulnerable Populations Will Be Hit Harder

Certain Bay Area populations and communities will be affected by climate change more than others. The degree to which individuals are impacted by climate change often depends upon a person's age, race, income, language, educational attainment, housing conditions and pre-existing physical conditions, such as diabetes and mobility restrictions.[55] Drought, flooding, fires, and heat waves all pose health, economic, and logistical challenges to disadvantaged communities that may lack adequate financial and organizational resources to respond to and recover from a disaster.[56]

For example, not everyone is equally vulnerable to heat risks. Some groups—including those with pre-existing health conditions, the elderly, infants and children, socially isolated individuals, non-English speakers and the poor—may be more sensitive to environmental stressors than others, and/or may lack the ability to cope or prepare for such impacts.[57] The most intense urban heat island effects are often seen in neighborhoods where dense land use and paved surfaces are predominant, and trees, vegetation and parks are less common.[58] Studies in the Bay Area find minority and poorer populations have significantly lower access to common heat adaptation options, such as tree canopy for shading or car ownership to go to public cooling centers, than other segments of the population.[59] An analysis of four major California cities—San Francisco, Los Angeles, San Diego and Sacramento—found a direct relationship between household income and land cover; e.g., neighborhoods with higher poverty rates have a higher percentage of paved surfaces and less tree coverage than wealthier neighborhoods.[60]

Elderly people, who have a higher incidence of pre-existing chronic health conditions, will experience the most difficulty in adapting to changing temperatures.[61] Human vulnerability to future extreme heat events will increase due to California's aging population. By 2050, the number of California residents age 65 and older will more than double, and the number of residents age 85 and older will triple.[62]

Extreme temperatures and poor air quality could also result in reduced productivity or job losses among outdoor workers in agriculture, construction, warehousing, delivery and service work.[63] Climate-related loss of jobs could increase food insecurity, cause some individuals to lose their homes, and produce other life- and health-changing situations, particularly for low-income individuals.

Finally, climate change poses immense challenges for efforts to reduce Bay Area health and economic inequities. Low-income communities already experience higher rates of chronic disease and lower life expectancy; these communities also have fewer resources to prepare for and respond to the impacts of climate change.[64] Moreover, increased governmental spending on climate change infrastructure protection could affect low-income communities by diverting funds from education, social programs, public transportation and other critical sectors.[65]

Building Bay Area Resilience

Although the Bay Area climate impacts described above are daunting, action can be taken now to prepare, respond and recover from drought, flooding, extreme heat, new disease vectors, and other impacts of climate change. Achieving a resilient Bay Area that can cope with the impacts of climate change requires a coordinated and comprehensive approach that brings together all levels of government with the private, non-profit, academic and community-based sectors. Fortunately, the work to build Bay Area climate resilience has already begun. Cities, counties, regional agencies and private asset owners are conducting local vulnerability assessments for sea-level rise. Experts from Bay Area universities and scientific organizations are implementing pilot projects to test new approaches to coastal and bayside flooding. State, regional and local authorities are exploring new policies to promote climate-appropriate development for a prosperous 21st century Bay Area. Local and state health departments are improving their plans to safeguard vulnerable populations during heat waves. These efforts should help the Bay Area to respond to the impacts of climate change.

Greenhouse Gases Addressed in the 2017 Plan

There are dozens of GHGs, but a small subset of these gases are the primary agents of climate change. For purposes of the 2017 Plan, we focus primarily on the key climate pollutants described below.

Carbon Dioxide (CO_2) is released into the atmosphere when fossil fuels (oil, gasoline, diesel, natural gas, coal), solid waste, and wood or wood products are burned.

Methane (CH_4) is emitted during the production and transport of coal, natural gas and oil. Methane emissions also result from the decomposition of organic waste in municipal solid waste landfills, wastewater, and the raising of livestock.

Nitrous oxide (N_2O) is emitted during agricultural and industrial activities, as well as during combustion of solid waste and fossil fuels. Note: There are no control measures in the 2017 Plan that specifically target N_2O emissions. However, many of the control measures that decrease emissions from fossil fuel combustion, agriculture, water treatment and composting, will reduce N_2O as a co-benefit.

Fluorinated gases (F-gases) include ***hydrofluorocarbons*** (HFCs), ***perfluorocarbons*** (PFCs), and ***sulfur hexafluoride*** (SF_6). The F-gases are generated by a variety of industrial processes. Emissions of F-gases are small on a mass basis, but they are potent agents of climate change on a per-unit basis.

Black carbon (BC): BC, a key component of fine particulate matter, has been identified as a potent agent of climate change and as a significant GHG on a CO_2-equivalent basis. Diesel engines and wood burning are key sources of BC in the Bay Area. Since exposure to fine PM has a wide range of health impacts, as discussed in Chapter 2, reducing emissions of BC will also provide important public health co-benefits.

For the purpose of this Plan, methane, nitrous oxide, F-gases and black carbon are all categorized as “super-GHGs” (even though black carbon is not, strictly speaking, a gas) based upon their high global-warming potential, as discussed below.

Global Warming Potential and Atmospheric Lifespan

The various greenhouse gases differ considerably in terms of their potency in heating the climate. i.e., their *global warming potential* (GWP). GWP factors are critical for climate planning because they provide a means to express all the GHGs in terms of a single metric: CO_2-equivalent (CO_2e). Carbon dioxide has a GWP of one. The CO_2e for a given quantity of any GHG is calculated by multiplying the mass of emissions by the appropriate GWP value.

Greenhouse gases also vary greatly in terms of their atmospheric lifespan. Black carbon remains in the atmosphere for just a few days or a few weeks, whereas some species of F-gases remain in the atmosphere for 3,000 years or more.

GWP values are typically expressed based upon how much a given GHG will contribute to global warming over a 100-year time frame. The 100-year time frame is appropriate for CO_2 and other gases that have a relatively long atmospheric lifespan. However, in the case of GHGs with a shorter atmospheric lifespan, such as black carbon and methane, a 20-year time frame provides a more realistic means to express their global warming potential.

For example, as shown in Table 3-1, methane has a GWP of 34 using a 100-year time frame, but its GWP increases to 86 using a 20-year time frame. For purposes of consistency with other GHG inventories, the GHG emissions inventory data shown in the figures and tables below are expressed using a 100-year time frame, unless otherwise noted.

Table 3-1 shows atmospheric lifespan, 20-year and 100-year GWP values, and key emission sources for the GHGs addressed in the 2017 Plan.

Table 3-1. Climate Pollutants Addressed in the 2017 Plan

Greenhouse Gas	Atmospheric Lifespan	GWP * (20-year timeframe)	GWP * (100-year timeframe)	Key Emissions Sources
Carbon dioxide (CO_2)	20 to 200 years	1	1	Fossil fuel combustion
Nitrous oxide (N_2O)	114 years	268	298	Motor vehicles, agriculture, water treatment, composting
Methane (CH_4)	12 years	86	34	Solid waste disposal, natural gas production and distribution, ranching, dairies
Hydrofluorocarbons (HFCs)	1.5 to 264 years	506 to 6,940	138 to 8,060	Refrigeration, air conditioning
Perfluorocarbons (PFCs)	3,000 years or more	6,500	6,500	Semiconductor manufacturing
Sulfur hexafluoride (SF_6)	3,200 years	17,500	23,500	Electricity grid losses
Black carbon (BC)**	Days to weeks	3,235	900	Diesel engines, wood burning

* GWP values in Table 3-1 are based on IPCC climate-carbon feedback values from the IPCC 5th Assessment Report (AR5), with the exception of BC.

** Black carbon values are based on U.S. EPA's 2012 report on black carbon: https://www3.epa.gov/blackcarbon/2012report/Chapter2.pdf.

Figure 3-4. 2015 Bay Area GHG Emissions by Pollutant, Based on 100-year GWPs (Total = 85 MMT CO_2e)

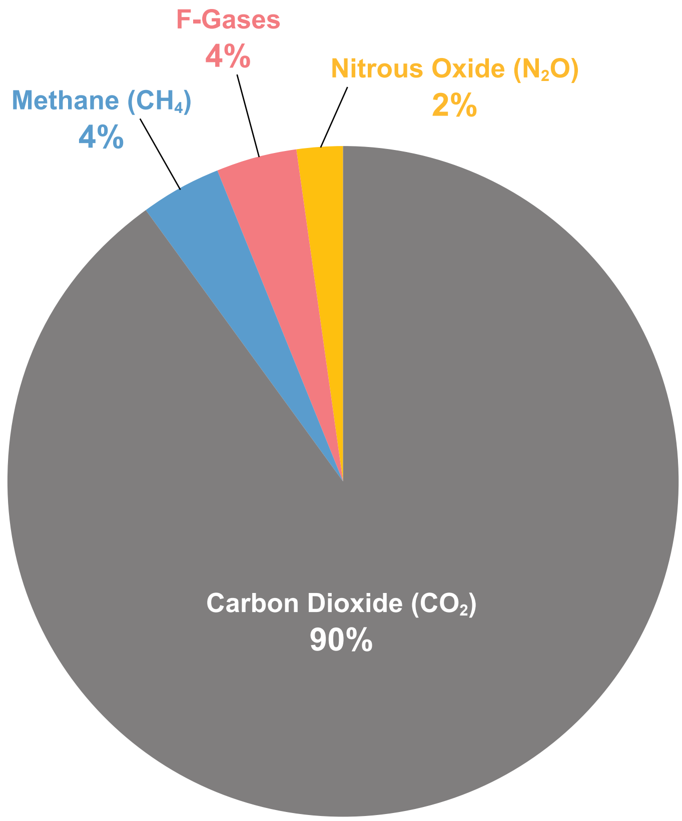
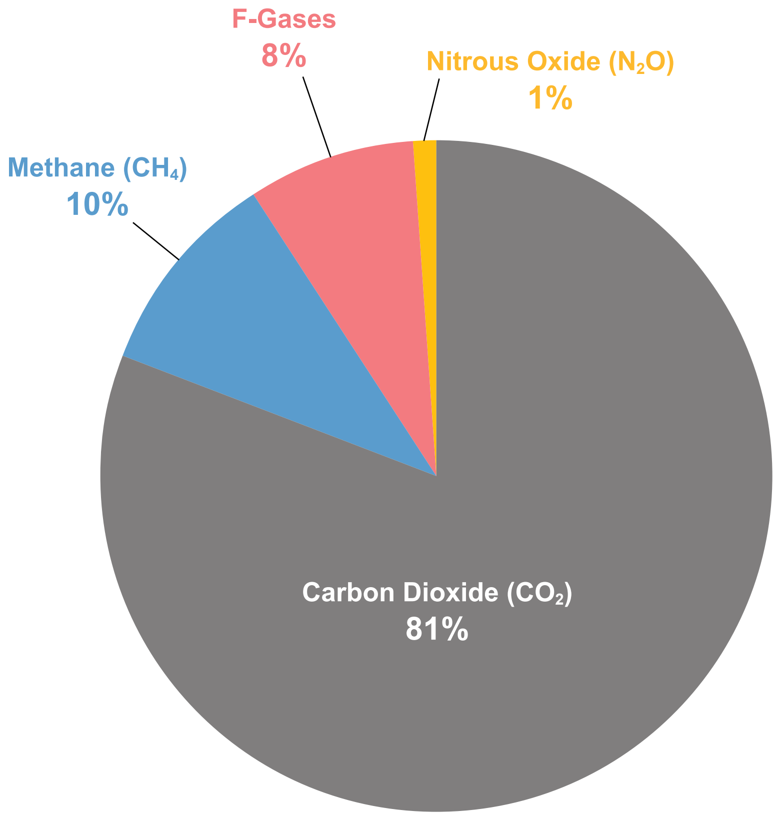


Figure 3-4 shows the contribution of the various GHGs to the total Bay Area inventory (with the exception of black carbon) for 2015 based on 100-year GWPs. GHG emissions totaled about 85 million metric tons CO_2e in 2015. Carbon dioxide accounts for 90 percent of total GHG emissions on a CO_2e basis, with the remainder from methane (about 4 percent); F-gases (about 4 percent); and nitrous oxide (about 2 percent). CO_2 emissions dominate the inventory because all fossil fuel combustion emits significant quantities of CO_2; for example, burning a single gallon of gasoline releases approximately 18 pounds of CO_2 into the atmosphere.

As noted above, the global warming potential of GHGs varies depending upon the time frame used to calculate it. Whereas Figure 3-4 shows the relative contribution of GHGs based upon a 100-year time frame, Figure 3-5 shows the contribution of the various GHGs to the total inventory based upon a 20-year time frame. CO_2 still dominates the inventory (about 81 percent) when GWPs are calculated based upon a 20-year time frame, but the proportion from the super-GHGs is higher in Figure 3-5 compared to Figure 3-4. It should also be noted that when 20-year GWP values are used, the total GHG emissions for 2015—as calculated on a CO_2-equivalent basis—increase (from 85 MMT CO_2e to 94 MMT CO_2e) because the 20-year time frame better reflects the fact that the global warming impact of high-GWP gases with a short atmospheric lifespan, such as methane, occurs primarily within this 20-year window.

Figure 3-5. 2015 Bay Area GHG Emissions by Pollutant, Based on 20-year GWPs (Total = 94 MMT CO_2e)



The Importance of Reducing Super-GHGs

Although CO_2 dominates the GHG inventory, it can persist in the atmosphere for many decades. CO_2 therefore heats the climate in a persistent, but gradual, way. However, certain super-GHGs such as methane and black carbon not only have high global warming potential, they also exert their impact on the climate over a much shorter timeframe. Therefore, reducing emissions of these short-lived super-GHGs can slow the rate of global warming in the near term. This provides an important opportunity to delay the worst effects of climate change while we develop and implement effective policies to reduce CO_2 emissions over the long term. In addition, reducing emissions of super-GHGs can also help to avoid or mitigate the feedback loops that, if left unchecked, will accelerate and exacerbate climate change in the near term.

To take advantage of this opportunity to delay and avoid the impacts of climate change, the regional climate protection strategy in the 2017 Plan places a high priority on measures to reduce emissions of the short-lived super-GHGs. (Note: Because nitrous oxide has an atmospheric lifespan of 114 years, we do not include N_2O among the short-lived super-GHGs.) This emphasis on reducing super-GHG emissions is consistent with recent actions at the state level. To highlight the importance of reducing super-GHGs emissions, the Air Resources Board has developed a comprehensive statewide strategy. ARB adopted a *Revised*

Proposed Short-Lived Climate Pollutant Reduction Strategy in March 2017.[66] In addition, SB 1383, which was signed into law in September 2016, establishes statewide targets for reducing methane, black carbon and F-gases. At the global scale, in October 2016, international negotiators reached an important binding agreement to phase out the production and use of HFCs, one of the key F-gases.

Reducing super-GHGs is an important opportunity to reduce global warming in the near term. However, it should be noted that the global climate can only be stabilized over the long term by making deep reductions in emissions of CO_2. Therefore, an aggressive near-term effort to reduce emissions of super-GHGs must be coupled with an effective strategy to reduce emissions of CO_2 in both the near term and the long term.

Bay Area GHG Emissions by Source

The Air District employs a variety of technical tools and methods to analyze Bay Area GHG emissions and concentrations. In November 2006, the Bay Area Air District became the first air district in the nation to develop a detailed GHG emissions inventory. The Air District recently established a network of monitors to measure and characterize ambient concentration of CO_2 and other GHGs in the Bay Area, as described in the GHG Monitoring Network section below.

Figure 3-6 shows the current Bay Area GHG inventory by source category, organized according to the economic sectors used in the AB 32 Scoping Plan Update.[67] The four largest sectors—transportation, stationary sources, energy and buildings—collectively account for 91 percent of the total inventory.

Figure 3-6. 2015 Bay Area GHG Emissions by Source Category, Based on 100-year GWP (Total = 85 MMT CO_2e)

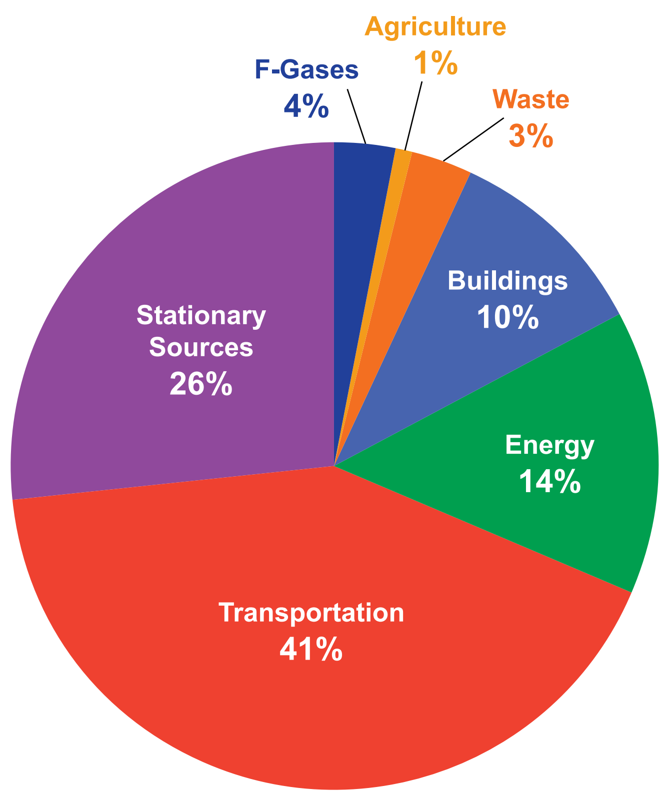


Figure 3-7. 2015 Bay Area GHG Emissions: Transportation (Total = 37 MMT CO_2e)

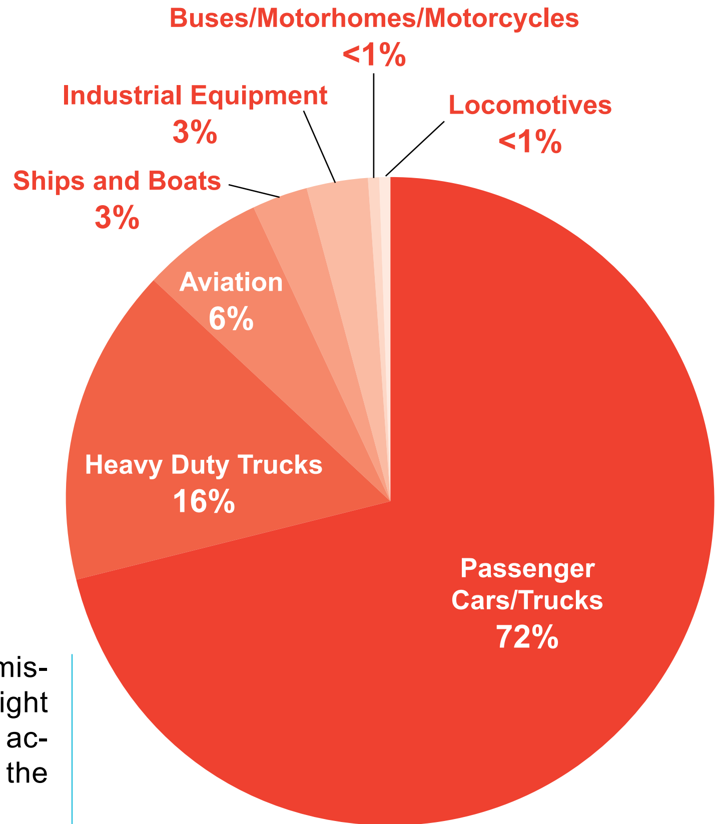


Figure 3-7 shows a breakdown of GHG emissions from transportation by vehicle type. Light and medium-duty cars and trucks currently account for 72 percent of GHG emissions from the transportation sector.

Figure 3-8. 2015 Bay Area GHG Emissions: Stationary Sources (Total = 22 MMT CO_2e)

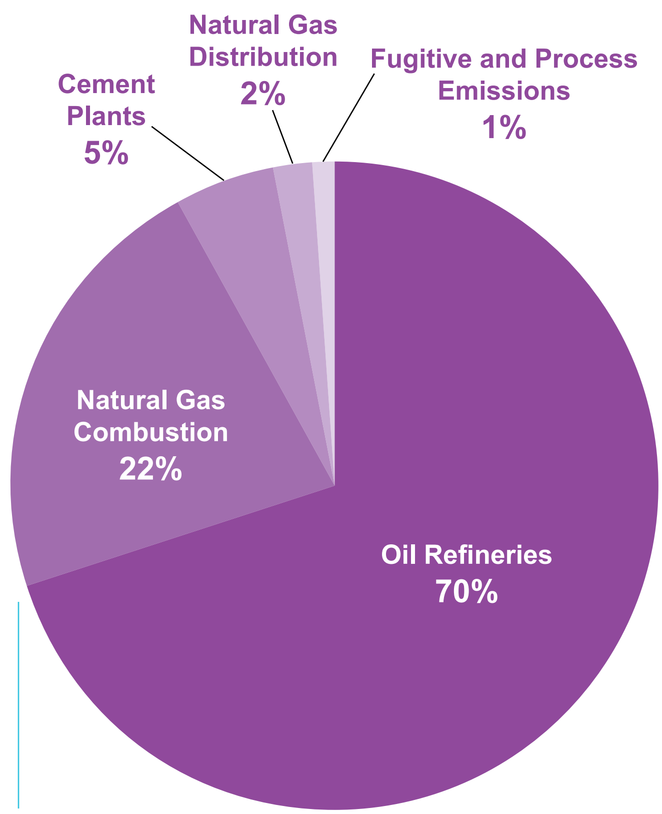


Figure 3-8 provides a breakdown of GHG emissions from stationary sources. The five Bay Area oil refineries account for 70 percent of GHG emissions from stationary sources. The other major stationary source of GHG emissions in the Bay Area is natural gas combustion (22 percent).

Table 3-2 shows Bay Area GHG emissions expressed in CO_2e (i.e., with each pollutant weighted by GWP) by source category for 2015. Note that the total emissions in Table 3-2 (86.5 MMT CO_2e) are greater than shown in the other charts because Table 3-2 includes estimated emissions of black carbon, whereas the other inventory charts and figures do not include black carbon.

Table 3-2. 2015 GHG Emissions (in 100-yr GWP CO_2 Equivalent Metric Tons per Year)

SOURCE CATEGORY	CO_2e (CH_4, N_2O, HFC/PFC, SF_6)	BC (CO_2e)	Total Emissions by Source (CO_2e)
TRANSPORTATION	**34,630,000**	**790,000**	**35,420,000**
On-Road	30,420,000	330,000	30,750,000
Off-Road	4,210,000	460,000	4,670,000
ELECTRICITY/CO-GENERATION	**12,110,000**	**130,000**	**12,240,000**
Co-Generation	5,790,000	90,000	5,880,000
Electricity Generation	5,040,000	40,000	5,080,000
Electricity Imports	1,280,000	-	1,280,000
BUILDINGS	**8,880,000**	**390,000**	**9,270,000**
Residential Fuel Usage	5,240,000	210,000	5,450,000
Commercial Fuel Usage	3,640,000	180,000	3,820,000
STATIONARY SOURCES	**22,020,000**	**340,000**	**22,360,000**
Oil Refineries	15,470,000	210,000	15,680,000
Natural Gas Combustion	4,870,000	110,000	4,980,000
Natural Gas Distribution*	460,000	-	460,000
Cement Manufacturing	990,000	-	990,000
Fugitive and Process Emissions*	230,000	20,000	250,000
WASTE MANAGEMENT	**2,280,000**	**20,000**	**2,300,000**
Landfills*	1,830,000	20,000	1,850,000
Composting/POTWs*	450,000	-	450,000
FLUORINATED GASES	**3,560,000**	**-**	**3,560,000**
HFCs and PFCs (Com., Indus., Transp.)*	3,470,000	-	3,470,000
SF_6 (Electricity Prod. and Semiconductor Mfg.)*	90,000	-	90,000
AGRICULTURE	**1,220,000**	**170,000**	**1,390,000**
Animal Waste*	740,000	20,000	760,000
Soil Management	280,000	-	280,000
Agricultural Equipment	190,000	40,000	230,000
Biomass Burning	10,000	110,000	120,000
TOTAL EMISSIONS (CO_2e)	84,700,000	1,840,000	86,540,000

*Significant source of super-GHGs

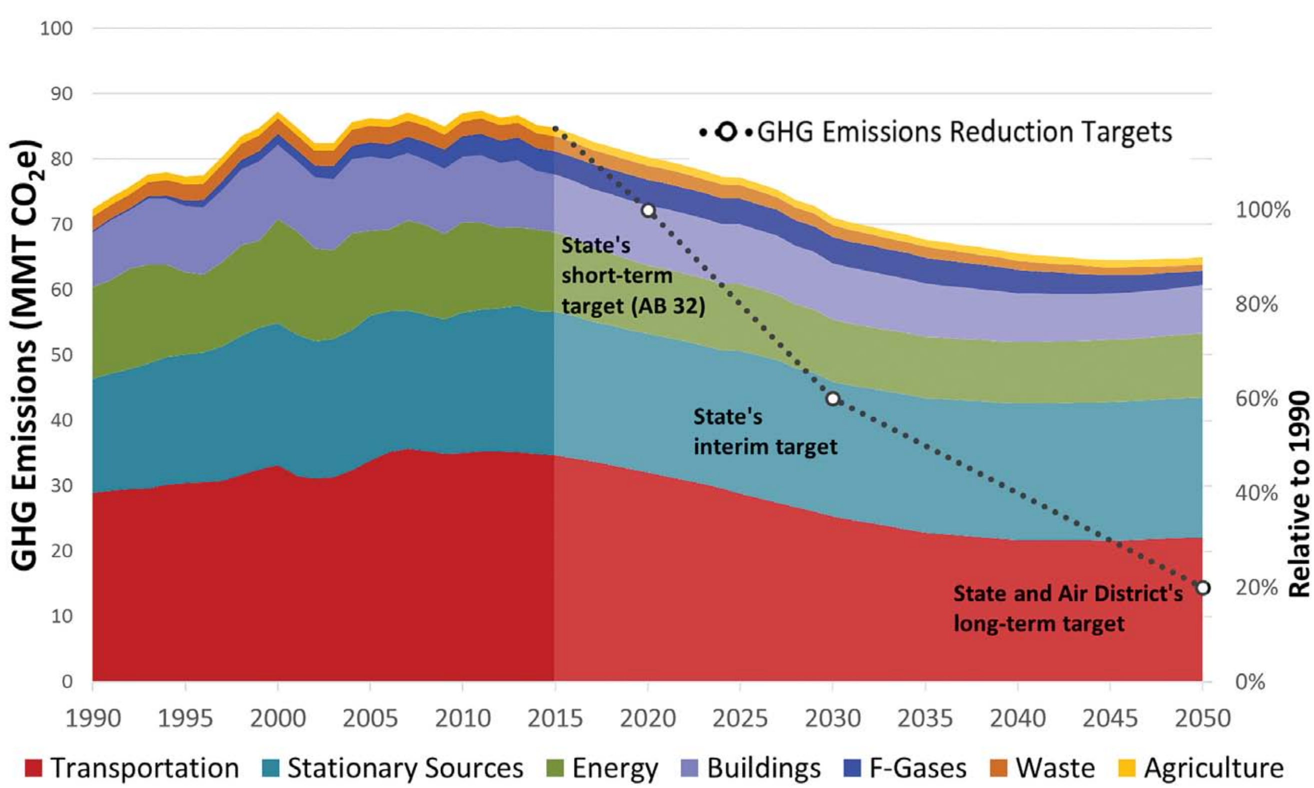
Historical and Projected Bay Area GHG Emission Trends

Projecting future GHG emissions is a challenging exercise. Future emissions will be influenced by a wide range of factors that are difficult to predict with precision, such as population and economic growth, changes in land use policies and patterns, the nature and rate of technological innovation, changes in business investment and consumer demand, the effectiveness of existing policies and programs in reducing GHG emissions over the long term, as well as the potential for new regulations or policies at the national, state, regional and local level.

Figure 3-9 shows estimated changes in Bay Area GHG emissions since 1990 and projected emissions through 2050. The projections represent the Air District's best estimate of future GHG emissions, taking into account State policies and regulations already adopted, as well as those that are likely to be adopted and implemented over the next 10–15 years, as briefly described below. It should be emphasized that the state will need cooperation and assistance from regional and local agencies to successfully implement many of these policies and regulations.

Bay Area GHG emissions under the scenario shown in Figure 3-9 are predicted to decrease gradually from 2015 to 2040, and to level off in the 2040 to 2050 period. The assumptions embedded in Figure 3-9 are based upon the regulatory and policy landscape as of the January 20, 2017 version of ARB's 2017 Climate Change Scoping Plan Update. This landscape includes adopted regulations and associated policies that were not adopted regulations at the time of the January Scoping Plan Update that are deemed likely be implemented or adopted as regulation in the future, i.e. the next 10 to 15 years.

Figure 3-9. Projected Bay Area GHG Emissions by Sector Based on State Policies (100-year GWP)



Key technical and policy assumptions included in the emissions projection for each economic sector are briefly described below. The document entitled *Greenhouse Gas Emission Estimates and Draft Forecasts* provides additional explanation of the methodology and assumptions used to develop Figure 3-9.[68]

Transportation: The emissions for transportation include tailpipe emissions only.[69] The projection takes into account anticipated impacts from policies such as SB 375 sustainable communities strategies to reduce motor vehicle travel, the "Pavley" Clean Car Standards, the Renewable Portfolio Standard (RPS), the Low-Carbon Fuel Standard and the Zero Emission Vehicle mandate.

Stationary Sources: Emissions reported in the stationary source sector are primarily based on emissions from combustion of fossil fuels in industrial processes. The projected emissions for future years are based on ARB's PATHWAYS model. The projection assumes that the state's Cap-and-Trade program will continue beyond 2020 with the same allowances and cap reduction formula as the current program. The PATHWAYS model projects that GHG emissions from stationary sources in the Bay Area's industrial sector will remain relatively constant in future years. Oil refineries currently account for 70 percent of the GHG emissions from stationary sources in the Bay Area. Although in-state demand for fuels produced by Bay Area refineries is expected to decrease in future years, in response to transportation measures described above, the PATHWAYS model projects that GHG emissions from oil refining in California (and, by inference, the Bay Area) will remain the same from 2015 through 2050. The PATHWAYS model apparently assumes that Bay Area and California refineries will export more product to consumers outside of California in future years in response to the expected decrease in demand by in-state consumers. (Note: It should be emphasized that the Air District is not endorsing the idea that emissions from oil refining should remain constant in future years. Reducing fossil fuel combustion is a major element of the regional climate protection strategy proposed in this Plan.)

Energy: GHG emissions from the energy sector include all electricity generation within the Bay Area, electricity imported into the region, plus co-generation at oil refineries. The projection in Figure 3-9 assumes that the state's Renewal Portfolio Standard will increase from 33 percent in 2020 to 50 percent by 2030 as required by SB 350. In addition, the projection assumes that local actions, such as the expansion of local Community Choice Energy programs in the region, will push the percentage of renewable electricity in the Bay Area portfolio to 54 percent by 2030.

GHG emissions from the energy sector include all electric generation within the Bay Area as well as electricity imported into the region.

Buildings: Emissions in this sector are primarily from combustion of natural gas for space and water heating in residential and commercial buildings. The projection in Figure 3-9 includes a variety of measures to improve energy efficiency in both existing buildings and new buildings, and to switch from natural gas to clean electricity. The projection assumes that 100 percent of new residential construction will be zero net energy (ZNE) by 2020, while new commercial construction will be 100 percent net zero by 2030, with solar photovoltaic power offsetting any emissions from electricity and natural gas use. For existing buildings, the projection assumes that 50 percent of commercial buildings will be retrofit to ZNE by 2030, and 100 percent of commercial buildings will be retrofit to ZNE by 2050. The projection assumes that no existing residential building are retrofits to ZNE.

F-Gases: F-gases include HFCs, PFCs and SF_6. Projected F-gas emissions are consistent with ARB's SLCP Reduction Strategy, including an assumed 5 percent reduction in HFC usage by 2020; a 50 percent reduction by 2035; and near complete elimination by 2050. Note: F-gases are projected to still account for a small portion of the GHG inventory in 2050 because there will be an estimated time lag of 10 to 20 years from the date that HFCs are prohibited until leakage of HFCs from retired equipment is eliminated.

Agriculture and Waste: The projected emissions for these sectors assume minor reductions from agriculture, but major reductions for recycling and waste management, based upon the statewide targets established by AB 341 and SB 1383 to increase recycling, achieve a 75 percent waste diversion rate for landfills by 2020, and reduce methane emissions from wastewater treatment.

GHG Monitoring Network

The Air District is implementing a GHG monitoring program to inform its climate protection strategy. This effort includes a fixed-site network to monitor ambient concentrations of carbon dioxide (CO_2) and methane (CH_4), as well as a research van serving as a mobile GHG measurement platform. The GHG monitoring data provided by this effort will be used to improve the Air District's GHG emission inventory, to identify GHG emission 'hotspots,' to measure trends in ambient concentrations of GHGs, and to help evaluate the effectiveness of Air District and state measures to reduce GHG emissions.

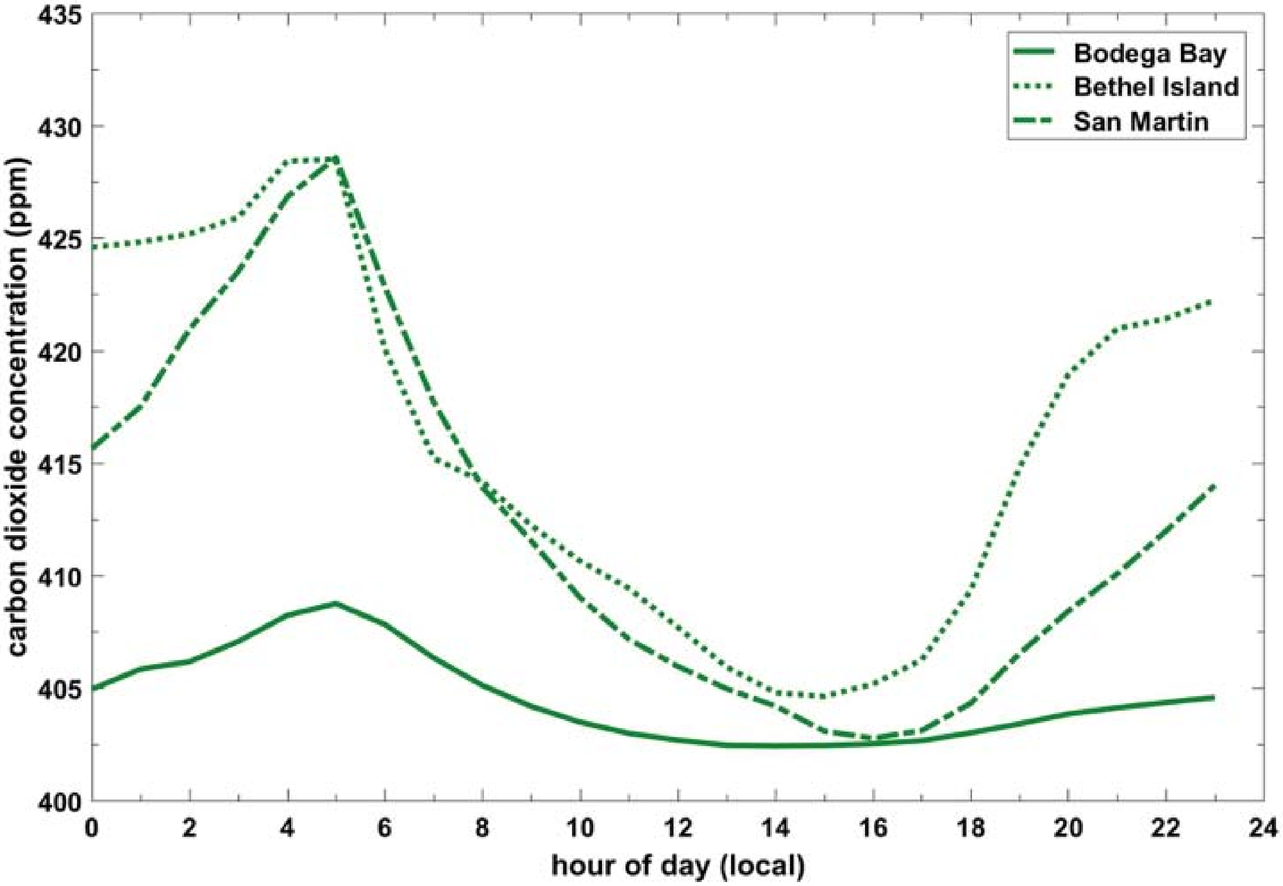
The fixed-site network includes four sites, consistent with protocols of international atmospheric monitoring networks. One site, located upwind of the urban core at Bodega Bay (operational as of October 2015) along the Pacific Coast, serves as a regional background site, measuring GHG levels in air coming into the region from the Pacific Ocean. The other three sites are strategically located at exit points for Bay Area air plumes that presumably contain GHG enhancements from Bay Area sources. These stations are in San Martin (operational as of mid-April 2016), which is located south and generally downwind of the San Jose metropolitan area; in Bethel Island (operational as of October 2015) at the mouth of the Sacramento-San Joaquin River Delta; and in Livermore (operational as of December 2016), near the eastern edge of the Air District's boundary. At all sites, CO_2 and CH_4 are measured continuously, along with combustion tracer carbon monoxide and other air pollutants.

The mobile van, which began source-specific investigations in fall 2016, is equipped with instruments to measure CO_2, CH_4, nitrous oxide (N_2O) and other compounds to identify and attribute emissions to specific GHG sources. The van measures GHG concentrations close to emission sources such as oil refineries, landfills, wastewater treatment plants, dairies, natural gas co-generation plants, gas pipelines, etc. The measured estimates of GHGs from local sources will allow verification and validation of the Air District's GHG emissions inventory for the Bay Area.

Preliminary findings from the first year of operation of the fixed site network (through summer 2016) are summarized below.

Carbon dioxide: As shown in Figure 3-10, CO_2 concentrations vary over the course of the day at the (downwind) Bethel Island and San Martin sites in response to changes in meteorology in combination with local emissions of CO_2. During a typical day, CO_2 concentrations are lowest in the afternoon when vegetation is most effective at absorbing CO_2 and local CO_2 emissions are well mixed vertically within the lower atmosphere. Hence, daily mean low CO_2 levels are similar at all three sites during the summer. However, the daily mean peak CO_2 concentrations at both Bethel Island and San Martin, that occur during nighttime as emissions accumulate in a stable atmosphere with little vertical mixing, are significantly elevated as compared to the background levels at Bodega Bay. This suggests the presence of strong regional emission sources of CO_2 in the urban core of the Bay Area upwind of the downwind monitoring sites.

Figure 3-10. Average Daily Variation in Bay Area CO_2 Concentrations—Summer 2016



Average daily concentration profiles of CO_2 (in ppm) at Bodega Bay (solid line), Bethel Island (dotted line) and San Martin (dash-dot line) during summer 2016 (Jun.1 - Aug.31). The hourly data values represent averages over the entire season.

Source: BAAQMD 2016

There are minor seasonal variations in CO_2 concentrations over the course of the year, with the highest concentrations observed during winter months as shown in Table 3-3. This may be due to less absorption of CO_2 by vegetation during the winter, in combination with the fact that CO_2 emissions tend to be trapped close to the ground in winter due to less vertical mixing of the atmosphere.

Table 3-3. Seasonal Variation in Bay Area Carbon Dioxide Concentrations

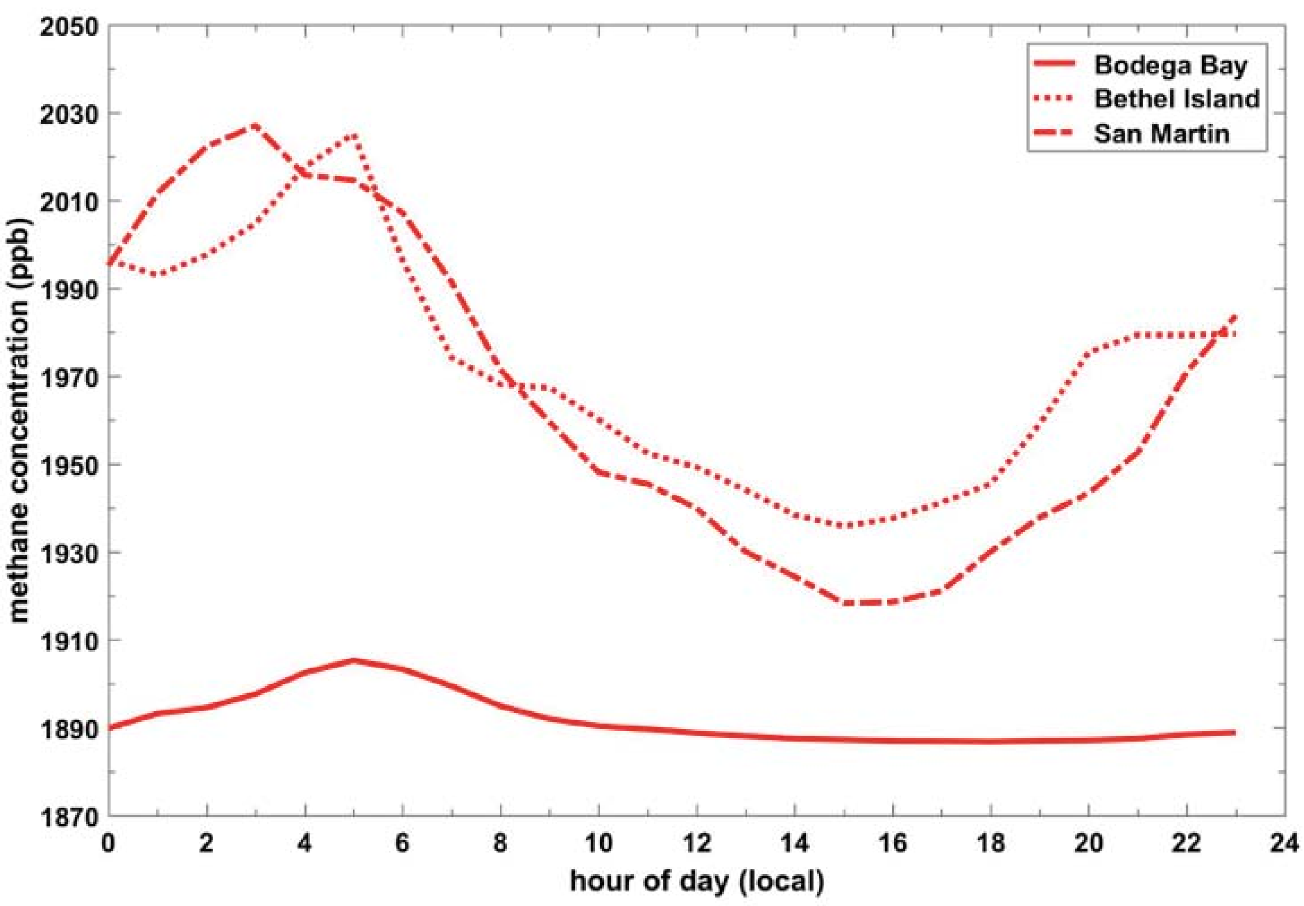
Site	Concentration	CO_2 (parts per million)			
		Fall (Sep.–Nov. 2015)	**Winter** (Dec. 2015–Feb. 2016)	**Spring** (Mar.–May 2016)	**Summer** (Jun.–Aug. 2016)
Bodega Bay	Daily Mean Low	405.3	411.1	408.7	402.4
	Daily Mean Peak	415.3	428.6	419.1	408.8
Bethel Island	Daily Mean Low	405.2	407.7	403.9	405.0
	Daily Mean Peak	463.6	458.1	440.7	431.4
San Martin*	Daily Mean Low	NA	NA	404.4	401.0
	Daily Mean Peak	NA	NA	446.2	428.9

* Site operational as of mid-April 2016.

Methane (CH_4): Methane emissions from Bay Area sources result in higher concentrations of methane, during all seasons and all times of day, when methane levels at the downwind monitoring sites in Bethel Island and San Martin are compared with the background levels measured at Bodega Bay. Over the course of a typical day, as in the case of CO_2, methane concentrations are lowest during the afternoon when local methane emissions are well mixed vertically in the lower atmosphere, as shown in Figure 3-11. Methane levels are significantly elevated during the nighttime at the downwind sites as emissions from upwind regional sources accumulate in the stable atmosphere and are transported.

In terms of seasonal variation, the Bethel Island site shows significantly higher levels of methane during the fall and winter periods compared to spring and summer, whereas the seasonal variation at the upwind site in Bodega Bay is relatively minor, as shown in Table 3-4. This suggests that the elevated levels of methane at Bethel Island during the winter may be caused by increased fugitive emissions (e.g., leaks from natural gas pipelines) of methane due to increased natural gas use for space heating during the cooler months, in combination with the fact that methane emissions tend to be trapped close to the ground in winter due to less vertical mixing of the atmosphere.

Figure 3-11. Average Daily Variation in Bay Area Methane Concentrations—Summer 2016



Average daily concentration profiles of CH_4 (in ppb) at Bodega Bay (solid line), Bethel Island (dotted line) and San Martin (dash-dot line) during summer 2016 (Jun.1 - Aug.31). The hourly data values represent averages over the entire season.

Source: BAAQMD 2016

Table 3-4. Seasonal Variation in Bay Area Methane Concentrations

Site	Concentration	Methane (parts per billion)			
		Fall (Sep.–Nov. 2015)	**Winter** (Dec. 2015–Feb. 2016)	**Spring** (Mar.–May 2016)	**Summer** (Jun.–Aug. 2016)
Bodega Bay	Daily Mean Low	1909.9	1922.1	1917.3	1886.8
	Daily Mean Peak	1932.5	1961.5	1938.7	1905.3
Bethel Island	Daily Mean Low	1968.4	2078.2	1958.2	1935.6
	Daily Mean Peak	2354.0	2332.3	2080.6	2031.6
San Martin*	Daily Mean Low	NA	NA	1933.1	1915.6
	Daily Mean Peak	NA	NA	2035.8	2023.5

* Site operational as of mid-April 2016.

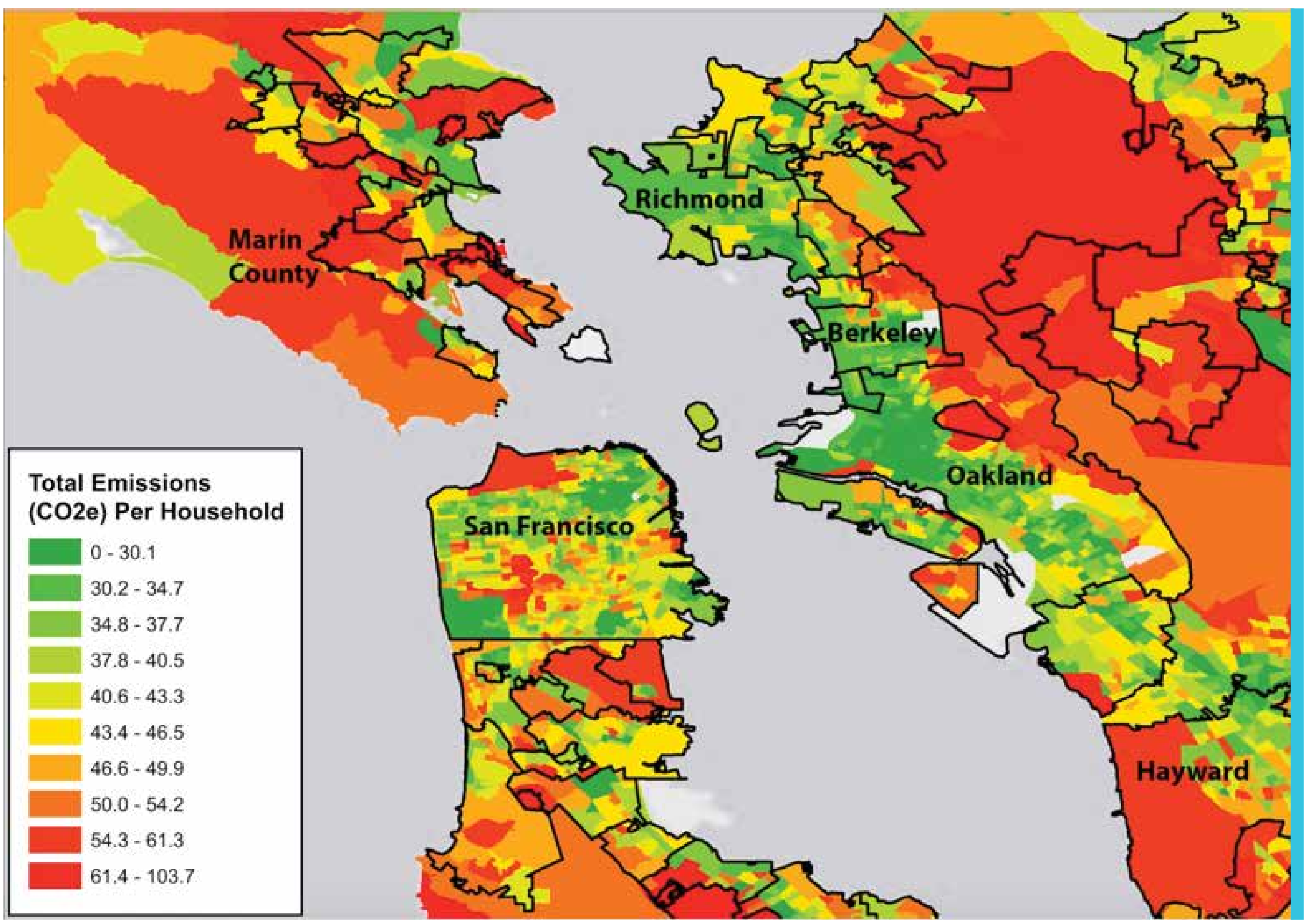
Consumption-Based GHG Emissions Inventory

The Air District's GHG emissions inventory categorizes and quantifies the GHGs produced or emitted within the geographic boundaries of the Air District. However, this emissions inventory does not tell the whole story of our impact on the climate since a significant portion of the goods and services consumed by Bay Area residents is produced outside the region, in other states or nations. Therefore, to more fully describe the amount of GHGs generated by Bay Area residents as consumers of goods and services, the Air District collaborated with the Cool Climate Network at UC Berkeley to develop a consumption-based GHG emissions inventory for the San Francisco Bay Area. The consumption-based inventory estimates the GHG emissions embedded in the goods, services, and activities consumed by Bay Area residents, regardless of where the goods were produced or the emissions were released. The consumption-based inventory is based on a full life-cycle analysis of the emissions generated by the production, use, and disposal of each activity or product. Emissions are grouped in five basic categories: transportation, housing, food, goods and services. The inventory calculates the average per-household GHG footprint for each Bay Area neighborhood, city and county.[70]

As shown in Figure 3-12, the GHG footprint varies substantially from neighborhood to neighborhood. There is significant variation in the magnitude of emissions, as well as in the composition of the GHG footprint, i.e., the proportion of emissions contributed by each of the five basic categories.

Figures 3-13 and 3-14 show the magnitude and composition of the GHG footprint for the average American household compared to the average Bay Area household. Emissions are categorized as transportation, housing, food, goods and services. Composting and recycling are shown as a credit, thus reducing the total GHG footprint.

Figure 3-12. Household Consumption-Based GHG Emissions by Census Block Group, 2013 * (in tons CO_2e per year)



* Black lines represent city boundaries

Figure 3-13. **U.S. Average Household GHG Footprint (Based on Consumption), 2013**

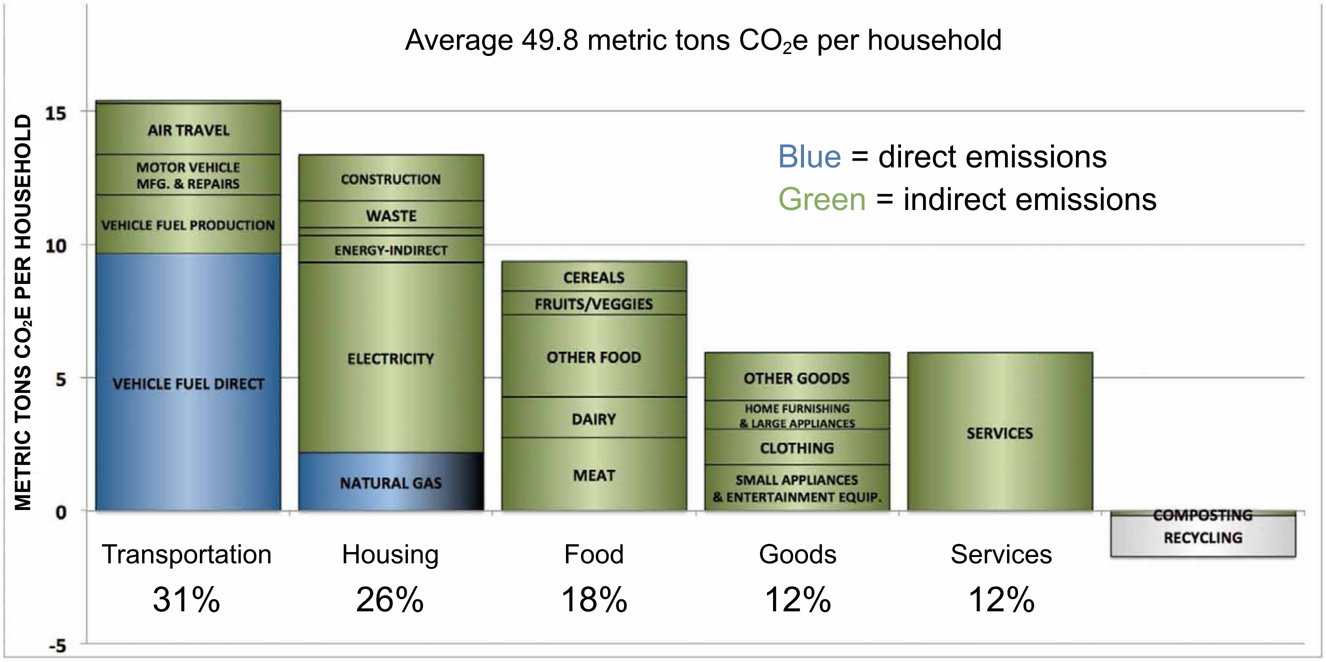
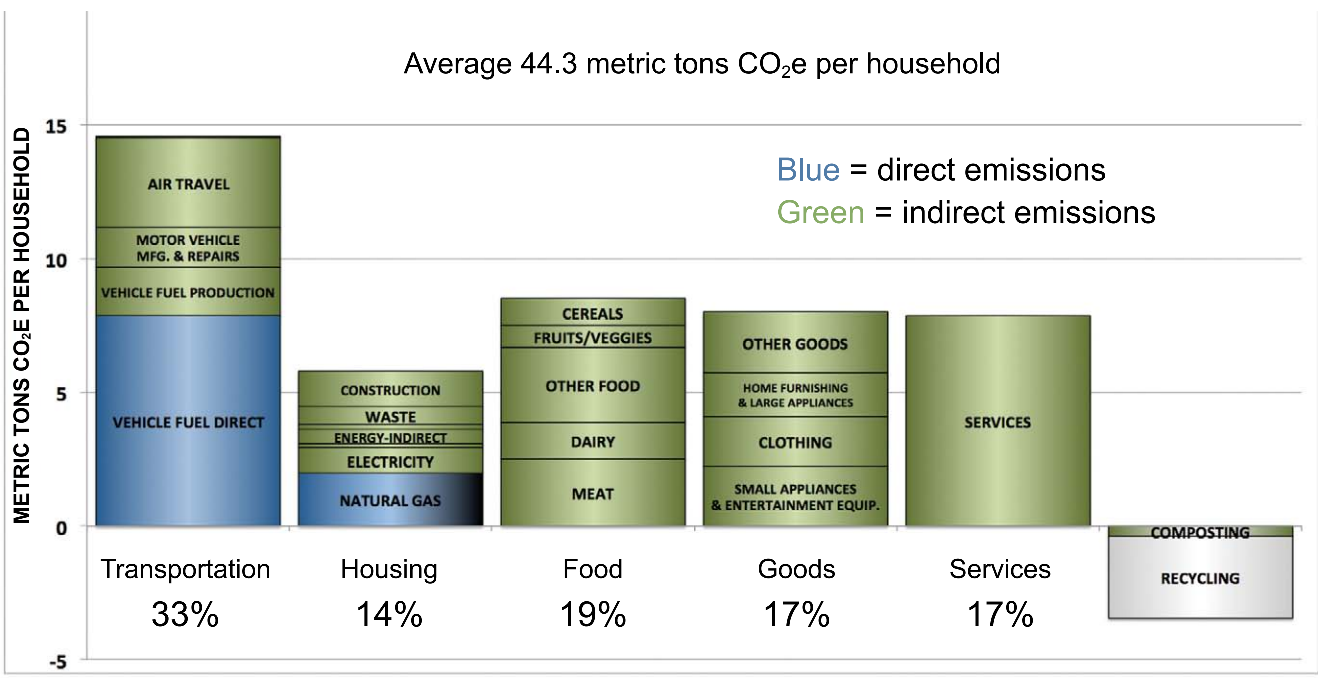


Figure 3-14. **Bay Area Average Household GHG Footprint (Based on Consumption), 2013**



...individual consumer choices can have a significant effect on each household's GHG footprint.

A comparison of national and Bay Area emissions yields the following observations:

Bay Area GHG emissions are lower than the U.S. average on a per household basis: GHG emissions for the average Bay Area household (44.3 metric tons per year) are less than the average American household (49.8 metric tons per year), even though Bay Area residents have significantly higher income than the national average.

The composition of the GHG footprint differs: The share of the GHG footprint from transportation and from food is similar for the Bay Area and the nation as a whole. However, the housing sector accounts for a much smaller share of the Bay Area footprint (14 percent) compared to the national average (26 percent). Conversely, goods and services, at 17 percent each, account for a larger share of Bay Area emissions than for the average American GHG footprint, where goods and services each account for 12 percent of the overall footprint.

Clean electricity is a big advantage: A major reason for the relatively low GHG footprint of the average Bay Area household, especially in terms of the housing sector, is that GHG emissions from residential electricity consumption in the Bay Area are well below the national average, roughly one metric ton per year for the average Bay Area household, compared to 7 tons per year as the national average. There are several reasons for this. To be sure, the region's moderate climate helps to reduce the need for home heating and cooling in the Bay Area. But forward-thinking public policies account for most of the difference. The electricity consumed in the Bay Area has a lower carbon intensity as a result of well-established state policies such as the Renewable Portfolio Standard (RPS) to promote renewable energy sources and phase out coal-fired power plants, in combination with local efforts in many cities to promote clean electricity through community choice energy (CCE) programs. State building codes and energy efficiency standards for appliances also help to reduce demand for electricity in the Bay Area and statewide. As a result of these policies, the low carbon intensity of our electricity creates a great opportunity to further reduce our GHG emissions by switching to electricity to power our cars and trucks, as well as for space-heating and water-heating in our homes and other buildings.

The consumption-based GHG inventory provides an additional perspective on Bay Area GHG emissions, helping us to better understand the GHG emissions associated with the goods and services that we import to the region, and calling attention to activity categories that are not typically captured in a production-based inventory. Several of the insights that can be drawn from the consumption-based GHG inventory are briefly described below.

Government cannot do it alone: Transportation and housing together account for 47 percent of the total GHG emissions in the Bay Area from a consumption-based perspective, as shown in Figure 3-14. Governmental policies can have an impact in reducing emissions from these two sectors. However, in the case of the food, goods and services sectors, which collectively account for 53 percent of total GHG emissions in the Bay Area, emissions are primarily driven by consumer choice and lifestyle. This suggests that governmental action cannot by itself achieve the necessary reductions in GHG emissions. Support and action from consumers and the business sector will be critical.

Bay Area residents have a key role to play: The consumption-based inventory shows that there is significant variation in the magnitude and the composition of the GHG footprint among Bay Area households. Individual consumer choices can have a significant effect on each household's GHG footprint. As discussed in the 2050 vision in Chapter 1, in order to achieve the ambitious GHG reduction target for year 2050, it will be critical to help Bay Area residents understand that they must play an active role as "conscientious consumers" in reducing GHG emissions. The Air District will use the consumption-based inventory to help Bay Area residents understand the factors that influence their GHG footprint and to provide them with information and resources so to make appropriate and effective choices to reduce their personal GHG footprint.[71]

Food is a major source of GHG emissions: One of the most interesting findings from the consumption-based inventory is that food accounts for nearly 20 percent of the GHG footprint in the average Bay Area household. GHGs embedded in food include carbon dioxide from combustion of fossil fuels used to produce, process, and distribute food products, nitrous oxide from fertilizers, and methane emitted in the production of dairy and meat products. Food waste also contributes to methane emissions from landfills. As discussed in Chapter 1, GHG emissions from the food sector can be reduced by decreasing food waste in markets and restaurants and in the home. Bay Area residents can also reduce their GHG footprint by decreasing consumption of processed foods, meat and dairy products, and food imported from long distances. Eating less meat and dairy would also provide public health benefits.

We still have a long way to go: The state and the Air District have adopted targets to reduce GHG emissions 80 percent below 1990 levels by 2050. If we assume that consumption-based emissions per Bay Area household were similar in 2013 and in 1990, then a reduction of this magnitude means that we need to reduce Bay Area GHG emissions from 44.3 metric tons (MT) per year to less than 9 MT per year on a per-household basis. Factoring in anticipated population growth, emissions would need to be reduced even further, to approximately 7 MT per household per year in order to achieve the 2050 target. It will be a major challenge to achieve emission reductions of this magnitude, while maintaining the standard of living to which we are accustomed.

Summary

Climate change is already occurring, and the Bay Area is experiencing a wide range of climate impacts. These impacts are expected to intensify in the future and negatively affect air quality and public health in the Bay Area. However, aggressive near-term efforts to reduce emissions of super-GHGs—including methane, black carbon, and F-gases—as well as to reduce combustion of fossil fuels for power, heating and cooling, and transportation can help decrease the speed and severity of climate change over the next several decades. Concurrently, GHG mitigation efforts must also be coupled with coordinated adaptation and resilience programs to strengthen the Bay Area's ability to cope with the impacts of climate change.

The long-term solution to protect the climate requires a comprehensive strategy to replace fossil fuels with renewable, low-carbon forms of energy. Since current regional, state, and national policies are insufficient to meet the necessarily ambitious GHG emission targets adopted by the state and the Air District for 2030 and 2050, additional regulations, policies and transformative technologies are needed.

The Air District and its partners in the Bay Area—including the Metropolitan Transportation Commission, the Association of Bay Area Governments, the Bay Conservation and Development Commission, local governments and many other stakeholders—all have a critical role to play in achieving GHG reduction targets for 2030 and 2050 and preparing the region to cope with the impacts of climate change.

FOOTNOTES

1 California Air Resources Board http://www.arb.ca.gov/cc/shortlived/shortlived.htm.

2 Adaptation and resilience efforts will require coordination and cooperation on the part of a wide range of state and local agencies such as the Association of Bay Area Governments, the Bay Conservation and Development Commission, Caltrans, local cities, county health departments and others. The Air District's efforts include more recent collaboration—through the Bay Area Regional Collaborative (BARC)—with the Alliance of Regional Collaboratives for Climate Adaptation (ARCCA), which works to give a strong voice to regional efforts at the state and federal levels.

3 For example, see the "2016 Arctic Report Card" issued by the National Oceanic and Atmospheric Administration: http://arctic.noaa.gov/Report-Card/Report-Card-2016

4 http://www.fire.ca.gov/communications/downloads/fact_sheets/20LACRES.pdf

5 *Safeguarding California Implementation Action Plans 2015,* California Natural Resources Agency pg. 8

6 *Indicators of Climate Change in California 2013,* CalEPA, pg. 37.

7 http://climate.nasa.gov/effects/.

[8] *Indicators of Climate Change in California 2013,* CalEPA, pg. 38.

[9] *California Climate Extremes Workshop Report 2011,* Scripps Institution of Oceanography, pg. 7.

[10] https://ww2.kqed.org/science/2016/01/20/2015-was-the-warmest-year-on-record-globally-but-not-in-california/.

[11] *Safeguarding California Implementation Action Plans 2015,* California Natural Resources Agency, pg. 69.

[12] *High Resolution Climate-Hydrology Scenarios for the San Francisco Bay Area 2013,* Terrestrial Biodiversity Climate Change Collaborative, pg. 3.

[13] Western Regional Climate Center, California Climate Data Archive, www.calclim.dri.edu.

[14] https://www.ncdc.noaa.gov/sotc/global/201604.

[15] *Climate Change Impacts, Vulnerabilities and Adaptations in the San Francisco Bay Area 2012,* Ekstrom & Moser, pg. 19. A temperature increase of this magnitude can potentially be avoided by aggressive near-term actions to reduce emissions of short-lived climate pollutants, as discussed later in this chapter.

[16] *Climate Change Impacts, Vulnerabilities and Adaptations in the San Francisco Bay Area 2012,* Ekstrom & Moser, pg. 19.

[17] *From Boom to Bust: Climate Change in the Golden State 2015,* Risky Business Project, pg. 26-27.

[18] *Indicators of Climate Change in California 2013,* CalEPA, pg. 66.

[19] *Trends in Atmospheric Patterns Conducive to Precipitation and Temperature Extremes in California,* Swain et al., Science Advances, 2016; 2:e150134. Also see http://news.stanford.edu/press-releases/2016/04/01/pr-drought-patterns-change-040116/.

[20] *Indicators of Climate Change in California 2009,* CalEPA, pg. 100.

[21] *Safeguarding California Implementation Action Plans 2015,* California Natural Resources Agency, pg. 69.

[22] Knowles and Cayan. *Potential Effects of Global Warming on the Sacramento/San Joaquin Watershed and the San Francisco Estuary.* Geophysical Research Letters 29, no. 18 (2002).

[23] *Unprecedented Drought Risk in the American Southwest and Central Plains,* Cook et al., Science Advances 12 Feb 2015: Vol. 1, no. 1, e1400082.

[24] *High Resolution Climate-Hydrology Scenarios for the San Francisco Bay Area 2013,* Terrestrial Biodiversity Climate Change Collaborative.

[25] *Indicators of Climate Change in California 2013,* CalEPA, pg. 88.

[26] *Climate Change Projections of Sea Level Extremes in California,* Cayan et al. 2008, pg. S-58.

[27] *Sea Level Rise for the Coasts of California, Oregon and Washington,* National Research Council, 2012, pg. 96.

[28] *Contribution of Antarctica to Past and Present Sea Level Rise,* DeConto, Pollard, 2016, Nature. March 30, 2016 pg.1.

[29] *Safeguarding California Implementation Action Plans 2015,* California Natural Resources Agency, pg. 101.

[30] *Climate Change Impacts, Vulnerabilities and Adaptations in the San Francisco Bay Area 2012,* Ekstrom & Moser, pg. 23.

[31] *Surviving the Storm,* Bay Area Council Economic Institute, 2015, pg. 34.

[32] California Department of Public Health, http://www.cdph.ca.gov/programs/Documents/CDPH_CC-and-Health-Equity-Issue-Brief.pdf.

[33] California Natural Resources Agency, pg. 114–15.

[34] California Natural Resources Agency, pg. 34.

[35] *Impacts of Climate Change on Human Health in the United States,* U.S Global Change Research Program, 2016, pg. 11.

[36] The Expected Peak Day Concentration for the state 1-hour ozone standard declined from 103 ppb in 1986–1988 to 77 ppb in 2012–2014, a decrease of 26 ppb in 26 years, or 1 ppb per year on average. Based on this rate of change, an 8 ppb increase in ozone concentrations would offset approximately 8 years of progress in reducing EPDC of ozone in the Bay Area.

[37] *California Adaptation Strategy 2009,* California Natural Resources Agency, pg. 34.

[38] *California Adaptation Strategy 2009,* California Natural Resources Agency, pg. 34.

[39] *Indicators of Climate Change in California 2009,* CalEPA, pg. 131.

[40] During the final week of June 2008, $PM_{2.5}$ levels increased between five- and ten-fold compared to normal readings at several Bay Area monitoring stations.

[41] Wegesser et al. *California Wildfires of 2008: Coarse and Fine Particulate Matter Toxicity.* Environmental Health Perspectives, Vol. 117, June 2009.

[42] *Climate Change Impacts, Vulnerabilities and Adaptations in the San Francisco Bay Area 2012,* Ekstrom & Moser, pg. 46.

[43] *Preparing California for Extreme Heat,* California Department of Public Health, 2013, pg. 4.

[44] *Safeguarding California 2014,* California Natural Resources Agency, pg. 194.

[45] *Climate Change Impacts, Vulnerabilities and Adaptations in the San Francisco Bay Area 2012,* Ekstrom & Moser, pg. 46.

[46] U.S. EPA: https://www.epa.gov/heat-islands/heat-island-impacts.

[47] *Safeguarding California Implementation Action Plans 2015,* California Natural Resources Agency, pg. 119.

[48] See Agenda Item #4: http://www.baaqmd.gov/~/media/files/board-of-directors/advisory-council/2015/ac_agenda_051315.pdf?la=en.

[49] *San Francisco Climate & Health Profile,* 2015, San Francisco Department of Public Health, pg. 14.

[50] San Mateo Department of Public Health, http://www.smcmvcd.org/invasive-aedes-aegypti-san-mateo-county.

[51] *San Francisco Climate & Health Profile,* 2015, San Francisco Department of Public Health, pg. 13.

[52] *Safeguarding California 2014,* California Natural Resources Agency, pg. 195.

[53] *Impacts of Climate Change on Human Health in the United States,* U.S. Global Change Research Program, 2016, pg. 16.

[54] *Impacts of Climate Change on Human Health in the United States,* U.S. Global Change Research Program, 2016, pg. 21.

[55] *San Francisco Climate & Health Profile,* 2015, San Francisco Department of Public Health, pg. iv.

[56] *Safeguarding California Implementation Action Plans 2015,* California Natural Resources Agency, pg. 9.

[57] *Climate Change Impacts, Vulnerabilities and Adaptations in the San Francisco Bay Area 2012,* Ekstrom & Moser, pg. 11.

[58] *Preparing California for Extreme Heat,* California Department of Public Health, pg. 5.

[59] *Our Changing Climate 2012,* California Climate Change Center, pg. 4.

[60] *Mapping Climate Change Exposures, Vulnerabilities and Adaptation to Public Health Risks in the San Francisco and Fresno Regions,* Jerrett et al, 2012, pg. 11-12.

[61] *Preparing California for Extreme Heat,* California Department of Public Health, 2013, pg. 8.

[62] *Safeguarding California Implementation Action Plans 2015,* California Natural Resources Agency, pg. 115.

[63] *Preparing California for Extreme Heat,* California Department of Public Health, 2013, pg. 8.

[64] *Safeguarding California 2014,* California Natural Resources Agency, pg. 193.

[65] *Environmental Health and Equity Impacts from Climate Change and Mitigation Policies in California,* Shonkoff et al, 2009.

[66] ARB uses the term “short-lived climate pollutants” or SLCPs to describe the super-GHGs. See: https://www.arb.ca.gov/cc/shortlived/shortlived.htm.

[67] The Air District’s greenhouse gas inventory includes GHGs that are emitted within the Bay Area, as well as GHGs emitted in the production of electricity that is imported to the region. The emissions inventory does not include GHGs generated in the production of goods or services that are produced outside the Bay Area and then imported for consumption within the region. To estimate and categorize the GHG emissions embedded in all goods and services consumed within the Bay Area, the Air District has developed a consumption-based GHG emissions inventory, described later in this chapter.

[68] http://www.baaqmd.gov/~/media/files/planning-and-research/plans/2017-clean-air-plan/ghg_emissions_and_forecasts_draft.pdf?la=en

[69] Leakage of refrigerants from mobile sources is accounted for in the ‘Super-GHG’ sector.

[70] For additional information, including links to detailed tables and maps, see: http://www.baaqmd.gov/research-and-data/emission-inventory/consumption-based-ghg-emissions-inventory

[71] Additional tools to help consumers evaluate their GHG emissions are available on the Cool Climate Network website. See http://coolclimate.berkeley.edu/calculator.

CHAPTER 4
PLANNING CONTEXT

The 2017 Plan builds on many other plans, policies and programs, including existing and new Air District initiatives, as well as plans developed and implemented by other agencies. This chapter describes the policy and planning context for the 2017 Plan, including:

- Progress in implementing the Bay Area 2010 Clean Air Plan,
- Key Air District programs and initiatives that support and complement the 2017 Plan, and
- Federal, state, regional, and local policies, plans and programs that complement the 2017 Plan.

Implementation of the 2010 Clean Air Plan

The 2017 Plan is an update to the Air District's most recent state ozone plan, the 2010 Clean Air Plan. The 2010 Clean Air Plan laid out a comprehensive strategy to reduce emissions of ozone precursors, particulate matter (PM), greenhouse gases (GHGs) and toxic air contaminants (TACs). The plan included 18 Stationary Source Measures (SSMs), 10 Mobile Source Measures (MSMs), 17 Transportation Control Measures (TCMs), six Land Use and Local Impact Measures (LUMs), and four Energy and Climate Measures (ECMs). The Air District and its partner agencies have taken action to implement the control measures in the 2010 Clean Air Plan, as summarized below. Stationary source measures have been implemented through the

Air District's rule development process. The mobile source, transportation, land use, and energy and climate measures have been implemented through a wide range of mechanisms, including partnerships, grants, and public outreach and education.

In addition, the 2010 Clean Air Plan identified 18 Further Study Measures (FSMs). The FSMs were not a formal part of the control strategy, but the Air District did commit to further evaluate these measures to determine whether or not they should be developed into control measures at a later date.

Stationary Source Measures

Table 4-1 shows the status of stationary source measures identified in the 2010 Clean Air Plan that are now adopted regulations and/or rules. Of the 18 stationary source measures, eight have been adopted into regulations/rules. The remaining ten control measures have been carried forward as part of the 2017 control strategy.

Table 4-1. Implementation of Stationary Source Measures in 2010 Clean Air Plan

2010 Clean Air Plan Control Measure (Reg. – Rule)	Date Adopted	Emissions Reduced (tons per day)			
		ROG	NO_x	PM	SO_2
SSM1: Metal Melting Facilities (6-4 and 12-13)	5/01/13	*a.*	*a.*	0.03	*a.*
SSM2: Digital Printing	Carried forward in 2017 Plan as SS27				
SSM3: Livestock Waste	Carried forward in 2017 Plan as AG4				
SSM4: Natural Gas Processing and Distribution	Carried forward in 2017 Plan as SS15				
SSM5: Vacuum Trucks (8-53)	4/18/12	1.05	*a.*	*a.*	*a.*
SSM6: General Particulate Matter Weight Rate Limitation	Carried forward in 2017 Plan as SS31				
SSM7: Open Burning (5, amended)	6/19/13	*b.*	*b.*	*b.*	*b.*
SSM8: Petroleum Refining Calcining Operations (9-14)	4/20/16	*a.*	*a.*	*a.*	1.76
SSM9: Cement Kilns (9-13)	9/19/12	0.03	1.95	0.002	*a.*
SSM10: Refinery Heaters and Boilers (9-10, amended)	10/19/13	*b.*	*b.*	*b.*	*b.*
SSM11: Residential Fan Type Furnaces	Carried forward in 2017 Plan as SS30				
SSM12: Large Residential and Commercial Space Heating	Carried forward in 2017 Plan as FSM_BL1.				
SSM13: Dryers, Ovens, Kilns	Carried forward in 2017 Plan as FSM_SS8				
SSM14: Glass Furnaces	The only glass furnace in Bay Area has closed.				
SSM15: GHG in Permitting	Carried forward in 2017 Plan as SS17				
SSM16: New Source Review for Addressing $PM_{2.5}$ (2-2, amended)	11/01/12	*a.*	*a.*	*c.*	*a.*
SSM17: New Source Review of TACs (2-5, amended)	12/07/2016	*c.*	*c.*	*c.*	*c.*
SSM18: Revise Air Toxics "Hot Spots" Program	Carried forward in 2017 Plan as SS21				

a. Rule does not reduce pollutant, or reduces only a nominal amount of pollutant.
b. Rule is designed to enhance enforcement, not further reduce emissions.
c. Emission reductions were not calculated for these measures.

Additional New Rules Adopted Since 2010

In addition to rules adopted pursuant to the stationary source measures in the 2010 Clean Air Plan, the Air District has adopted or amended a number of additional rules as shown in Table 4-2.

Details regarding the status of all 2010 stationary source measures may be found in Appendix F.

Table 4-2. **Additional Rules Adopted in 2010–2016**

Regulation-Rule and Selected Amendments	Date Adopted	Emissions Reduced (tons per day)				Emissions Reduced (metric tpy)
		ROG	NO_x	PM	SO_2	CO_2e
Limited Use Stationary Compression Ignition Engines in Agriculture Use (11-17)	5/18/11	0.01	0.08	0.01	*a.*	*a.*
Bay Area Commuter Benefits Program (14-1)	3/19/14	0.01	0.02	0	*a.*	12,714
Particulate Emissions from Refinery Fluidized Catalytic Cracking Units (6-5)	12/16/15	*a.*	*a.*	0.61	*a.*	*a.*
Equipment Leaks (8-18)	12/16/15	3.36	*a.*	*a.*	*a.*	*a.*
Cooling Towers (11-10)	12/16/15	2.36	*a.*	*a.*	*a.*	*a.*
Petroleum Refining Emissions Tracking (12-15)	4/20/16	*b.*	*b.*	*b.*	*b.*	*b.*

a. Rule does not reduce pollutant, or reduces only a nominal amount of pollutant.
b. Rule is designed to enhance enforcement, not further reduce emissions.

Mobile Source Measures

The 2010 Clean Air Plan included 10 mobile source measures. Mobile source measures were intended to promote lower emission vehicles and equipment. Eight of those measures have continued forward in the 2017 control strategy. Although the measure descriptions and numbering have been updated, continuing measures include:

- MSM-A1: Promote Clean, Fuel Efficient Light- and Medium-Duty Vehicles
- MSM-A2: Zero-Emission Vehicles and Plug-In Hybrids
- MSM-A4: Replacement or Repair of High Emission Vehicles

- MSM-B1: Fleet Modernization for Medium- and Heavy-Duty On-Road Vehicles
- MSM-B2: Low NO_x Retrofits in Heavy-Duty, On-Road Vehicles
- MSM-B3: Efficient Drive Trains
- MSM-C1: Construction and Farming Equipment
- MSM-C2: Lawn and Garden Equipment

Mobile source measures A1, A2, and A4 addressed replacing traditional cars and light trucks that have internal combustion engines with either hybrid or zero emission electric engines. These efforts are ongoing and will continue in the 2017 Plan via marketing, planning and funding for both electric vehicles (EVs) and EV infrastructure.

Mobile source measures B1, B2, and B3 addressed various funding programs and projects to accelerate compliance with ARB regulations to reduce emissions from medium and heavy-duty trucks. These measures are in the 2017 control strategy as TR19: Medium- and Heavy-Duty Trucks.

Green Fleets and Recreational Watercraft (MSM-A3 and MSM-C3) are not carried forward into the 2017 control strategy. The Air District has incorporated GHG reduction criteria into its various grant programs. Further work to direct incentives toward EVs is carried forward in the 2017 control strategy in TR14: Cars and Light Trucks. An incentive program to replace older, two-stroke marine outboard engines with low-emission, four-stroke engines will be revisited when funding becomes available.

Details regarding implementation activities on each of the 2010 mobile source measures during 2010 through 2016 may be found in Appendix F.

Transportation Control Measures

The 2010 Clean Air Plan included 17 transportation control measures. The measures were designed to encourage walking, bicycling, and transit use, improve transit service, improve efficiency of the regional roadway system, support infill development, and develop pricing strategies. Virtually all of the 2010 transportation measures are carried forward

into the 2017 control strategy, although the measure descriptions and numbering have been updated.

Details regarding implementation activities on each of the 2010 transportation control measures during 2010 through 2016 may be found in Appendix F.

Land Use and Local Impacts Measures

The 2010 Clean Air Plan included a new category of control measures, Land Use and Local Impacts. There were six measures in this category designed to promote mixed-use, infill development to reduce motor vehicle travel and emissions, as well as to protect people from exposure to air pollution from stationary and mobile sources of emissions, especially in communities most heavily impacted by air pollution. All six of these measures continue forward in the 2017 control strategy as follows:

- LUM1: Goods Movement as TR18
- LUM2: Indirect Source Review Rule as TR16

- LUM6: Enhanced Air Quality Monitoring as SS38
- LUM3: Updated CEQA Guidelines and Enhanced CEQA Review, LUM4: Land Use Guidance, and LUM5: Monitor Health Risks in Local Communities were combined into TR10: Land Use Strategies.

Details regarding implementation activities on each of the 2010 land use and local impacts control measures during 2010 through 2016 may be found in Appendix F.

Energy and Climate Measures

The 2010 Clean Air Plan included a new category of measures designed to reduce criteria pollutants and GHG emissions, known as Energy & Climate Measures (ECMs). The ECMs were designed to promote energy conservation and efficiency in new homes, schools, and commercial buildings. These measures were also designed to promote renewable energy, reduce the urban heat island effect, and promote planting of tree species with low emissions of volatile organic compounds (VOCs).

Since 2010, Air District staff has facilitated information-sharing among local governments developing climate action plans and implementing GHG reduction strategies. Air District staff worked with staff at Lawrence Berkeley National Laboratory (LBNL) to develop and promote the benefits of reflective pavement for local government planners and public works staff, cement and asphalt companies and researchers. Air District staff participated in an LBNL working group to develop a “cool schoolyards” program for cool paving. Further details regarding additional implementation activities on each of the 2010 energy and climate control measures during 2010 through 2016 may be found in Appendix F. All four ECMs in the 2010 Plan are carried forward in the 2017 Plan, as described in Appendix F.

Further Study Measures

Eighteen further study measures were identified for the 2010 Clean Air Plan. These measures appeared to have sufficient merit to warrant further research, but were not yet ready to be proposed as formal control measures. Many of the 2010 further study measures (10 of the 18) are now in the 2017 control strategy as formal control measures. Three measures are continuing in the 2017 control strategy as further study measures. Four measures, Emissions from Cooling Towers, Equipment Leaks, SO_2 from Refinery Processes, and Wood Smoke (FSM4, FSM5, FSM7 and FSM12) have been adopted as new Air District regulations—see Table 4-2. Three of these (FSM4, FSM5 and FSM12) will have further regulatory components and therefore are carried forward in the 2017 control strategy.

Three 2010 further study measures, FSM6: Wastewater From Coke Cutting, FSM11: Magnet Source Rule, and FSM17: Ferry System Expansion, are not carried forward into the 2017 Plan. For FSM6, Air District staff analyzed emission reduction opportunities for coke cutting operations and determined that facilities are already operating in such a way that the emissions are minimized to the extent technically feasible. The concepts in FSM11 are incorporated in the transportation sector control measure TR16: Indirect Source Rule. Issues raised in the Ferry System Expansion further study measure continue to be addressed in the 2017 measure TR21: Commercial Harbor Craft, which includes Air District programs to ensure new ferries meet ARB’s stringent engine standards.

Details regarding additional implementation activities on each of the 2010 further study measures may be found in Appendix F.

Air District Programs that Provide Foundation for the 2017 Plan

The 2017 Plan builds upon well-established Air District programs, including regulation, permitting and enforcement of stationary sources, air quality monitoring, public outreach and education, work with local governments, and grants and incentives. In addition to these core programs, the Air District has developed new programs and initiatives in recent years to respond to the challenges of protecting public health and protecting the climate. The section below summarizes the Air District's recent efforts to protect public health and protect the climate.

Protecting Public Health

Protecting public health, at the regional scale and in the communities most impacted by air pollution, is the Air District's fundamental mission and one of the key goals of the 2017 Plan. The Air District's efforts to protect the communities and populations most impacted by air pollution include:

- The Community Air Risk Evaluation (CARE) program to identify and support communities with higher pollution exposure and health vulnerabilities;
- Multi-pollutant control strategy to reduce air pollution and related health impacts, regionally and locally;
- The Bay Area refinery emission reduction strategy;
- Grants and incentives programs to reduce emissions from key sectors such as seaports and goods movement;
- The Mobile Source Compliance Plan to enforce ARB regulations to reduce emissions from diesel engines in impacted Bay Area communities;
- The Wood Burning Rule that bans burning when a *Winter Spare the Air Alert* is in effect; and
- The *Planning Healthy Places* guidance document, a resource to ensure that local land use planning and new development are designed so as to protect public health.

Community Air Risk Evaluation Program

In 2004, the Air District initiated the Community Air Risk Evaluation (CARE) program to evaluate and reduce health risks associated with local exposures to toxic air contaminants in the Bay Area.[1] Subsequently, the CARE program's focus expanded to include exposure to fine particles and ozone. The program analyzes emissions of TAC, PM and ozone precursors from point sources, area sources and on-road and off-road mobile sources, with an emphasis on reducing population exposure to diesel exhaust. CARE combines technical analyses, outreach to impacted communities, and policy mechanisms to reduce emissions and health risks in those communities. The technical analyses portion of the CARE program includes an assessment of the sources of air toxics and other pollutant emissions, modeling and monitoring to estimate concentrations of air toxics and other pollutant emissions, and an assessment of exposures and health risks and mapping of the most impacted communities. Information derived from the technical analyses is used to focus emission reduction strategies in areas with high air pollution exposures and high density of sensitive populations. The main policy goals of the program are to:

- Utilize the Air District's wide range of tools and resources, including regulations and guidance, air quality monitoring, public outreach and community dialogue, targeted grant funding, enforcement of diesel air toxics control measures, and collaboration with county health departments and other local agencies to address health impacts from air pollution;
- Identify locations within the Bay Area where air pollution is most contributing to health impacts and where populations are most vulnerable to air pollution impacts;
- Design and focus effective mitigation measures in areas with highest impacts; and
- Engage communities and stakeholder groups in the program and develop productive

relationships with local agencies to craft mitigation measures that extend beyond what the Air District could do alone.

For additional information on the CARE program, see the report entitled *Improving Air Quality and Health in Bay Area Communities*.[2] Maps of communities impacted by air pollution, generated through the CARE program, are being integrated into many of the Air District's programs. The maps, along with information about pollutants and their sources that lead to the impacts, help prioritize a broad array of actions designed to foster healthy communities.

Programs to Reduce Emissions from Stationary Sources

Key elements of the Air District's program to reduce emissions from stationary sources are briefly described below.

- **Rule Development:** The Air District develops regulations to improve air quality, protect public health, and protect the climate based on control measures identified in the Clean Air Plan. In developing or amending rules to reduce emissions from stationary sources, Air District staff perform technical research, analyze cost effectiveness, engage with affected stakeholders, hold public meetings to solicit input from interested parties such as industries and communities, and prepare environmental (CEQA) and socioeconomic analyses for each newly proposed rule. Once adopted by the Board of Directors, new or amended rules are enforced via the Air District's Permit and Compliance and Enforcement programs.

- **Compliance and Enforcement:** The Air District routinely inspects and audits various facilities and operations to ensure compliance with air quality laws and regulations. The Air District may inspect refineries, chemical plants, semiconductor manufacturing facilities, dry cleaners, ink and coating operations, gasoline dispensing facilities, asbestos demolition and renovation, and any operation or activity that can result in air pollution. The Air District also investigates residents' complaints about air pollution. Inspectors determine whether the pollutant source is operating in compliance with relevant rules and regulations.

- **New Source Review:** The Air District's New Source Review (NSR) program is a comprehensive air quality permitting program that applies to a wide-range of stationary source facilities within the Air District's regulatory jurisdiction. The program requires a facility to obtain a permit and implement state-of-the-art air pollution control technology whenever a facility installs a new source of emissions or makes a modification to an existing source. The Air District's NSR program is set out in Regulation 2, Rule 2 and Regulation 2, Rule 5. Regulation 2, Rule 2 is the Air District's fundamental permitting requirement for regulating criteria pollutant emissions. It requires facilities to obtain an NSR permit for any new or "modified" source of air emissions, and to satisfy a number of air pollution control requirements in order to be eligible for the permit.

  Regulation 2, Rule 5, outlines permitting requirements for regulating toxic air contaminants. Rule 2-5 requires new or modified emissions sources to perform health risk screening analysis for TACs and to utilize Best Available Control Technology to reduce emissions of TACs. The Air District amended Regulation 2, Rule 5 in December 2016 to incorporate new and revised TAC emission rate trigger levels and other elements in its health risk assessment (HRA) requirements pursuant to revised HRA guidelines issued by CalEPA's Office of Environmental Health Hazard Assessment (OEHHA). The revised rule will increase the stringency of the Air District's NSR Program to reduce health risks from TACs.[3]

- **TACs Hot Spots Program:** The Air Toxics "Hot Spots" Information and Assessment Act (AB 2588) is a state program implemented by regional air districts in California. Pursuant to AB 2588 (1987) and SB 1731 (1992), facilities were required to provide information about their TAC emissions, and facilities that pose a significant risk were required to develop and implement site-specific risk reduction plans and audits.

- **Draft Rule 11-18:** As noted above, in December 2016 the Air District amended Rule 2-5 to apply the revised, more stringent OEHHA guidelines for the purpose of assessing TAC risk from new or modified emissions sources. To enhance its program to reduce health risks from emissions of TACs at existing sources, the Air District is developing a new rule, Rule 11-18. The proposed draft rule, to be considered by the Air District Board of Directors in spring 2017, would apply the revised OEHHA guidelines for the purpose of assessing risk from TACs from existing sources. For additional information, see proposed control measure SS20 in Chapter 5.

Bay Area Refinery Emissions Reduction Strategy

The San Francisco Bay Area has five major oil refineries that produce air pollution and GHGs. Oil refineries are subject to more than 20 specific Air District regulations and programs. Emissions of most pollutants from refineries have been steadily decreasing over the past several decades. Despite this progress, the refineries are major sources of criteria air pollutants, TACs and GHGs.

In October 2014, the Air District Board of Directors adopted a *Refinery Emissions Reduction Resolution,* which established a goal of reducing refinery criteria air pollutant emissions by 20 percent, or as much as feasible, by 2020. In response to that directive, the Air District has developed a Bay Area Refinery Emissions Reduction Strategy. The Refinery Strategy ensures that refineries are taking the strongest feasible steps to reduce emissions and minimize their health impacts on neighboring residents and the region as a whole.

> *Emissions of most pollutants from refineries have been steadily decreasing over the past several decades.*

The Refinery Strategy involves five components:

1. **Overall Goals:** Achieve a 20 percent reduction in criteria air pollutants from refineries by 2020, as well as a 20 percent reduction in health risk to local communities.
2. **Reduction of Criteria Pollutants:** Under a focused Best Available Retrofit Control Technology program, investigate significant sources at refineries and pursue a variety of additional pollution controls at these sources.
3. **Reduction of Health Risks from Toxic Air Pollution:** Explore requirements and adopt rules that reduce toxic emissions from key refinery sources. Include site-wide Health Risk Assessments and the identification of sources for further emission controls, using health benefits as an important evaluative tool in future rulemaking.
4. **Evaluation of GHG emissions:** Track emission reductions at refineries incurred as a result of the Cap-and-Trade system under AB 32.
5. **Continuous improvement:** To ensure continuous improvement in emission reductions, refineries could be required to periodically evaluate the sources of the majority of their emissions in order to determine if additional pollution controls are needed.

Progress on the Refinery Strategy includes the adoption of five rules, and one that is currently being developed. Three rules were adopted in December 2015, Particulate Emissions from Refinery Fluidized Catalytic Cracking Units (Reg. 6, Rule 5), Equipment Leaks (Reg. 8, Rule 18) and Cooling Towers (Reg. 11, Rule 10). Two rules were adopted in April 2016. The Petroleum Refining Emissions Tracking rule (Reg. 12, Rule 15) mandates improved reporting of emissions inventories, tracking of crude slate changes, and improved real-time monitoring of emissions at refinery fencelines in order to protect local communities. The Petroleum Coke Calcining Operations rule (Reg. 9, Rule 14) will reduce emissions of sulfur dioxide from coke calcining. Other rules under development to reduce refinery emissions are summarized in the 2017 control strategy, as described in Chapter 5.

Grant and Incentive Programs

The Air District operates several programs that provide grants and incentives for projects to provide "surplus" emission reductions, i.e., reductions in advance of, or over and above, regulatory requirements or standards. Key grant programs are summarized in Table 4-3.

The Air District awarded approximately $285 million in grants during the six-year period from January 2010 through December 2015. In aggregate, these projects achieved estimated emission reductions of approximately 1,700 tons of ROG, 16,400 tons of NO_X, 830 tons of PM, and nearly 300,000 tons of CO_2e over the project term (useful life), which was used to evaluate cost-effectiveness for these projects.[4]

Table 4-3. **Grant Funding Programs and Eligible Project Types**

Grant Program	Eligible Equipment/Projects
Transportation Fund for Clean Air	• Shuttles and Regional Rideshare Services • Bicycle Parking and Bikeways • Zero and Near-Zero On-Road Vehicles • Electric Vehicle Charging Stations • Hydrogen and Compressed Natural Gas Fueling Stations • Light-Duty Vehicle Buy Back
Carl Moyer Program	• On-Road Heavy-Duty Vehicles • Off-Road Equipment • Marine Engines • Shore-Power for Ships • Agricultural Equipment
Goods Movement Diesel Emission Reduction Program	• Drayage Trucks • Other Trucks • Shore-Power for Ships • Cargo Handling Equipment • Locomotives • Marine Engines
Lower-Emission School Bus Program	• School Buses

One of the most direct, effective, and tangible ways to reduce emissions and population exposure in communities that are disproportionately impacted by air pollution is to replace or retrofit dirty engines and vehicles that operate in these communities. The Air District has made a commitment to focus its grant funds on projects in impacted communities. Over the past six years, approximately 60 percent of the Air District's grant funds have been directed to impacted communities. Table 4-4 summarizes the funding awarded to projects in impacted communities over the past six funding cycles and the emissions reduced over each project's useful life. As discussed in more detail in the "Reducing Emissions from Seaports and Goods Movement" section below, the grants provided to reduce emissions from trucks and ships in Bay Area ports have been highly effective in reducing population exposure to air pollution in the adjacent communities. Table 4-5 summarizes the funding awarded for projects in other, less heavily-impacted communities and the emission reductions for the same time period.

Table 4-4. Emissions Reduced Through Grants to Projects in Impacted Communities, 2010–2015

	Tons Reduced[a]				
Project Type	ROG	NO_x	PM	CO_2	Funding Amount
Light-Duty Vehicles	2.1	1.7	0.4	240.2	$1,728,255
Vehicle Buy Back	932.5	1,061.8	9.4	*b.*	$18,927,931
Shuttle and Rideshare Services	151.3	148.5	129.1	140,620.7	$18,375,785
Bicycle Parking and Bikeways	6.7	5.6	4.2	1,125.6	$2,589,929
On-Road Trucks and Buses	6.7	3,525.1	108.2	*b.*	$40,929,800
On-Road Trucks (Ports)	*b.*	3,411.4	177.2	*b.*	$37,841,975
Off-Road/AG	16.8	118.2	5.6	*b.*	$3,740,381
Locomotive	17.5	377.0	4.4	*b.*	$3,015,850
Marine	18.2	1,521.3	48.2	*b.*	$14,246,623
Shore Power	18.6	4,243.9	180.9	*b.*	$26,630,048
School Buses	*b*	*b.*	*b.*	*b.*	$10,835,004
Total	**1,170**	**14,415**	**668**	**141,986**	**$178,861,582**

a. Emission reductions are total tons reduced over the "lifetime" of a project. Lifetime means the useful life, which is used to evaluate cost-effectiveness for those projects and the term varies by project type, i.e. it can be one year for a shuttle project, and 10 or 15 years for a bicycle project.

b. Projects where emission reductions were achieved but not calculated due to lack of data.

Table 4-5. Emissions Reduced Through Grants to Projects Not in Impacted Communities, 2010–2015

	Tons Reduced[a]				
Project Type	**ROG**	**NO_x**	**PM**	**CO_2**	**Funding Amount**
Light-Duty Vehicles	27.6	152.7	6.8	4,635.7	$10,057,772
Vehicle Buy Back	250.4	279.7	2.4	*b.*	$12,184,512
Fueling/Charging Stations	0.2	4.6	0.0	608.1	$74,961
Shuttle and Rideshare Services	5.3	*b.*	4.4	2,102.7	$2,056,922
Bicycle Parking and Bikeways	2.1	1.4	1.2	1,450.8	$632,919
On Road Trucks and Buses	4.5	216.8	6.8	4,174.9	$4,475,677
Off Road/AG	191.4	1,197.0	63.9	*b.*	$35,473,772
Marine	0.5	18.5	0.7	*b.*	$440,828
School Buses	*b.*	*b.*	*b.*	*b.*	$34,955,069
Spare the Air	77.8	90.6	81.1	143,070.3	5,510,346
Total	**560**	**1,959**	**167**	**156,043**	**$105,862,778**

a. Emission reductions are total tons reduced over the “lifetime” of a project. Lifetime means the useful life, which is used to evaluate cost-effectiveness for those projects and the term varies by project type, i.e. it can be one year for a shuttle project, and 10 or 15 years for a bicycle project.

b. Projects where emission reductions were achieved but not calculated due to lack of data.

Electrification of the Bay Area Fleet

As discussed in Chapter 5, decarbonizing the motor vehicle fleet by transitioning to electric vehicles (EVs) and other zero- or near-zero-emission technologies is an essential element of the 2017 Plan. Replacing gasoline and diesel vehicles with EVs will help the region to achieve air quality standards and GHG emission reduction targets, as well as help to reduce toxic air contaminants. In August 2010, the Air District’s Board of Directors authorized a $5 million investment to spur the adoption of EVs that resulted in the installation of approximately 1,500 residential home charging stations and 200 publicly available Level 2 charging stations. To ensure that the region was well prepared for the mass-market deployment of EVs, the Air District adopted the Bay Area Plug-In Electric Vehicle (PEV) Readiness Plan in 2013.

The Readiness Plan identifies EV adoption goals of 110,000 EVs on Bay Area roads by 2020, and 247,000 by 2025. The Plan also outlines a series of strategies to help accelerate the transition to EVs and identifies opportunities for focusing the Air District's incentive funds to meet these ambitious vehicle targets. Following the adoption of the PEV Readiness Plan, the Air District's Board of Directors committed an additional $15 million to accelerate the deployment of new light-, medium-, and heavy-duty vehicles and buses; EV charging infrastructure; and outreach initiatives to increase the visibility of electric vehicles.

By the end of October 2015, there were approximately 60,000 EVs registered to Bay Area drivers, exceeding the interim goals of the Readiness Plan.

Reducing Emissions from Seaports and Goods Movement

Goods movement activities are a major source of emissions in impacted communities identified in the CARE program and along major freeways. Therefore, reducing emissions from seaports and the goods movement sector has been a major focus of Air District efforts in recent years. To provide a technical foundation, the Air District developed detailed emissions inventories for each of the five Bay Area seaports.[5] Based on these inventories, the Air District has prioritized reducing emissions at the Port of Oakland, the fifth largest port in the United States, with a large environmentally disadvantaged community adjacent to the port. The Air District also works to achieve emission reductions at the other Bay Area ports.

Improvements have been made from all of the major port emissions sources over the past eight years.

Since 2009, the Air District has invested approximately $100 million from the Goods Movement Program and other Air District programs to reduce emissions and health risks from freight movement along the Bay Area's highest travelled trade corridors. These funds came from a combination of sources: state funding, federal funding, local Air District funding, and funding from the Port of Oakland. The majority of the funding for this effort was provided by the ARB Proposition 1B Goods Movement Bond Program (I-Bond), which was approved in 2006 by California voters who authorized the Legislature to appropriate $1 billion in bond funding to reduce air pollution and health risk.

The Air District primarily has used these funds to reduce emissions in and around the Port of Oakland and the region's major trade corridors. These funds have reduced truck emissions from thousands of heavy-duty diesel powered trucks (via retrofit or replacement), and supported shore power projects at 12 berths at the Port of Oakland. Studies have confirmed regulations, incentives, enforcement and monitoring efforts, and local actions have combined to make significant reductions in emissions from mobile sources at the Port of Oakland. Improvements have been made from all the major port emissions sources over the past eight years. The recent success in reducing emissions at the Port is a direct result of the collaboration of regulatory agencies, businesses and community groups.

Despite this progress, additional action will be needed to continue improving air quality in the communities surrounding the Port of Oakland. Opportunities for continued air quality improvement include: taking action to move goods more efficiently and with zero (or near-zero) emissions; transitioning to cleaner, renewable transportation energy sources; providing reliable speed at which goods move and expanded system capacity; and improving integration with national and international freight transportation systems.

Moving forward, the Air District expects to provide an additional $48.1 million to further reduce emissions from goods movement activities. This funding consists of $40.1 million in new funding from ARB (Year 5 I-Bond program) and approximately $8 million remaining from previous I-Bond grant awards. The Air District began to award these funds in 2016 to the following project equipment categories:

- **Heavy-duty diesel trucks:** $25.1 million for truck projects to upgrade more than 500 older diesel trucks to zero-emission vehicles, hybrid vehicles that are capable of zero-emission miles, or vehicles certified to the lowest optional NO_x emissions standard. This funding is designed to achieve early or extra emission reductions by assisting small truck fleets with upgrading to cleaner technology than required by the ARB Truck & Bus Regulation. These funds are estimated to reduce 3,577 tons of NO_x over the lifespan of the projects and will continue to reduce the health risk in communities throughout the region, especially those near freeways and freight facilities.

- **Locomotives and railyards:** $15 million for locomotive and railyard projects to upgrade engines to meet the most stringent national emission standards (Tier 4). This funding will replace approximately seven locomotives, and is estimated to reduce 64 tons of PM and 1,062 tons of NO_x over the lifespan of the funded projects. These projects will further reduce the health risks near railyards.

- **Transportation refrigeration units (TRU):** $3 million to upgrade approximately 66 TRUs. These funds are estimated to reduce 3 tons of PM and 106 tons of NO_x over the lifespan of the funded projects.

- **Ships at berth and cargo handling equipment:** $5 million to upgrade four pieces of cargo-handling equipment. These funds are estimated to reduce 3 tons of PM and 296 tons of NO_x over the lifespan of the funded projects.

From 2017 through 2024, the Air District expects to provide approximately $288 million for additional projects to reduce emissions of air pollutants and GHGs in the Bay Area through grant programs that it directly administers. In addition, the region may receive a significant amount of funding from the California Cap-and-Trade Program, assuming that the program is extended beyond 2020. Cap-and-Trade funds could provide significant capital to spur the innovation and growth in clean technology needed to achieve the 2050 vision for a post-carbon Bay Area.

Mobile Source Compliance Plan

The Air Resources Board has primary responsibility for enforcing its mobile source regulations. However, ARB's diesel PM Air Toxic Control Measures (ATCMs) allow air districts to help enforce these regulations. In Fall 2009, the Air District initiated a Mobile Source Compliance Plan (MSCP) based on a Memorandum of Understanding (MOU) between the Air District and ARB which defines the roles and responsibilities of each agency. The Air District is the first air district in California to enter into a comprehensive mobile source enforcement partnership agreement with ARB.

The MSCP lays out the Air District's comprehensive strategy for enforcement of specified ARB ATCMs and related mobile source statutes and/or agreements. The goal of the MSCP is to reduce diesel PM health risk in disadvantaged communities, with special focus on the Port of Oakland and West Oakland, using a robust enforcement program. The initial focus of the MSCP was to provide a strong enforcement presence at the Port of Oakland to ensure compliance with the Drayage Truck

The Air District has been implementing and strengthening its efforts to reduce wood smoke over the past two decades...

Rule compliance deadline of January 1, 2010. By demonstrating leadership on mobile source enforcement, the MSCP reduces diesel PM exposures and improves air quality in the communities that the Air District serves.

Reducing PM from Wood Smoke

As described in Chapter 2, residential wood burning poses health risks for Bay Area residents. Wood smoke is a major component of PM in the Bay Area, especially on winter days when exceedances of the 24-hour $PM_{2.5}$ standard are most likely to occur. Reducing emissions from wood burning is therefore a key component of the Air District's efforts to reduce PM levels in the Bay Area. The Air District has been implementing and strengthening its efforts to reduce wood smoke over the past two decades, as described below.

Public education and voluntary compliance were the early foundation of the Air District's efforts to reduce wood burning. The Air District began implementing its *Winter Spare the Air* program in 1991, requesting that Bay Area residents voluntarily curtail wood burning on days when an exceedance of PM standards is forecast.

In 1998, the Air District developed a model wood smoke ordinance for fireplaces and woodstoves as a guidance document for cities and counties to regulate sources of PM in their communities. In 2012, the Air District developed a new model ordinance that includes an extensive menu of options for reducing neighborhood wood smoke. To date, wood smoke ordinances have been adopted in at least 41 Bay Area cities and eight counties which encompass a large percentage of the region's population.

In 2006, the U.S. EPA significantly strengthened the national 24-hour $PM_{2.5}$ standard, reducing the standard from 65 to 35 µg/m^3. In July 2008, recognizing the need to more aggressively reduce PM from wood smoke, especially on days when the region is likely to exceed the standard, the Air District adopted Regulation 6, Rule 3: Wood Burning Devices. The Air District also amended Regulation 5, its open burning rule, to prohibit outdoor recreational fires during periods of elevated $PM_{2.5}$ levels. In addition, the Air District enhanced and expanded its wood smoke public outreach and education program, and lowered the threshold for when to issue *Winter Spare the Air Alerts* to conform to the national standard. To further protect public health, the Air District amended Regulation 6, Rule 3: Wood Burning Devices in October 2015. The new amendments tighten exemptions and requirements in the original rule.[6] In addition to the rule amendments, the Air District launched an incentive program to encourage Bay Area residents to remove fireplaces and wood stoves, or to replace them with cleaner devices.[7]

Summary of Wood Burning Rule

Key provisions of Regulation 6, Rule 3 include the following:

- Prohibits operation of any indoor fireplace, fire pit, wood or pellet stove or fireplace insert on specific days during the winter when the Air District forecasts that $PM_{2.5}$ levels may exceed the 35 µg/m^3 national 24-hour $PM_{2.5}$ standard. The rule provides limited exemptions from this provision for households whose sole source of heat is a wood burning device, or in the event of an interruption in gas or electrical service.

- Requires cleaner burning technology when wood burning devices are sold or resold or installed.
- Prohibits the burning of garbage, non-seasoned wood, plastics, and other inappropriate types of materials.
- Requires labeling and disclosure of the moisture content in wood sold for use within the boundaries of the Air District.
- Requires a label on packages of wood and other solid fuels (such as compressed logs and pellets) instructing the user to check local air quality status before burning these products.

Key amendments effective November 1, 2016:

- No wood burning devices may be installed in new building construction.
- Households applying for a Sole Source Heat Exemption must replace their wood burning device to an EPA-certified wood burning device.

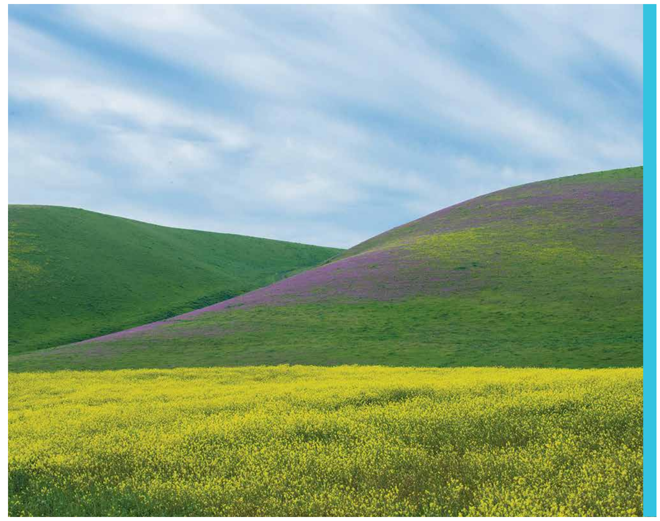
Key amendments effective November 1, 2018:

- Rental properties in areas with natural gas service will be required to install a source of heat that does not burn wood.
- Rental properties in areas with natural gas service may no longer qualify for a Sole Source Heat Exemption.

Wood Smoke Reduction Incentive Program: In August 2016, the Air District launched a Wood Smoke Reduction Incentive Program. The program allocates $3 million in funding to help Bay Area homeowners and landlords replace their wood burning fireplaces and wood stoves with cleaner heating options. To promote social equity and ensure that families at all income levels can participate in this program, "highly impacted residents" can qualify for larger incentives based upon financial need as well as the level of wood smoke in their community.

Protecting the Climate

In 2005, the Air District launched its Climate Protection Program. Since then, we have achieved many "firsts." The Air District developed the first



GHG inventory for a major metropolitan region; adopted the first GHG fee on industrial and commercial sources; and became one of the largest climate funders in the nation when we implemented a $3 million climate protection grant program in 2007. A reinvigoration of the program in 2013 included adopting an aggressive goal of reducing greenhouse gas emissions in the Bay Area 80 percent below 1990 levels by 2050, and launched the regional climate protection strategy work reflected in this plan. Key Air District climate protection programs and activities are described below.

Demonstrating Climate Leadership for the Region and State

Since establishing a Climate Protection Program in June 2005, the Air District has worked to integrate climate protection into all its core functions and initiated innovative climate protection efforts. Through its regulatory functions, in 2008 the Air District became the first local air district in the nation to impose a cost-recovery fee on stationary sources of GHGs, to defray the costs of the Air District's climate protection work related to these sources. Industrial facilities and businesses currently subject to Air District permit requirements pay a fee of $0.096 per metric ton of GHG emissions. As a regional planning agency, the Air District also developed the first recommended thresholds of significance for GHG emissions under the California Environmental Quality Act. And as a science-based institution, the Air District is becoming the first regulatory agency to establish a fixed-site network for monitoring regional GHG emissions on the West Coast.

Issuing Grants and Incentives

Through the Climate Protection Program, the Air District has issued the following grants and incentives:

- Investing approximately $240 million to reduce GHGs and air pollutants through mobile source grants and incentives.
- Awarding $3 million in grants to 53 local projects to reduce GHG emissions. The innovative grant program funded the development of local climate action plans, and also provided seed funding for municipal energy officers, renewable energy programs and youth-based projects.
- Launching the Greenhouse Gas Reduction Grant Program in 2009, using $4.4 million in funds generated by a settlement between the California Attorney General's Office and ConocoPhillips, for projects that reduce GHG emissions in the communities nearest the ConocoPhillips refinery: Rodeo, Crockett, Hercules and Pinole. The proceeds from the settlement were used to fund energy efficiency, cool roofs and onsite renewable energy projects at public facilities.
- Providing seed funding to jump-start game-changing initiatives including the first Community Choice Energy (CCE) program in California, Marin Clean Energy; and the first Property-Assessed Clean Energy (PACE) program, BerkeleyFirst.

Developing a Regional GHG Emissions Inventory

In 2006, the Air District became the first local air district in the nation to develop a detailed regional GHG emissions inventory. The inventory is updated regularly with new methodologies and sources. In addition, the Air District worked with UC Berkeley's Cool Climate Program to develop a consumption-based GHG emissions inventory for the Bay Area.

Providing Technical Assistance to Local Governments

Local governments play a critical role in enacting on-the-ground policies and programs that reduce GHG emissions, and are thus key partners in implementing the Air District's Climate Protection Program. The Air District provides extensive technical assistance to local governments in developing community-wide GHG inventories and local climate action plans and programs. The Air District also provides a variety of assistance to help local governments implement their climate action plans.

- Guidance and training to assist with community-wide GHG inventories and developing climate action plans,
- Review and feedback on draft inventories and climate action plans,
- Tools and data to increase knowledge of local GHG emissions and impacts from local policies,
- Regional and sub-regional events to share best practices and case studies, and
- Connections between state and federal agencies and local governments to facilitate policy development and funding.

The Air District has developed a tool, in collaboration with MTC, to deliver motor vehicle travel data directly to local governments for use in community GHG emissions inventories.

Serving as Regional Convener for Climate Action

In November 2006, the Air District convened a Bay Area-wide summit on climate protection. The event was attended by over 500 local leaders from government, education, youth, business, research and the non-profit community and set the stage for wide-spread collaboration and action. Another summit was convened in May 2009 for over 400 local government planners and elected officials. Most recently, in October 2016, the Air District convened a regional summit on climate innovation and leadership entitled *Climate Forward Bay Area:*

A Leadership Forum. The forum brought together leaders from technology, business, environmental and community groups, and public agencies to share ideas and approaches on reducing Bay Area GHG emissions while advancing economic development. The Air District has also organized multiple smaller-scale events, partnering with state agencies, local governments and other air districts.

In addition, the Air District works closely with its regional agency partners—MTC, the Association of Bay Area Governments (ABAG) and the Bay Conservation and Development Commission (BCDC)—along with local governments, business groups, community organizations, and other stakeholders to reduce emissions of GHGs in the Bay Area.

External Policies, Plans and Programs that Complement the 2017 Plan

Numerous state, regional and local policies, plans and programs complement and reinforce the 2017 Plan. Working together, these plans provide an integrated air quality and climate protection framework for the Bay Area. Key state policies and programs are described below.

State Policies, Plans and Programs

State Climate Protection Legislation

In September 2006, Governor Schwarzenegger signed Assembly Bill 32, the Global Warming Solutions Act, establishing a statewide target of reducing GHG emissions to 1990 levels by 2020. This Act required ARB to prepare a “scoping plan” to lay out how the state will achieve these reductions. Since then, additional legislation has been enacted to authorize and guide the state’s climate protection efforts. These bills include:

- Senate Bill 605 (2014) directed the Air Resources Board to develop a statewide Short-Lived Climate Pollutant (SLCP) reduction strategy.[8]
- Senate Bill 350 (2015) increased the requirement for utilities to procure electricity from renewable sources to 50 percent by 2030.

- Senate Bill 32 (2016) established a new target to reduce GHG emissions 40 percent below 1990 levels by 2030.
- Senate Bill 1383 (2016) established targets to reduce emissions of super-GHGs, with a target of reducing methane and hydrofluorocarbon emissions 40 percent below 2013 levels by 2030 and reducing black carbon emissions 50 percent below 2013 levels by 2030.
- Assembly Bill 197 (2016) requires the Air Resources Board to make available an annual report of GHG, criteria pollutant and toxic air contaminants emissions for each facility that is required to report these emissions.
- Assembly Bill 2722 (2016) requires the Strategic Growth Council to award competitive grants to eligible entities for the development and implementation of neighborhood-level transformative climate community plans that provide local economic, environmental, and health benefits to disadvantaged communities.

Assembly Bill 32 Scoping Plan

The AB 32 Scoping Plan, adopted by the ARB Board in December 2008, set forth the main strategies California would pursue to meet the 2020 climate protection goal.

The first update to the Scoping Plan was approved by ARB in May 2014. It highlights California’s progress toward meeting the “near-term” 2020 GHG emission reduction goal defined in the initial Scoping Plan, and defines ARB’s climate change priorities through 2030. The 2014 update also lays the groundwork to reach long-term goals set forth in Executive Orders S-3-05 and B-16-2012.[9] The

Transportation accounts for some 40 percent of GHG emissions in California, with cars and light-duty trucks accounting for almost three-quarters of those emissions...

Scoping Plan Update uses a framework that assesses policy opportunities across major economic sectors and recommends specific GHG emission reduction strategies for each sector. The sectors include energy, transportation, agriculture, water, waste management, natural and working lands, short-lived climate pollutants, green buildings, and the Cap-and-Trade Program. The Air District is using the same economic sector framework for the purpose of defining the control strategy in the 2017 Plan. ARB is currently in the process of preparing a second update to the Scoping Plan to address the requirements of SB 32 and the target of reducing GHG emissions by 40 percent below 1990 levels by 2030. ARB issued a proposed revised Scoping Plan for public review in January 2017.

Short-Lived Climate Pollutant Strategy

The Air Resources Board adopted a statewide Short-Lived Climate Pollutant (SLCP) Reduction Strategy in March 2017. The strategy establishes targets to reduce emissions of climate pollutants with high global warming potential such as methane, black carbon, and fluorinated gases. (The Air District refers to these climate pollutants as "super-GHGs" and highlights the importance of reducing their emissions in our regional climate protection strategy.)

To help implement the SLCP strategy, ARB adopted regulations in March 2017 to reduce methane emissions from the production and distribution of oil and natural gas.[10] This regulation affects onshore and offshore crude oil and natural gas production, processing and storage; natural gas underground storage; and natural gas transmission compressor stations. The regulation addresses fugitive and vented methane emissions from new and existing operations.

Senate Bill 375

Transportation accounts for some 40 percent of GHG emissions in California, with cars and light-duty trucks accounting for almost three-quarters of those emissions, with similar percentages in the Bay Area. SB 375 (Steinberg, 2008), directed ARB to set regional targets for the reduction of GHG emissions from cars and light-duty trucks. The legislation also calls for the state's 18 major metropolitan planning organizations (MPOs) to develop strategies to meet these goals in their long-term transportation plans via a new element of the plan, called the "Sustainable Communities Strategy (SCS)." In addition, SB 375 requires that regions house all of their projected population, by income level, without displacing current low-income residents.

In 2011, ARB set GHG reduction targets for each of the state's major metropolitan regions. ARB called for the Bay Area to reduce per-capita CO_2 emissions from cars and light-duty trucks by 7 percent by 2020 and by 15 percent by 2035. As discussed in the section on *Plan Bay Area* below, in April 2014, ARB determined that the *Plan Bay Area* Sustainable Communities Strategy adopted by MTC and ABAG in 2013 will achieve the Bay Area's SB 375 target. ARB is currently working with MPOs to revise the SB 375 targets for future planning cycles.

Regional Housing Needs Allocation

The Regional Housing Needs Allocation (RHNA) is a state-mandated program to identify the total number of housing units, by household income level, that each jurisdiction must plan for to meet state housing goals. Since the adoption of SB 375, RHNA also plays a key role in meeting regional GHG targets. ABAG is responsible for developing a methodology to allocate the housing need to local cities and counties, taking into account projected job and population growth, access to transit and

ARB adopts fuel specifications for motor vehicle fuels: gasoline, diesel, alternative gasoline fuels, and alternative diesel.

existing development. The allocation method must be consistent with the long-term development pattern described in the SCS.

Mobile Source Regulations

Mobile source emissions are regulated by U.S. EPA and ARB using three basic approaches:

- establishing emission standards for new vehicles, engines and equipment,
- regulating the content of gasoline, diesel and other fuels, and
- in-use performance standards, such as the Inspection and Maintenance "Smog Check" program.

Emission Standards

Under a provision of the federal Clean Air Act, ARB is authorized to adopt standards and regulations to control emissions from motor vehicles and other mobile sources in California. The California standards cover motor vehicles (cars, motorcycles and trucks), construction equipment, off-highway vehicles (dirt bikes and all-terrain vehicles), and lawn, garden and other utility engines. U.S. EPA is responsible for regulating emissions from locomotives, ships and aircraft. Since 2004, ARB and U.S. EPA have harmonized their emissions standards for new heavy-duty engines used in trucks, buses and construction equipment.

ARB standards for motor vehicle engines and fuels have great impact in reducing emissions of ozone precursors and other pollutants in the Bay Area. ARB's Low Emission Vehicle (LEV) program has greatly reduced emissions of ROG and NO_x throughout the state. In 2012, ARB adopted the LEV III amendments to the LEV regulations. These amendments include more stringent emission standards for both criteria pollutants and GHGs for new passenger vehicles. For model years beyond 2017, ARB is combining the LEV III and its zero-emission vehicle regulations into an Advanced Clean Cars Initiative, bringing the control of smog-causing pollutants and GHG emissions into a single coordinated package of standards.

State and federal regulations on off-road diesel construction equipment are also important in reducing ozone precursor and diesel PM emissions in the Bay Area. This category of equipment is currently subject to "Tier 4" standards which can be achieved through the use of control technologies—including advanced exhaust gas after treatment—similar to those required by the 2010 standards for highway engines.

The federal Clean Air Act directs U.S. EPA to establish emission standards for aircraft engines, new locomotive engines and new non-road engines less than 175 horsepower used in construction or farm equipment. U.S. EPA has promulgated regulations or otherwise established programs to control emissions from these important source categories.

To further reduce emissions from commercial jet engines, the Federal Aviation Administration established the Continuous Lower Energy, Emissions and Noise (CLEEN) program in partnership with commercial airlines, jet engine and airplane manufacturers. The CLEEN program aims to accelerate development and commercial deployment of cleaner aircraft technologies and sustainable alternative fuels.

Fuel Content

ARB adopts fuel specifications for motor vehicle fuels: gasoline, diesel, alternative gasoline fuels, and alternative diesel. The most current gasoline regulations—the Phase 3 Reformulated Gasoline standards—went into effect on December 31, 2003, requiring lower evaporative compounds and prohibiting the use of the fuel additive MTBE. As of June 2006, the sulfur content in diesel fuel was reduced from 500 ppm to 15 ppm for trucks, buses and locomotives. The low sulfur content enables after-combustion exhaust abatement devices, such as diesel particulate filters, to operate at high levels of efficiency.

ARB and the California Energy Commission have also developed regulations and incentive programs to lower the carbon content of fuels and to transition California to renewable substitutes for gasoline and diesel in order to reduce emissions of GHGs from mobiles sources. The centerpiece of this effort is the Low Carbon Fuel Standard (LCFS) Program adopted by ARB in April 2009 pursuant to AB 32 and the Governor's Executive Order S-01-07. The LCFS, which went into effect in 2011, requires a minimum 10 percent decrease by 2020 in the carbon content of California's transportation fuels. ARB adopted additional revisions to the LCFS regulation in 2015. The revisions included provisions designed to foster investments in the production of low-carbon fuels, provide additional flexibility to regulated parties, simplify and streamline program operations, and enhance enforcement of the LCFS through 2020. In the coming years, ARB is also expected to consider extending the LCFS with more aggressive targets for 2030 in a future rulemaking.

In-Use Performance

Motor vehicle emissions are also controlled through in-use performance standards to ensure that the systems continue to operate properly. The state of California's Inspection and Maintenance (I&M) program operated by the California Bureau of Automotive Repair (BAR) since 1984, tests light-duty on-road gasoline powered vehicles every other year. An enhanced program which requires the use of a dynamometer to test the vehicle's emissions simulating on-road conditions began in the Bay Area in October 2003.

State Programs to Reduce Emissions from Stationary Sources

State programs to reduce emissions of GHGs and other air pollutants from stationary sources include the Cap-and-Trade Program to reduce emissions from major industrial sources, the Renewable Portfolio Standard to reduce emissions from the energy sector, Title 24 to reduce emissions from buildings and the Air Toxics Program.

Cap-and-Trade

The Cap-and-Trade (CAT) Program is a market-based regulation to reduce GHG emissions from major stationary sources by setting a declining cap on GHG emissions from these sources. The cap establishes tradable emission allowances that can either be allocated to covered sources or auctioned for use by other facilities; this system establishes a price signal to drive long-term GHG reductions.

The CAT Program began in 2013, initially covering electric utilities and large industrial facilities that emit more than 25,000 metric tons of CO_2e per year. The second compliance period began in January 2015, when the program expanded to include fuel distributors (e.g., natural gas, propane and transportation fuel providers). The CAT Program is expected to reduce overall GHG emissions from regulated facilities 17 percent below 2013 levels by 2020.[11] The CAT Program covers approximately 450 major stationary sources of GHG emissions statewide. Some 40 of these sources are located within the Air District. In 2011, these sources were responsible for approximately 25 million metric tons of CO_2e of GHG emissions in the Bay Area.

Assembly Bill 758 (2009) required the CEC and the CPUC to develop a comprehensive program to reduce energy consumption in existing buildings.

Energy Sector: Renewable Portfolio Standard

California's Renewable Portfolio Standard (RPS), jointly implemented by the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC), is one of the most ambitious renewable energy standards in the country.[12] The RPS program requires investor-owned utilities, electric service providers, and community choice energy programs to increase procurement from eligible renewable energy resources to 33 percent of total procurement by 2020. Passage of SB 350 in September 2015 increased the procurement requirement from renewable sources to 50 percent by 2030. The RPS program has spurred investment in renewable resources, particularly solar and wind, and played a key role in increasing the use of renewable energy sources in the Bay Area power supply.[13]

Energy Efficiency in New Buildings: Title 24

Since 1976, the California Energy Commission has adopted and regularly strengthened energy-efficiency standards for residential and commercial buildings (Title 24) as well as home appliances and electronic devices (Title 20). These standards have greatly improved energy efficiency in the state. While per capita energy consumption has been increasing in most of the United states in recent decades, it has been holding steady in California. The average Californian consumes about 40 percent less energy than the average American, whereas in 1960 their consumption levels were nearly identical. California's energy-efficiency standards have saved residents and businesses billions of dollars in energy expenses and reduced over 250 million metric tons of CO_2e since its implementation.

Building energy efficiency standards are updated approximately every three years. The 2013 standards improve upon the 2008 standards for new construction of, and additions and alterations to, residential and nonresidential buildings. The 2013 standards went into effect July 1, 2014. The 2016 revisions to Title 24 energy efficiency standards, which took effect on January 1, 2017, will reduce emissions by an additional 25 percent for residential buildings and 30 percent for commercial buildings over the 2013 standards, decreasing statewide GHG emissions by 170,000 metric tons of CO_2e annually. The standards include energy-saving strategies for residential uses such as advanced lighting technology, high performance walls and attics, and tankless water heating. Measures for non-residential buildings include revisions to building envelopes; updating lighting standards; more efficient elevators and escalators; and connecting door and window sensors to HVAC systems.

In addition, Green Building Standards (CALGreen) in Title 24, Part 11 define more stringent voluntary standards to establish a path to zero-net-energy buildings. CALGreen provides voluntary options, known as tiers, which local governments can elect to adopt as mandatory standards.

Energy Efficiency in Existing Buildings

Title 24, Part 6 only addresses existing buildings when undergoing additions or alterations. However, more than half of California's 13 million residential buildings and more than 40 percent of commercial buildings were built prior to 1978; almost 70 percent of the Bay Area housing stock was built prior to 1980. Because these buildings do not meet the latest Title 24 standards, Assembly Bill

758 (2009) required the CEC and the CPUC to develop a comprehensive program to reduce energy consumption in existing buildings. The CEC recently released the final Existing Buildings Energy Efficiency (EBEE) Action Plan that provides a 10-year framework for key stakeholders to focus on improving energy efficiency in existing buildings, including single-family, multi-family, commercial and public buildings sectors.

Air Toxics

There are both national and state programs to regulate TACs. U.S. EPA regulates TACs using the term hazardous air pollutants pursuant to Title III, Section 112(b) of the 1990 Clean Air Act Amendments.[14] California's program to reduce exposure to TACs was established by the Toxic Air Contaminant Identification and Control Act via AB 1807 (the Tanner Act) in 1983, and the TACs "Hot Spots" Information and Assessment Act via AB 2588 in 1987. The Tanner Act established criteria to be used by ARB and OEHHA to determine if a substance should be formally identified as a toxic air contaminant in California. ARB assesses the potential for human exposure to a substance and OEHHA evaluates the health effects.

The AB 1807 program was amended in 1993 by AB 2728, which required ARB to identify the 189 federal hazardous air pollutants as TACs. AB 2588 supplements the AB 1807 program, by requiring a statewide TACs inventory, notification of people exposed to a significant health risk, and facility plans to reduce these risks. In 1992, the Air Toxics "Hot Spots" Information and Assessment Act (AB 2588) was amended by Senate Bill 1731, which required facilities that pose a significant health risk to the community to reduce their risk through a risk management plan.

In August 1998, ARB identified diesel particulate matter (DPM) from diesel-fueled engines as TACs. In September 2000, ARB approved a comprehensive Diesel Risk Reduction Plan, which recommends control measures to reduce the risks associated with DPM from both new and existing diesel-fueled engines and vehicles. The goal of the plan is to reduce DPM emissions 75 percent by 2010 and by 85 percent by 2020.

Other State Plans

In addition to the policies, programs and plans described above, the 2017 Plan also draws upon other plans produced by various state agencies to address GHGs and climate protection. For example, ARB's Mobile Source Strategy, released in May 2016, lays out a comprehensive strategy to reduce motor vehicle emissions to meet federal and state ambient air quality standards, reduce GHG emissions towards long-range targets, reduce risk from vehicle emissions, and reduce petroleum use. The strategy emphasizes replacing today's cars and trucks with zero-emission models fueled by renewable grid electricity or with hydrogen. Other state plans that the 2017 Plan draws upon include:

- the state SIP Strategy,
- the AB 32 Scoping Plan Update,
- ARB's Short-Lived Climate Pollutant Reduction Strategy,
- CEC's Existing Buildings Energy Efficiency Action Plan,
- CNRA and CalEPA's State Forest Carbon Plan, and
- ARB's Sustainable Freight Strategy.

Regional Plans and Programs

Plan Bay Area

The Bay Area's first Sustainable Communities Strategy – known as *Plan Bay Area* – was adopted by MTC and ABAG in 2013. *Plan Bay Area* serves as the region's integrated land use and transportation plan. The plan provides a long-term transportation funding strategy, allocates housing construction, and defines a strategy to meet the GHG reduction goals for cars and light trucks established by ARB pursuant to SB 375 (discussed above). The plan pursues the region's goals through a strategy to direct 80 percent of the region's future housing needs to Priority Development Areas (PDAs), while protecting open space, scenic areas, and agricultural lands that face near-term development pressure through Priority Conservation Areas (PCAs). PDAs and PCAs complement one another, because promoting development within PDAs takes development pressure off the region's open space.

The GHG reduction target for the Bay Area, set by ARB as required by SB 375, called for a per capita reduction in GHG emissions from cars and light-duty trucks by 7 percent by 2020 and by 15 percent by 2035. In April 2014, ARB issued an Executive Order which confirmed that the land use policies and transportation projects and investments included in *Plan Bay Area* are expected to reduce per capita GHG emissions from on-road motor vehicles in the Bay Area by 10 percent by 2020 and by 16 percent by 2035 compared to the 2005 baseline.[15]

For the transportation component of the plan, *Plan Bay Area* specifies how $292 billion in anticipated federal, state and local funds will be spent through 2040. Federal, state and local funds or revenue includes fuel taxes, public transit fares, bridge tolls, property taxes and dedicated sales taxes. According to the plan, nearly 87 percent ($253 billion) will be used to maintain and operate the existing transportation network.

In addition to changes in land use and transportation investments, Plan Bay Area includes a number of complementary policies and programs designed

PLANNING HEALTHY PLACES

Directing new development to areas that are well served by transit and provide good access to jobs and services is an essential strategy to reduce motor vehicle travel and GHG emissions, as discussed above. However, locating new development near major sources of air pollution could result in increased local exposure to unhealthy levels of air pollutants, unless steps are taken to minimize exposure and reduce emissions. To assist local governments in addressing and minimizing potential air quality issues, the Air District released a guidance document in May 2016 entitled *Planning Healthy Places.* This document provides recommended best practices that can be implemented to reduce emissions of, and population exposure to, local air pollutants. *Planning Healthy Places* includes a web-based mapping tool that shows locations throughout the region with elevated levels of air pollution (based on conservative screening-level modeling), where the Air District recommends implementing best practices to address air quality. The purpose of *Planning Healthy Places* is to ensure that we protect public health while promoting and facilitating infill development that will reduce motor vehicle travel. For more information, see http://www.baaqmd.gov/plans-and-climate/planning-healthy-places.

Plan Bay Area includes a number of complementary policies and programs designed to provide additional reductions in vehicle travel and GHG emissions from on-road vehicles.

to provide additional reductions in vehicle travel and GHG emissions from on-road vehicles. The Climate Initiatives Program adopted in conjunction with Plan Bay Area included $67 million to fund GHG reduction pilot projects, public education and outreach, Safe Routes to Schools, and program evaluation. Projects funded via the Climate Initiatives Program include a regional electric vehicle charging program; incentives for the purchase of electric cars; incentives to encourage the purchase of fuel-efficient vehicles; expansion of carsharing programs; a "smart-driving" initiative; implementation of a regional commuter benefit program; and expansion of vanpool and employer shuttle programs. MTC issued a report summarizing the results of these projects; findings in this report will help to determine which projects will be funded in future cycles of the Climate Initiatives Grants program.[16]

MTC and ABAG are currently updating *Plan Bay Area.* The update is scheduled for completion in Summer 2017.

Plan Bay Area directs most future development to Priority Development Areas (PDAs), based upon the concept of transit-oriented development. PDAs are neighborhoods with frequent transit service and a variety of housing options, that offer services and amenities such as shopping, restaurants, libraries, and community centers. PDAs can also include focused employment growth.

The PDA concept provides a mechanism to link local community development aspirations with regional land use and transportation planning objectives. Local jurisdictions have defined the character of their PDAs according to existing conditions and future expectations. PDAs range from regional centers like downtown San Jose to suburban centers like Walnut Creek's West Downtown area, and smaller town centers such as the Suisun City Waterfront.

Plan Bay Area also includes Priority Conservation Areas, or PCAs. PCAs are open spaces that provide agricultural, natural resource, scenic, recreational, and/or ecological values and ecosystem functions. These areas are identified through consensus by local jurisdictions and park/open space districts as lands in need of protection due to pressure from urban development or other factors. PCAs are categorized by four designations: Natural Landscapes, Agricultural Lands, Urban Greening and Regional Recreation.

Regional Goods Movement Planning

MTC and the Alameda County Transportation Commission (ACTC) are leading a Bay Area-wide *Goods Movement Collaborative,* bringing together partners, community members and stakeholders to identify, prioritize and advocate for short- and long-term strategies for both improved infrastructure and better community health.[17] As part of this collaboration, MTC has updated its Regional Goods Movement Plan, while ACTC adopted a county-specific plan. Both plans outline a long-range strategy for how to move goods efficiently, reliably, and sustainably within, to, from and through the county and the entire region. MTC is also devel-

Both plans outline a long-range strategy for how to move goods efficiently, reliably, and sustainably within, to, from and through the county and the entire region.

oping a *Freight Emission Reduction Action Plan* which will recommend strategies for implementing zero-emission technologies for moving goods by rail and truck. The *Action Plan* will be incorporated in the forthcoming *Plan Bay Area 2040.*

San Francisco Bay Plan Amendments

BCDC administers the *San Francisco Bay Plan,* which guides development on and around the shoreline of the Bay Area. In October 2011, BCDC unanimously approved an amendment to the *San Francisco Bay Plan* to address climate change, and the expected impacts to the Bay from sea-level rise. These findings and policies have been incorporated into the *Bay Plan.* The 2011 amendments direct development away from low-lying shoreline areas vulnerable to flooding and support the region's PDA development and PCA conservation strategy by ensuring the region does not develop in ways that increase threats to public safety from flooding. The amendments also outline a process for developing a regional adaptation strategy for areas vulnerable to sea-level rise. In response to this, BCDC has launched the Adapting to Rising Tides (ART) Program. ART is a program that leads and supports multi-sector, cross-jurisdictional projects that build local and regional capacity in the San Francisco Bay Area to plan for and implement comprehensive adaptation responses to sea-level rise.

Bay Area Regional Collaborative (Formerly Joint Policy Committee)

State law created the Bay Area Regional Collaborative (BARC)—originally called the Joint Policy Committee—to help coordinate the development of major plans and initiatives by the Air District, MTC, ABAG and BCDC. These plans and initiatives include: the regional transportation plan/ sustainable communities strategy *(Plan Bay Area),* the regional housing needs assessment, air quality plans, adaptation planning and more. BARC helps to coordinate climate protection and adaptation efforts among the agencies, such as the following:

- Resilient Shorelines Partnership (ABAG, Air District, BCDC, MTC),
- Regional Climate Protection Strategy (Air District),
- Resilience Program (ABAG), and
- Regional Adaptation Planning/Adapting to Rising Tides (BCDC).

Local Plans

General Plans and Area Plans

In California, local governments have primary authority and responsibility for land use planning. State law requires all cities and counties to prepare a comprehensive, long-term general plan as a guide "for the physical development of the county or city, and any land outside its boundaries which bears relation to its planning" (Government Code §65300). The general plan must contain a minimum of seven state-mandated elements, including: Land Use, Open Space, Conservation, Housing, Circulation, Noise and Safety. The plan may also contain any other elements that a county or city wishes to adopt. Common additional elements include: Environment, Climate, and/or Health.

In addition to the general plan, cities and counties also frequently develop area, neighborhood, or station area (transit station) plans. Area plans cover only a small portion of a city or county. Typically, the planning area is a specific neighborhood that is being planned for new development, or an area where the city or county would like to change land use designations, densities or other features, such as roadway width, building heights or parking requirements.

Although local plans may seem predominantly concerned with uses and zoning, in actuality, land use plans and policies touch on every aspect of local government concern. Land use involves multi-layered issues that affect air quality, water quality, access to transportation options, economic vitality, access to affordable housing, environmental justice, and other significant quality of life issues. Cities and counties, in developing their plans, must also consider regional and global issues that may affect their community's viability and growth potential, such as the regional economy, regional transportation investments, state affordable housing requirements and increasingly, their role in reducing GHGs to slow global climate change.

State and regional agencies also look to local land use plans as the primary tool for implementing a regional Sustainable Communities Strategy to significantly reduce GHGs and air pollution from the transportation sector, and to meet state affordable housing goals. Research demonstrates that land use decisions exert a strong influence on travel demand and travel behavior. People who live in areas with higher densities, a mix of residential, retail and office uses, with well-designed pedestrian, bicycle and transit infrastructure take more trips by transit, bicycle and walking, which results in reduced driving. Land use and zoning, therefore, are powerful tools which local governments can use to reduce vehicle travel and emissions.

Local Climate Action Plans

Cities and counties have a key role to play in reducing GHG emissions. Local agencies can take action to reduce GHG emissions and to prepare their communities to adapt to climate change, by using their broad authority and their funding in relation to land use, transportation, building and energy standards and other issues. They also have a critical role to play in educating local businesses and residents about how they can reduce their own GHG emissions.

A climate action plan may take the form of a stand-alone plan, a component of a general plan, or a set of climate action policies, ordinances and programs that have been adopted by a local jurisdiction. Local climate action plans typically include a community-wide GHG emission inventory, GHG emission reduction targets consistent with the state's reduction targets, and specific measures to reduce GHG emissions. Many plans also include climate adaptation strategies to address the adverse impacts of climate change.

Local agencies can take action to reduce GHG emissions and to prepare their communities to adapt to climate change...

To date, at least 65 cities and counties in the Bay Area have adopted some type of local climate action plan. These plans collectively contain almost 2,400 emission reduction measures aimed at a wide range of activities. In addition to reducing GHG emissions, many of these measures also provide desirable co-benefits such as decreasing air pollutant emissions, increasing the livability of a community, improving property values, reducing utility bills and preserving water and other natural resources for future generations.

Because local government agencies are critical partners in its climate protection efforts, the Air District provides technical and policy assistance to support local climate planning. Many of the GHG reduction measures in the 2017 Plan include actions to support local efforts, such as developing model ordinances, sharing best practices, etc. The Air District will continue to work closely with local agencies to coordinate and integrate our climate protection efforts.

FOOTNOTES

[1] Technical information on TACs is provided in Chapter 2.

[2] http://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/CARE%20Program/Documents/CARE_Retrospective_April2014.ashx?la=en.

[3] http://www.baaqmd.gov/rules-and-compliance/rule-development/regulatory-workshops.

[4] Greenhouse gas emissions were only calculated for 127 of the 21 TFCA projects awarded during this period. GHG emissions were not calculated for the remaining TFCA projects or for projects that received funding from the state, such as the Carl Moyer Program, Goods Movement Program, and Lower Emission School Bus Program, due to lack of data.

[5] Bay Area seaports include the ports of Oakland, Richmond, Redwood City, Benicia and San Francisco.

[6] For additional information, see http://www.baaqmd.gov/rules-and-compliance/wood-smoke.

[7] See http://www.baaqmd.gov/grant-funding/residents/wood-smoke-rebate.

[8] In this plan, we refer to SLCPs as “super-GHGs.”

[9] Executive Order S-3-05 establishes California’s GHG reduction targets, which are to reduce GHG emissions to 1990 levels by 2020, and to 80 percent below 1990 levels by 2050. Executive Order B-16-2012 establishes benchmarks for the rapid commercialization of zero-emission vehicles (ZEVs) and GHG reduction goals for the transportation sector, which include 1.5 million ZEVs to be in use by 2025 and an 80 percent decrease in GHG emissions from the transportation sector from 1990 levels by 2050.

[10] https://www.arb.ca.gov/regact/2017/2017rmcal.pdf

[11] Center for Climate and Energy Solutions, California Cap-and-Trade Program Summary, http://www.c2es.org/us-states-regions/key-legislation/california-cap-trade, June 4, 2015.

[12] California Public Utilities Commission, California Renewables Portfolio Standard (RPS), http://www.cpuc.ca.gov/PUC/energy/Renewables/.

[13] According to CEC data for year 2014, nearly 60 percent of the power-generating facilities located in the Bay Area operate on renewable energy. Collectively, these facilities generate over 20 percent of the total electricity-generation capacity located within in the Bay Area.

[14] For more details on the 1990 CAAA, see http://www.epa.gov/air/caa/.

[15] The anticipated reductions in per capita GHG emissions attributed to *Plan Bay Area* are based on per capita reductions in vehicle miles traveled. They do not include projected GHG reductions due to state programs to promote cleaner, more efficient vehicles and fuels, such as the Advanced Clean Car initiative or the Low Carbon Fuel Standard.

[16] See MTC’s *Climate Initiatives Program: Evaluation Summary Report* (July 2015): http://mtc.ca.gov/sites/default/files/CIP%20Evaluation%20Summary%20Report_7-13-15_FINAL.pdf

[17] See http://mtc.ca.gov/our-work/plans-projects/economic-vitality/san-francisco-bay-area-goods-movement-plan.

CHAPTER 5
CLIMATE AND AIR POLLUTION CONTROL STRATEGY

The 2017 Plan is a multi-pollutant plan focused on protecting public health and the climate. The control strategy described in this chapter, which serves as the backbone of the 2017 Plan, builds upon existing regional, state and national programs described in Chapter 4 that have successfully reduced air pollution and improved public health over the past several decades. The control strategy includes an integrated set of control measures designed to:

- Reduce ozone precursors, in order to fulfill California Health & Safety Code ozone planning requirements
- Protect public health by reducing emissions of ozone precursors, particulate matter (PM) and toxic air contaminants (TACs)
- Serve as a regional climate protection strategy by reducing emissions of greenhouse gases (GHGs) across the full range of economic sectors

To comply with California Health & Safety Code ozone planning requirements, the 2017 Plan must include “all feasible measures” as discussed in Appendix A.

The control strategy includes 85 control measures, listed in Table 5-13 at the end of this chapter. Detailed descriptions of individual control measures are provided in Volume 2.[1] Some measures focus on reducing a single type of air pollutant. Many of the measures, however, reduce multiple pollutants and serve both to protect public health and to protect the climate. The process used to evaluate and develop potential control measures is described in Appendix G. In addition to the proposed control measures described below, the Air District has also identified a number of further study measures that will undergo further analysis to determine if they should be pursued as control measures.

The proposed control strategy is based on four key priorities, which are described more fully in Chapter 1:

- Reduce emissions of criteria air pollutants and toxic air contaminants from all key sources
- Reduce emissions of super-GHG pollutants such as methane
- Decrease demand for fossil fuels by:
    - Increasing efficiency of industrial processes, energy, buildings, and transportation sectors
    - Reducing demand for vehicle travel, and high-carbon goods and services
- Decarbonize our energy system
    - Making the electricity supply carbon-free
    - Electrifying the transportation and building sectors

Tools and Resources

To implement the 2017 Plan control strategy, the Air District will employ a wide range of tools and resources including its regulatory, permitting, and enforcement authorities; grants and incentives; partnerships; collaboration with local governments via best practices, model ordinances, and other local programs; air quality monitoring and research; issuing CEQA guidelines for air quality and climate impacts, and providing CEQA comment letters on major plans and projects; public outreach and education; and advocacy. The "Primary Implementation Tools" in Table 5-13 can be described as follows:

Rulemaking: Employ the Air District's regulatory authority to develop new or amend existing rules to reduce emissions.

Funding: Provide grants and incentives through Air District grant programs, *Plan Bay Area*, or other sources. From 2017 through 2024, the Air District expects to provide approximately $288 million for additional projects to reduce emissions of air pollutants and GHGs in the Bay Area through ongoing grant programs that it directly administers. In addition, the region may receive a significant amount of funding from the California Cap-and-Trade Program, assuming that the program is extended beyond 2020. Cap-and-Trade funds could provide significant capital to spur the innovation and growth in clean technology needed to achieve the 2050 vision for a post-carbon Bay Area described in Chapter 1. To help achieve the 2050 vision, the Air District will implement a new $4.5 million climate protection grant program to facilitate implementation of control measures in this Plan at the local level. In addition, the Air District is creating a Technology Implementation Office to catalyze the development and commercialization of new energy and vehicle technologies needed to achieve the transition to a post-carbon economy.

Partnerships and Best Practices: Work in partnership with public agencies and other entities by providing technical support and funding, collaborating on research, evaluating pilot programs, and promoting the use of best practices through model ordinances and guidance documents, including general plan, specific plans, CEQA and other land use planning guidance.

Outreach and Education: Conduct marketing or media campaigns; disseminate information and educational materials; engage with community groups, businesses and other organizations.

Advocacy: Support legislative action at the federal or state level and advocate for funding to support implementation of the measures in the 2017 control strategy.

Individual control measures will use the tools and resources that are most relevant and effective for the specific emission source in question. Implementation actions for each control measure are briefly summarized in the individual sector tables below, and are described in greater detail in Volume 2 of the 2017 Plan.

Like the economy as a whole, these sectors are interconnected.

Control Strategy by Economic Sector

For purposes of consistency with climate planning efforts at the state level, the control strategy in this Plan is based upon the same economic sector framework used by the Air Resources Board for its 2014 update to the AB 32 Scoping Plan. The sectors are as follows:

- Stationary Sources
- Transportation
- Energy
- Buildings
- Agriculture
- Natural and Working Lands
- Waste Management
- Water
- Super-GHG Pollutants

Like the economy as whole, these sectors are interconnected. For example, motor vehicles (transportation sector) require gasoline and diesel; the demand for these products leads to emissions from oil refineries (stationary source sector). Conversely, as the number of electric vehicles in the Bay Area fleet increases, emissions from motor vehicles (transportation sector) and oil refineries (stationary source sector) may be reduced, but emissions from the energy sector may increase as a result of additional demand for electricity to charge EV batteries.

To inform the development of the control strategy, the Air District analyzed each economic sector to: identify key emission sources and the projected emissions trend for each sector; analyze relevant policies and programs at the federal, state, and local level; clarify the Air District's authority and available tools relevant to the sector; and identify potential criteria pollutant, TAC and GHG emission reduction measures.

Stationary Sources

Stationary sources include oil refineries, cement plants, natural gas distribution facilities, crude oil and natural gas production facilities, gas stations, dry cleaners, metal fabricators, chemical and pharmaceutical production facilities, diesel generators, and large boilers used in commercial and industrial facilities. The Air District regulates emissions from stationary sources through its rulemaking, permitting and enforcement programs.

The 40 proposed stationary source measures in the 2017 Plan are briefly described in Table 5-1. Eleven of the proposed measures focus primarily on reducing GHG emissions; the remainder of the stationary source measures aim to protect public health by reducing emissions of criteria pollutants and TACs from oil refineries and other sources.

Oil refineries are the largest source of Bay Area GHG emissions from the stationary source sector, accounting for 70 percent of stationary source GHG emissions in 2015. The Air District has developed a Refinery Emissions Reduction Strategy to reduce criteria air pollutant emissions by 20 percent from oil refineries and to reduce exposure to toxic air contaminants in order to reduce health risks to local communities by 20 percent, as described in more detail in Chapter 4. Several control measures in the 2017 Plan propose regulatory action in support of the 20 percent refinery emissions reduction goal (SS1 – SS8). In addition, three of the proposed measures in the Plan support and expand the climate component of the Refinery Strategy work by requiring improved refinery emissions inventories, fenceline monitoring and feedstock data (SS10), and by setting limits related to GHG emissions from these facilities (SS11 and SS12).

Oil refineries are the largest source of Bay Area GHG emissions from the stationary source sector.

In developing measures to reduce GHG emissions from the stationary source sector, the Air District has placed a high priority on reducing emissions of methane and other super-GHGs with high global warming potential. In the stationary source sector, these efforts include reducing fugitive emissions of methane from oil and gas wells (SS13 and SS14), natural gas pipelines and processing operations (SS15), and major leaks of organic gases (SS2), all part of a concerted basin-wide methane strategy (SS16).

There are multiple proposed measures in the 2017 Plan that apply to a wide range of stationary source facilities. Measure SS17 would establish a more stringent threshold for the purpose of determining which facilities must implement Best Available Control Technology (BACT) to reduce GHG emissions through its New Source Review program. Measure SS18 would limit combustion of fossil fuels at stationary sources by applying a “basin-wide combustion strategy” that would prioritize sources based on the magnitude of their emissions, analyze the efficiency of combustion processes, and optimize energy-efficiency of production processes. Several proposed measures target specific criteria pollutants such as particulate matter (e.g., measures SS33–SS38), or a particular industrial process or sector such as cement plants (e.g., SS19).

All the proposed stationary source control measures will protect public health by reducing emissions, capping or monitoring air pollutants. However, as discussed in Chapter 4, the Air District has identified a number of Bay Area communities that are disproportionately impacted by air pollution and has made a commitment to prioritize actions to protect these communities. To that end, two measures specifically focus on reducing risk from exposure to toxic air contaminants from both existing facilities (SS20) and new facilities (SS21). In addition, the measures to reduce emissions from oil refineries, as well as the control measures that will reduce emissions of particulate matter and TACs from a wide variety of sources, will also help to protect impacted communities.

Proposed stationary source measures are briefly described in Table 5-1.

Table 5-1. Stationary Source Control Measures

Number	Name	Pollutant	Description
SS1	Fluid Catalytic Cracking in Refineries	PM	Establish emission limits to reduce secondary PM emissions at Fluid Catalytic Cracking Units (FCCUs). Work with FCCU operators to provide sampling ports that will allow a source-test program using EPA Method 202 to quantify total FCCU PM emissions, including condensable PM. Evaluate progress in ammonia optimization, as well as the results of Method 202 testing, to determine appropriate further actions.
SS2	Equipment Leaks	ROG, GHG	Reduce fugitive emissions of organic gases, including methane, from refineries, chemical plants, bulk plants and bulk terminals. Develop an implementation plan for Rule 8-18 to require future monitoring of equipment in heavy liquid service, require facilities to identify the causes of background readings greater than 50 parts per million volume (ppmv), etc.
SS3	Cooling Towers	ROG, TACs	Establish hydrocarbon limits for cooling towers.

(continued)

Table 5-1. Stationary Source Control Measures *(continued)*

Number	Name	Pollutant	Description
SS4	Refinery Flares	ROG, SO_2, PM	Review the results of refinery flare monitoring Rule 12-11 and flare reduction Rule 12-12 at each of the five refineries in the Bay Area to identify amendments that may make the rules more effective at reducing emissions.
SS5	Sulfur Recovery Units	SO_2	Consider amendments to Air District Rule 9-1 to achieve the lowest SO_2 emissions feasible at sulfur recovery units without the addition of caustic scrubbing.
SS6	Refinery Fuel Gas	SO_2	Consider amendments to Rule 9-1 that would reduce the sulfur limits for RFG and determine the appropriate averaging periods.
SS7	Sulfuric Acid Plants	SO_2	Consider amendments to Rule 9-1 that would limit SO_2 emissions from acid plants associated with petroleum refining.
SS8	Sulfur Dioxide from Coke Calcining	PM, SO_2	Limit SO_2 emissions from petroleum coke calcining operations equivalent to meet a mass emissions limit of 1,050 tons per year and an hourly limit of 320 pounds per hour.
SS9	Enhanced NSR Enforcement for Changes in Crude Slate	All Pollutants	Require a refinery to obtain a permit for any significant change in crude slate. Requiring a review of all such significant crude slate changes will allow the Air District to evaluate such changes in detail and ensure that they will comply with applicable NSR permitting requirements.
SS10	Petroleum Refining Emissions Tracking	All Pollutants	Implement a newly adopted rule (Rule 12-15) which will: 1) improve petroleum refinery emissions inventories of criteria pollutants, toxic air contaminants (TACs) and greenhouses gases (GHGs), 2) collect volume and composition data on crude oil and other feedstocks processed by refineries, 3) expand refinery fenceline air monitoring and community air monitoring, and 4) collect information about equipment and operational practices where refinery energy utilization could be improved so that GHG emissions could be reduced.
SS11	Petroleum Refining Facility-Wide Emission Limits	GHG, PM, NO_X, SO_2	Consider limiting facility-wide emissions of GHG and three criteria air pollutants—PM, NO_X and SO_2—from Bay Area petroleum refineries through Air District Rule 12-16.

(continued)

Table 5-1. Stationary Source Control Measures *(continued)*

Number	Name	Pollutant	Description
SS12	Petroleum Refining Climate Impacts Limit	GHG	Limit facility-wide carbon intensity at each Bay Area petroleum refinery through a new Air District regulation. Carbon intensity limit for each refinery would be calculated on a simple-barrel basis, and require execution of cost-effective energy efficiency projects.
SS13	Oil and Gas Production, Processing and Storage	TAC, ROG, GHG	Work with ARB on the development of its Oil and Gas Rule. In addition, consider amending Rule 8-37 to limit emissions from oil and natural gas production, processing and storage operations.
SS14	Methane from Capped Wells	ROG, TAC, GHG	Estimate the magnitude and approximate composition of the fugitive emissions from Bay Area capped wells. Establish emission limits for methane to support CARB's AB32 Scoping Plan and the Air District's GHG reduction goals. Adopt thresholds for ROG and toxic pollutant emissions from relevant existing regulations.
SS15	Natural Gas Processing and Distribution	GHG	Review the utility-reported data, when available, to glean additional information on GHG emissions and practices used to prevent and minimize methane emissions. Continue to participate in the CPUC regulatory process.
SS16	Basin-Wide Methane Strategy	GHG	Quantify and reduce emissions of methane, and its co-pollutants, from all sources throughout the Air District by implementing a coordinated strategy that combines research, rulemaking and collaborations with state agencies and other programs.
SS17	GHG BACT Threshold	GHG	Revise Air District rules to reduce the threshold at which facilities must implement Best Available Control Technology to control their GHG emissions.
SS18	Basin-Wide Combustion Strategy	GHG, PM	Stabilize and then reduce emissions of GHGs, criteria air pollutant and toxic emissions from stationary combustion sources throughout the Air District by first establishing carbon intensity caps on major GHG sources, and then adopting new rules to (1) reduce fuel use on a source-type by source-type basis, and (2) evaluate alternatives to decarbonize abatement devices.

(continued)

Table 5-1. **Stationary Source Control Measures** *(continued)*

Number	Name	Pollutant	Description
SS19	Portland Cement	SO_2, PM, GHG	Amend sections of existing Air District Rule 9-13 pertaining to ammonia emissions to allow for replacement of the rolling 24-hour average with a different operating day averaging period for ammonia emissions. Amend Rule 9-13 to impose a standard for SO_2 consistent with other Air District rules; amend the rule as necessary to incorporate language regarding detached plumes, and consider amendments to the rule to reduce GHG emissions.
SS20	Air Toxics Risk Cap and Reduction from Existing Facilities	TAC	Reducing public exposure to toxic air contaminants (TACs) from existing facilities through Draft Rule 11-18.
SS21	New Source Review for Toxics	TAC	Propose revisions to Air District Rule 2-5, New Source Review of Toxic Air Contaminants, based on OEHHA's 2015 Health Risk Assessment Guidelines and CARB/CAPCOA's 2015 Risk Management Guidance. Revise the Air District's health risk assessment trigger levels for each toxic air contaminant using the 2015 Guidelines and most recent health effects values.
SS22	Stationary Gas Turbines	NO_X	Reduce nitrogen oxide emissions from stationary gas turbines.
SS23	Biogas Flares	NO_X	Develop a new Air District rule to reduce NO_X from non-refinery flares and investigate potential for more stringent limits on emissions from non-refinery flares.
SS24	Sulfur Content Limits of Liquid Fuels	SO_2, PM	Revise Rule 9-1 to include fuel-specific sulfur content limits for diesel and other liquid fuels.
SS25	Coatings, Solvents, Lubricants, Sealants and Adhesives	ROG	Review existing Air District rules and compare the ROG limits with limits in other Air District rules; propose more stringent ROG limits as appropriate.
SS26	Surface Prep and Cleaning Solvent	ROG	Lower the ROG limits for surface preparation, cleanup, and equipment cleaning in Air District Rules 8-24, 8-29, 8-30, 8-35 and 8-38.

(continued)

Table 5-1. Stationary Source Control Measures *(continued)*

Number	Name	Pollutant	Description
SS27	Digital Printing	ROG	Reduce emissions of ROG from digital printers.
SS28	LPG, Propane, Butane	ROG	Investigate potential ROG reductions by regulating filling of, and leakage from LPG, propane and butane tanks.
SS29	Asphaltic Concrete	ROG	Evaluate the cost effectiveness, and feasibility of limiting solvent content of emulsified asphalt and the availability of substitutes for diesel to clean asphalt related equipment.
SS30	Residential Fan Type Furnaces	NO_X	Reduce NO_X emission limits on new and replacement central furnace installations. Explore potential Air District rulemaking options regarding the sale of fossil fuel-based space and water heating systems for both residential and commercial use.
SS31	General Particulate Matter Emission Limitation	PM	Reduce or revise the Air District's allowable weight rate limitations for particulate matter.
SS32	Emergency Backup Generators	Diesel PM, TAC	Reduce emissions of diesel PM and black carbon from BUGs through Draft Rule 11-18, resulting in reduced health risks to impacted individuals, and in climate protection benefits.
SS33	Commercial Cooking Equipment	PM	Consider PM limits for additional commercial cooking sources, specifically under-fire charbroilers.
SS34	Wood Smoke	PM	Consider further limits on wood burning, including additional limits to exemptions from Air District Rule 6-3: Wood Burning Devices.
SS35	PM from Bulk Material Storage, Handling and Transport, Including Coke and Coal	PM	Develop Air District rule limits to prevent and control wind-blown fugitive dust from bulk material handling operations. Establish enforceable visible emission limits to support preventive measures such as water sprays, enclosures and wind barriers.

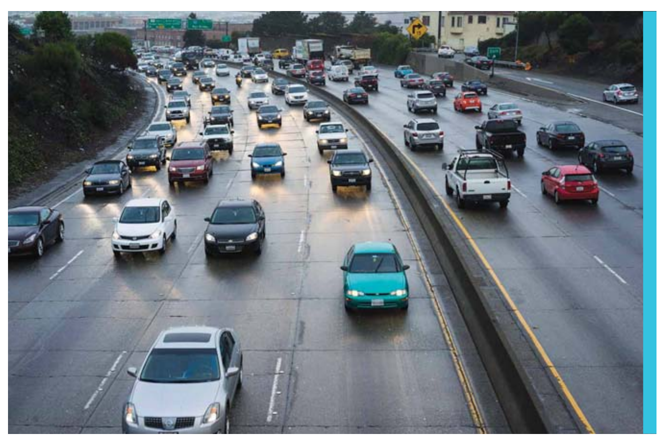
(continued)

Table 5-1. Stationary Source Control Measures *(continued)*

Number	Name	Pollutant	Description
SS36	PM from Trackout	PM	Develop new Air District rule to prevent mud/dirt and other solid trackout from construction, landfills, quarries and other bulk material sites.
SS37	PM from Asphalt Operations	PM	Develop an Air District rule to require abatement/control of blue smoke emissions related to asphalt delivery to roadway paving projects.
SS38	Fugitive Dust	PM	Consider applying the Air District's proposed fugitive dust visible emissions limits to a wider array of sources.
SS39	Enhanced Air Quality Monitoring	All Pollutants	Ensure representative air quality data is being collected in impacted communities. Partner with county Health Departments to identify areas of poor air quality and collaborate with the community on ways to potentially measure and reduce exposure and emissions from local and regional sources. Require petroleum refineries to prepare and submit to the Air District an air monitoring plan for establishing an air monitoring system. Implement the Community Monitoring Program.
SS40	Odors	Odors	Propose amendments to Regulation 7 to strengthen odor standards and enhance enforceability. An evaluation of newer air monitoring technologies will be aimed at increasing enforceability of the rule with respect to a wider range of odorous compounds and sources.

Transportation

The transportation sector includes on-road motor vehicles, categorized by weight class, such as light-duty automobiles or heavy-duty trucks; off-road vehicles, including airplanes, locomotives, ships and boats; and off-road equipment, such as airport ground-support equipment, construction equipment and farm equipment.[2] Due to the fact that California has the most stringent standards in the world to control emissions from vehicle fuels and vehicle engines, emissions of most air pollutants from transportation sources have declined significantly in recent decades, even as the Bay Area vehicle fleet and total vehicle travel have grown substantially. In response to regulations and grant programs implemented by ARB and the Air District, emissions of criteria pollutants, ozone precursors and diesel PM—the TAC that poses the greatest cancer risk—have been greatly reduced.



Multiple state and regional programs have also reduced GHG emissions in the transportation sector. Despite progress in reducing vehicle emissions and emission rates, the transportation sector remains the largest source of GHGs, ozone precursors (ROG and NO_X), and TACs in the Bay Area, as well as a major source of fine particulate matter.

The transportation measures proposed in the 2017 Plan will decrease emissions of criteria pollutants.

Many of the transportation measures in this control strategy support and complement critical land use and transportation strategies outlined in *Plan Bay Area.* In part due to the strategies included in *Plan Bay Area,* GHG emissions from the Bay Area transportation sector are currently projected to decline over the 2015 to 2035 period. However, these emissions are projected to gradually increase from 2035 through 2050. The projected trend falls considerably short of the emissions reduction that would be required to achieve both the governor's interim target of reducing GHG emissions to 40 percent below 1990 by 2030 and the long-range target of reducing GHG emissions to 80 percent below 1990 by 2050. The projected GHG emission trend varies significantly among the different components of the transportation sector. GHG emissions from heavy-duty vehicles, off-road equipment, aviation, ships and locomotives are currently projected to increase. GHG emissions from light-duty vehicles, by contrast, are projected to decline substantially; however, they will still account for the majority of total GHG emissions from the transportation sector. For more information on GHG emissions data for each of the transportation sub-sectors see Figure 3-7 in Chapter 3.

The transportation measures proposed in the 2017 Plan will decrease emissions of criteria pollutants, TACs, and GHGs by reducing demand for motor vehicle travel, promoting efficient vehicles and transit service, decarbonizing transportation fuels, and electrifying motor vehicles and equipment. As noted above, the Air District has identified a number of Bay Area communities that are disproportionately impacted by air pollution and made a commitment to prioritize actions to protect these communities. Exposure to diesel particulate matter is an important factor in defining the communities that are most impacted by air pollution. Although diesel PM emissions have already been greatly reduced, as discussed in Chapter 4, measures to further reduce emissions of diesel PM will be especially effective in further protecting public health in these communities.

Key elements of the strategy to reduce transportation emissions include the following:

- Collaborate with MTC and other partners to reduce motor vehicle travel by promoting alternative means of transportation—such as walking, bicycling and transit—and partnering with employers to expand commuter benefits.
- Collaborate with MTC, ABAG and local governments to direct future development to mixed-use neighborhoods that are well-served by transit and provide safe and convenient bicycle and pedestrian access to shopping and services.
- Continue to work with Bay Area ports and the neighboring communities to reduce emissions from the freight sector, including heavy-duty trucks, ships and locomotives.
- Accelerate the retirement of older, high-emitting vehicles.
- Rapidly expand the number and the percentage of zero-emission vehicles (battery electric and fuel cell) in the Bay Area fleet and provide the charging/fueling infrastructure needed to support them.
- Promote the use of advanced technology, zero- or near-zero emission vehicles in all vehicle types and applications.
- Collaborate with ARB to enforce regulations on key sources of transportation sector emissions, such as diesel engines, in the most impacted and vulnerable communities.
- Advocate for more stringent vehicle tailpipe emission standards and fuel economy standards at the state and federal levels for all components of the vehicle fleet.

Proposed transportation measures are briefly described in Table 5-2 .

Table 5-2. **Transportation Control Measures**

Number	Name	Pollutant	Description
TR1	Clean Air Teleworking Initiative	All Pollutants	Develop teleworking best practices for employers and develop additional strategies to promote telecommuting. Promote teleworking on Spare the Air Days.
TR2	Trip Reduction Programs	All Pollutants	Implement the regional Commuter Benefits Program (Rule 14-1) that requires employers with 50 or more Bay Area employees to provide commuter benefits. Encourage trip reduction policies and programs in local plans, e.g., general and specific plans while providing grants to support trip reduction efforts. Encourage local governments to require mitigation of vehicle travel as part of new development approval, to adopt transit benefits ordinances in order to reduce transit costs to employees, and to develop innovative ways to encourage rideshare, transit, cycling, and walking for work trips. Fund various employer-based trip reduction programs.
TR3	Local and Regional Bus Service	All Pollutants	Fund local and regional bus projects, including operations and maintenance.
TR4	Local and Regional Rail Service	All Pollutants	Fund local and regional rail service projects, including operations and maintenance.
TR5	Transit Efficiency and Use	All Pollutants	Improve transit efficiency and make transit more convenient for riders through continued operation of 511 Transit, full implementation of Clipper® fare payment system and the Transit Hub Signage Program.
TR6	Freeway and Arterial Operations	All Pollutants	Improve the performance and efficiency of freeway and arterial systems through operational improvements, such as implementing the Freeway Performance Initiative, the Freeway Service Patrol and the Arterial Management Program.
TR7	Safe Routes to Schools and Safe Routes to Transit	All Pollutants	Provide funds for the regional Safe Routes to School and Safe Routes to Transit Programs.
TR8	Ridesharing, Last-Mile Connection	All Pollutants	Promote carpooling and vanpooling by providing funding to continue regional and local ridesharing programs, and support the expansion of carsharing programs. Provide incentive funding for pilot projects to evaluate the feasibility and cost-effectiveness of innovative ridesharing and other last-mile solution trip reduction strategies. Encourage employers to promote ridesharing and carsharing to their employees.

(continued)

Table 5-2. Transportation Control Measures *(continued)*

Number	Name	Pollutant	Description
TR9	Bicycle and Pedestrian Access and Facilities	All Pollutants	Encourage planning for bicycle and pedestrian facilities in local plans, e.g., general and specific plans, fund bike lanes, routes, paths and bicycle parking facilities.
TR10	Land Use Strategies	All Pollutants	Support implementation of *Plan Bay Area,* maintain and disseminate information on current climate action plans and other local best practices, and collaborate with regional partners to identify innovative funding mechanisms to help local governments address air quality and climate change in their general plans.
TR11	Value Pricing	All Pollutants	Implement and/or consider various value pricing strategies.
TR12	Smart Driving	All Pollutants	Implement smart driving programs with businesses, public agencies and possibly schools and fund smart driving projects.
TR13	Parking Policies	All Pollutants	Encourage parking policies and programs in local plans, e.g., reduce minimum parking requirements; limit the supply of off-street parking in transit-oriented areas; unbundle the price of parking spaces; support implementation of demand-based pricing (such as “SF Park”) in high-traffic areas.
TR14	Cars and Light Trucks	All Pollutants	Commit regional clean air funds toward qualifying vehicle purchases and infrastructure development. Partner with private, local, state and federal programs to promote the purchase and lease of battery-electric and plug-in hybrid electric vehicles.
TR15	Public Outreach and Education	All Pollutants	Implement the Spare the Air Every Day Campaign including Spare the Air alerts, employer program, and community resource teams, a PEV Outreach campaign and the Spare the Air Youth Program.
TR16	Indirect Source Review	All Pollutants	Consider a rule that sets air quality performance standards for new and modified development projects.

(continued)

Table 5-2. Transportation Control Measures *(continued)*

Number	Name	Pollutant	Description
TR17	Planes	NO_X	Work with the appropriate partners to increase the use of cleaner burning jet fuel and low-NO_X engines in commercial jets arriving and departing the Bay Area.
TR18	Goods Movement	All Pollutants	Continue participation in the preparation and implementation of the Regional Goods Movement Plan. Participate in the Goods Movement Collaborative, led by the Alameda County Transportation Commission, and assist MTC in development of the Freight Emissions Action Plan.
TR19	Medium and Heavy Duty Trucks	All Pollutants	Directly provide, and encourage other organizations to provide, incentives for the purchase of 1) new trucks with engines that exceed ARB's 2010 NO_X emission standards for heavy-duty engines, 2) new hybrid trucks, and 3) new zero-emission trucks. The Air District will work with truck owners, industry, ARB, the California Energy Commission, and others to demonstrate additional battery-electric and hydrogen fuel cell zero-emission trucks.
TR20	Ocean Going Vessels	All Pollutants	Replicate the Green Ship Program that has been implemented at the ports of Los Angeles and Long Beach. Financial incentives for cleaner Tier 2 and Tier 3 ocean-going vessels to call at the ports serve as the basis of the Program. The Program was initiated as part of the San Pedro Bay Ports Clean Air Action Plan. This measure also recognizes the need to monitor progress under such programs and augment them as necessary to ensure sufficient results.
TR21	Commercial Harbor Craft	All Pollutants	Focus on assisting fleets to achieve early compliance with the CARB harbor craft air toxic control measure and supporting research efforts to develop and deploy more efficient engines and cleaner, renewable fuels for harbor craft.
TR22	Construction, Freight and Farming Equipment	All Pollutants	Provide incentives for the early deployment of electric, Tier 3 and 4 off-road engines used in construction, freight and farming equipment. Support field demonstrations of advanced technology for off-road engines and hybrid drive trains.
TR23	Lawn and Garden Equipment	All Pollutants	Seek additional funding to expand the Commercial Lawn and Garden Equipment Replacement Program into all nine Bay Area counties. Explore options to expand Lawn and Garden Equipment Program to cover shredders, stump grinders and commercial turf equipment.

Energy

The energy sector includes emissions of criteria pollutants, local air toxics and GHGs from electricity generated and used within the Bay Area, as well as GHG emissions from electricity generated outside the Bay Area that is imported and used within the region.[3] About two-thirds of the electricity consumed in the Bay Area is produced within the region and one-third is imported from other areas in and outside California.[4] On average, the energy produced within the Bay Area has a lower fossil fuel content than energy imported from outside the region.

Power plants located in the Bay Area must obtain an authority to construct and a permit to operate from the Air District that outlines the operating conditions and emission limits at each facility. Among the permit requirements imposed by the Air District is the condition that combustion equipment—such as gas turbines and heat recovery boilers—use the Best Available Control Technology (BACT) to minimize emissions. In addition, projects may be subject to emission offset requirements, Prevention of Significant Deterioration (PSD) analysis requirements and health risk screening analysis requirements. The Air District has already used these processes and procedures to establish limits on GHG emissions. For example, in issuing a PSD permit for the Russell City Energy Center in Hayward in 2010, the Air District established enforceable BACT limits on GHG emissions, making this Plant the first in the nation to be subject to GHG emission limits.

The energy sector currently accounts for an estimated 14 percent of total Bay Area GHG emissions.

The energy sector currently accounts for an estimated 14 percent of total Bay Area GHG emissions. The GHGs emitted by the energy sector are dominated by carbon dioxide (CO_2), representing approximately 99 percent of all GHGs emitted by the sector, with methane (CH_4) and nitrous oxide (N_2O) emitted in far smaller quantities. In response to the Renewables Portfolio Standard

CLEAN ELECTRICITY PROVIDES A KEY OPPORTUNITY

The carbon intensity of the electricity consumed in the Bay Area is already much lower than the national average, and our electricity will become even cleaner in future years, as a result of the state's Renewable Portfolio Standard, as well as local efforts, such as Community Choice Energy (CCE) programs. To achieve our long-range GHG reduction targets, we need to capitalize on the opportunity provided by our clean electricity by expanding the use of electricity in key sectors such as transportation (electric vehicles) and buildings (electric space heating and water heating). Since these efforts will drive up demand for electricity, the success of this strategy depends upon an aggressive effort to further reduce the carbon content of the electricity consumed in the Bay Area.

COMMUNITY CHOICE ENERGY (CCE)

California law allows cities and counties to aggregate the buying power of individual consumers in order to secure alternative energy supply contracts on a community-wide basis. As such, local governments serve as the electric power purchaser for their communities. The first community choice energy program in the Bay Area—Marin Clean Energy—was launched in 2008 with a grant from the Air District. Marin Clean Energy provides residents and businesses in Marin County, unincorporated Napa County and the cities of Benicia, El Cerrito, Richmond, San Pablo, Lafayette and Walnut Creek two choices for their electricity. One provides electricity generated with 50 percent renewable energy, the other with 100 percent renewable energy. The CCE concept has been adopted in many Bay Area cities and counties. Sonoma Clean Power began operation in 2014, San Francisco launched CleanPower SF in 2016, and Peninsula Clean Energy launched in San Mateo County in October 2016. Silicon Valley Clean Energy and Alameda County are planning to begin implementing CCE programs in 2017, and additional counties are currently exploring CCE options.

and other policies briefly described below, GHG emissions from the energy sector are projected to decrease over the next several decades. However, the projected rate of decrease falls short of the rate needed to achieve GHG reduction targets for 2030 and 2050.

California and the Bay Area have already made great strides in reducing GHG emissions from the energy sector through efforts to reduce the fossil fuel content of electricity, which also reduces emissions of criteria pollutants and TACs. California's Renewables Portfolio Standard (RPS), first established in 2002, is one of the most ambitious renewable energy standards in the country.[5] The RPS program requires investor-owned utilities, electric service providers, and community choice energy program providers to increase procurement from eligible renewable energy resources to 33 percent of total procurement by 2020, and 50 percent by 2030. In addition, large electric utilities are subject to the statewide GHG Cap-and-Trade (CAT) Program. Across California, these efforts are expected to reduce GHG emissions from regulated facilities 17 percent below 2013 levels by 2020.[6] Also, pursuant to SB 1368 (2006), the state adopted the world's first GHG emission performance standard for power-plant investments.[7]

Electricity in the Bay Area is produced, imported and delivered by a combination of an investor-owned utility (PG&E), several municipally-owned utilities, and a growing number of community choice energy programs (CCE). Three state agencies regulate the investor-owned utility (municipal utilities are not regulated by the state): the California Public Utilities Commission (CPUC), California Energy Commission (CEC), and the California Independent System Operator (CA ISO). In addition, the Federal Energy Regulatory Commission (FERC) regulates some hydropower projects and interstate electricity transmission. The CPUC has developed rules for the implementation of CCEs. Electricity production and delivery in California is a complex and heavily regulated industry. Nonetheless, there may be opportunities for the Air District to help reduce GHG emissions, both within the electricity supply chain and through consumer practices, by working to support and complement emission reduction activities at the state, utility and local power program levels.

The energy measures proposed in the 2017 Plan will reduce emissions of criteria air pollutants, TACs, and GHGs by decreasing (1) the amount of electricity consumed in the Bay Area, and (2) the carbon intensity of the electricity we use, by switching to less GHG-intensive fuel sources for electricity generation.

The strategy to decrease demand focuses on promoting energy efficiency and conservation. To that end, the Air District will:

- Conduct education and outreach about energy-efficiency programs and financing available to residents and businesses in the Bay Area.
- Increase consumer awareness about energy-efficiency benefits by incorporating this message into existing outreach programs such as Spare the Air, outreach to Bay Area schools, booths at fairs, etc.
- Work with utilities and community choice energy providers to develop messaging to decrease electricity demand during peak times.
- Distribute information on state and local energy-efficiency programs to permitted sources.

To further decarbonize the energy sector, the Air District will:

- Engage with electric utilities and CCE providers to maximize the amount of renewable energy supplied to the Bay Area.
- Support the formation or expansion of CCE programs.
- Support the development of bioenergy to displace electricity generated from fossil fuels for applications where renewable electricity is unsuitable.
- Expedite Air District permitting for new renewable energy, and high-efficiency combined heat and power (CHP) facilities, as well as for biofuel facilities where necessary.

Proposed energy measures are briefly described in Table 5-3.

Table 5-3. Energy Control Measures

Number	Name	Pollutant	Description
EN1	Decarbonize Electricity Production	All Pollutants	Engage with PG&E, municipal electric utilities and CCEs to maximize the amount of renewable energy contributing to the production of electricity within the Bay Area as well as electricity imported into the region. Work with local governments to implement local renewable energy programs. Engage with stakeholders including dairy farms, forest managers, water treatment facilities, food processors, public works agencies and waste management to increase use of biomass in electricity production.
EN2	Decrease Electricity Demand	All Pollutants	Work with local governments to adopt additional energy-efficiency policies and programs. Support local government energy efficiency program via best practices, model ordinances, and technical support. Work with partners to develop messaging to decrease electricity demand during peak times.

Direct emissions from the buildings sector accounted for approximately 10 percent of Bay Area GHG emissions in 2015.

Buildings

The buildings sector includes residential, commercial, governmental and institutional buildings. Buildings generate emissions through energy use for heating, cooling, and operating the building, and from the materials used in building construction and maintenance. Energy use in buildings typically includes electricity—often produced elsewhere—as well as natural gas combustion in building furnaces, boilers, water heaters and appliances. In addition to direct emissions from gas combustion, the buildings sector also accounts for a major share, 64 percent, of regional electricity consumption. Therefore, the buildings sector provides important opportunities to improve the efficiency of electricity usage, as discussed in the energy sector. Natural gas, fuel oil, and wood may be used for space and water heating as well as cooking. Production of building materials such as cement and steel is very energy intensive. Maintenance of buildings requires the use of products that emit air pollutants such as paint and cleaning products. Architectural coatings (primers, paint), adhesives, solvents and sealants used in buildings account for a significant amount of total ROG emissions. In addition to these emissions, the building sector produces substantial emissions of particulate matter, primarily from residential wood burning. Buildings also emit TACs from combustion of fuel and off-gassing of building materials, such as formaldehyde, and solvents used in construction and maintenance.

Direct emissions from the buildings sector accounts for approximately 10 percent of Bay Area GHG emissions in 2015.[8] Although California has very stringent energy efficiency requirements for new construction, as discussed in Chapter 4, most of the existing building stock is not subject to these requirements. Almost 70 percent of the housing units in the Bay Area were built prior to 1980. This means that most residential structures in the Bay Area are not required to meet even the earliest energy efficiency standards. Improving energy efficiency in the existing building stock provides a significant challenge and an important opportunity. To achieve the long-range GHG reduction targets, existing residential and commercial buildings will need to switch from fossil fuels to low-carbon electricity (or ground-source heat pumps) for space heating and water heating. The control measure implementation actions for the building sector therefore emphasize actions to reduce the energy use in existing buildings, as well as increasing on-site renewable energy generation to reduce demand for electricity from the grid.

New construction is also important, since buildings constructed in coming years will remain in use for many decades. Because buildings are very long-lasting, failure to require best available measures today will mean a missed opportunity for years to come. One of the key strategies to achieve the 2050 GHG reduction targets recommended in the final report for the Bay Area consumption-based GHG emissions inventory is that all new buildings should be required to use electricity (or other non-carbon-based power) for space heating and water heating.[9]

SOLAR MASTER PLANS FOR SCHOOLS

With support from the Air District, KyotoUSA is helping school districts across the Bay Area reduce greenhouse gas emissions by switching to solar power, saving millions of dollars in utility bills that can be invested in the education and well-being of our children. Many school districts have considered installing solar systems, but have not moved forward because of a lack of knowledge, uncertainty about the cost, and uncertainty about whether solar panels would provide any real economic benefit to the school district. Through this partnership, KyotoUSA provides free assessments to Bay Area school districts to determine their potential solar capacity and financing options. KyotoUSA develops these initial assessments into Solar Master Plans for school districts that provide information on:

- the installed cost of PV systems
- the overall savings (annual and over 25 years)
- how much electricity will be generated
- how different financing options affect the payback period and overall savings
- how much greenhouse gas emissions are eliminated

Via this partnership with the Air District, KyotoUSA has provided solar investment information to 58 Bay Area school districts covering hundreds of schools and thousands of students through the end of 2016. Across the Bay Area more than 50 solar installations are in process.

The Air District has authority to regulate emissions from certain sources in buildings such as boilers and water heaters, but has limited authority to regulate buildings themselves. Therefore, the strategies in the control measures for this sector focus on working with local governments, that do have authority over local building codes, to facilitate adoption of best GHG control practices and policies.

The proposed control measures for the buildings sector, which are briefly described in Table 5-4, will reduce emissions of air pollutants and GHGs by:

- Increasing the scope and pace of programs to improve the energy efficiency of existing buildings;
- Promoting the use of electricity and on-site renewable energy in both existing and new buildings to reduce fossil fuel consumption; and
- Working to ensure that new construction is designed to achieve zero net GHG emissions by 2020 (or the earliest possible date).

Table 5-4. **Buildings Control Measures**

Number	Name	Pollutant	Description
BL1	Green Buildings	All Pollutants	Collaborate with partners such as KyotoUSA to identify energy-related improvements and opportunities for on-site renewable energy systems in school districts; investigate funding strategies to implement upgrades. Identify barriers to effective local implementation of the CALGreen (Title 24) statewide building energy code; develop solutions to improve implementation/enforcement. Work with ABAG's BayREN program to make additional funding available for energy-related projects in the buildings sector. Engage with additional partners to target reducing emissions from specific types of buildings.
BL2	Decarbonize Buildings	All Pollutants	Explore potential Air District rulemaking options regarding the sale of fossil fuel-based space and water heating systems for both residential and commercial use. Explore incentives for property owners to replace their furnace, water heater or natural-gas powered appliances with zero-carbon alternatives. Update Air District guidance documents to recommend that commercial and multi-family developments install ground source heat pumps and solar hot water heaters.
BL3	Market-Based Solutions	All Pollutants	Implement a call for innovation to support market-based approaches that bring new, viable solutions to significantly reduce GHG emissions associated with existing buildings.
BL4	Urban Heat Island Mitigation	All Pollutants	Develop and urge adoption of a model ordinance for "cool parking" that promotes the use of cool surface treatments for new parking facilities, as well existing surface lots undergoing resurfacing. Develop and promote adoption of model building code requirements for new construction or re-roofing/roofing upgrades for commercial and residential multi-family housing. Collaborate with expert partners to perform outreach to cities and counties to make them aware of cool roofing and cool paving techniques, and of new tools available.

Agriculture

The Bay Area currently has more than 8,500 agricultural operations that produce a diversity of fruits, vegetables, meat, dairy products and wines. The Bay Area agricultural sector is predominantly comprised of small farms selling niche products locally.[10] Over the past 50 years, a large amount of agricultural land has been converted to urban/suburban uses in the Bay Area, with losses of over one-third of farmland.

Sources of air pollution from agricultural operations include on and off-road trucks and farming equipment, aircraft for crop spraying, animal waste, pesticide and fertilizer use, crop residue burning, travel on unpaved roads and soil tillage. Although these activities emit a wide range of air pollutants, including ozone precursors (ROG and NO_X), particulate matter, ammonia, hydrogen sulfide and nitrogen, the agricultural sector accounts for a small portion of overall Bay Area air pollutant emissions.

The agricultural sector also accounts for a small portion, roughly 1.5 percent, of the Bay Area GHG emissions inventory. The GHGs from agriculture include methane and nitrous oxide, in addition to carbon dioxide. Methane emissions from animal waste in the form of enteric fermentation and manure management account for the majority (62 percent) of GHG emissions from the agriculture sector. As discussed in Chapter 3, reducing emissions of super-GHGs presents a key opportunity to reduce global warming in the near term. Since methane is one of the leading super-GHGs, the Air District will maximize opportunities to reduce methane emissions through the agricultural sector control measures.

Table 5-5. Agriculture Control Measures

Number	Name	Pollutant	Description
AG1	Agricultural Guidance and Leadership	GHG	Reduce GHGs from the agriculture sector, including working to obtain funding for on-farm GHG reduction activities; promoting carbon farm plans; providing guidance to local governments on including carbon-based conservation farming measures and carbon sequestration in local climate actions plans; and conducting outreach to agriculture businesses on best practices, including biogas recovery, to reduce GHG emissions.
AG2	Dairy Digesters	GHG	Promote implementation of dairy digester facilities (also known as biogas recovery) at farms to capture methane as an energy source and to reduce methane emissions.
AG3	Enteric Fermentation	GHG	Promote dietary strategies and grazing management measures to reduce methane emissions from enteric fermentation.
AG4	Livestock Waste	PM, ROG, ammonia	Require best management practices already being implemented in the SJVAPCD and SCAQMD to be applied at Bay Area dairies and other confined animal facilities.

The Air District regulates agricultural (biomass) burning via Regulation 5, but has limited direct regulatory authority over agricultural equipment and soil management. The proposed agricultural measures focus on reducing criteria pollutants and GHG emissions by:

- Requiring/and or promoting best practices for manure management and farming techniques to reduce criteria and GHG emissions;
- Developing partnerships with the agricultural community to encourage voluntary actions to reduce GHG emissions;
- Capturing GHGs by means of carbon sequestration and biogas recovery; and
- Providing grants and monetary incentives for dairy digesters or other equipment or practices that reduce GHG emissions.

Open space and agricultural preservation will be addressed through implementation of *Plan Bay Area,* specifically through protection of Priority Conservation Areas (see TR10: Land Use Strategies).

The proposed agriculture measures are briefly described in Table 5-5.

Natural and Working Lands

The natural and working lands sector, including forests, woodlands, shrub lands, grasslands, rangelands, and wetlands, encompasses 2.8 million acres, nearly two-thirds of the Bay Area's land mass.[11] Approximately two-thirds of this undeveloped land (1.9 million acres) functions as rangeland suitable for livestock grazing.[12]

While the other economic sectors addressed in the 2017 Plan focus on preventing emissions of CO_2 or other GHGs, the natural and working lands sector provides an opportunity to actually remove carbon from the atmosphere. Depending upon how the soil and vegetation on the various types of lands are managed, they can either absorb or "sequester" carbon from the atmosphere, or they can release stored carbon to the atmosphere when soil, vegetation or wetlands are disturbed or disrupted. When properly managed, most lands within the natural and working lands sector help to mitigate global warming by sequestering carbon. Research by the Marin Carbon Project (MCP), a local consortium of agricultural producers, academic researchers, and government agencies, demonstrated that applying compost on grazed rangelands can significantly increase plant growth, water retention in the soil, and soil carbon sequestration. In addition to removing CO_2 from the atmosphere, carbon sequestration improves soil and water quality, reduces water use, soil erosion and nutrient loss, and may improve crop yields by increasing the amount of carbon stored in agricultural soils. The Air District has been working with the MCP to promote the potential of compost amendments to grazed rangelands as a method to sequester carbon.

The control measures for the natural and working lands sector focus on increasing carbon sequestration on rangelands and wetlands. In addition, measure NW2 will promote urban tree-planting in order to absorb CO_2, provide shade to reduce urban heat island effects, and increase carbon sequestration in urban areas. The tree-planting measure also has social equity benefits, since lower-income communities typically have fewer street trees than higher income communities.[13] Tree-plantings in low-income communities can improve air quality and mitigate the impacts of climate change (e.g., heat waves). Street trees can also help to improve the aesthetic appearance and enhance property values in urban areas. Therefore, planting trees in disadvantaged communities can provide multiple benefits to their residents.

The proposed natural and working lands measures are briefly described in Table 5-6.

Table 5-6. Natural and Working Lands Control Measures

Number	Name	Pollutant	Description
NW1	Carbon Sequestration in Rangelands	GHG	Include off-site mitigation of GHG emissions through carbon sequestration projects in the Air District's CEQA guidance and comments. Develop climate action plan guidance and/or best practices on soil management for local agencies and farmers and their associations to maximize GHG sequestration on rangelands.
NW2	Urban Tree Planting	Criteria pollutants, GHG	Develop or identify an existing model municipal tree planting ordinance and encourage local governments to adopt such an ordinance. Include tree planting recommendations the Air District's technical guidance, best practices for local plans and CEQA review.
NW3	Carbon Sequestration in Wetlands	GHG	Identify federal, state and regional agencies, and collaborative working groups that the Air District can assist with technical expertise, research or incentive funds to enhance carbon sequestration in wetlands around the Bay Area. Assist agencies and organizations that are working to secure the protection and restoration of wetlands in the San Francisco Bay.

Waste Management

The waste management sector includes GHG emissions from landfills and composting activities. A variety of air pollutants are produced as waste decomposes in landfills and composting operations. On average, landfill gas contains 55 percent methane and 40 percent carbon dioxide, with the remaining 5 percent composed of other gases. When landfill gas is collected and burned in internal combustion engines or flares, methane is reduced, but additional pollutants, such as NO_X, are created. Composting is also a source of methane and CO_2, as well as ROG, particulate matter and ammonia. Compost facilities and landfills can produce odors if they are not operated and maintained rigorously.

REDUCING FOOD WASTE

Food scraps and other organic waste do not belong in landfills. Yet, the Bay Area still throws away more than 1 million tons of food each year. Reducing food waste and facilitating donations of unused food to food banks should be the first priority. Any food that cannot be consumed, however, should be directed to centralized compost and anaerobic digestion facilities that use best management practices to contain emissions and odors. Besides producing methane that can be used as fuel, composting organic waste provides a valuable resource that can sequester carbon and greatly improve soil conditions in gardens, farms and rangelands.

The waste management sector has achieved significant emission reductions in the past several decades in response to new laws and regulations limiting emissions from waste facilities, as well as voluntary waste diversion programs that seek to reduce the amount of refuse material going into the waste stream. Key contributors to this trend have been the significant increase in recycling and other waste stream diversion programs implemented at the local level since 1990, as well as regulations adopted by the Air Resources Board and Air District to control emissions from landfills and composting facilities. The Air District's Regulation 8, Rule 34 limits emissions of methane and non-methane compounds at solid waste disposal sites. Currently, there is no Air District rule regulating GHG emissions from compost facilities. However, through its permitting program, the Air District does impose conditions on composting facilities to address emissions of other air pollutants; these conditions can also reduce GHG emissions.[14]

In the Bay Area, GHG emissions from landfills have been declining, and are projected to continue to decrease. Nonetheless, landfills remain the largest source of GHGs from the waste management sector, due to methane from the uncontrolled decomposition of organic materials, as well as the fact that landfills are much larger in scale than composting facilities. In addition to reducing GHG emissions, composting organic waste, rather than sending it to landfills, provides other benefits.[15] Applying compost to gardens and urban landscapes reduces the need for artificial fertilizers and pesticides.[16] Applying compost to rangeland can also increase carbon sequestration, as described in the Natural and Working Lands section. In addition, compost reduces the amount of water needed in agricultural operations and landscaping.

This Plan emphasizes the need for early and aggressive action to reduce emissions of methane and other super-GHGs. To this end, the proposed waste management sector measures focus on reducing or capturing methane emissions from landfills and composting facilities, diverting organic materials away from landfills, and increasing waste diversion rates through efforts to reduce, reuse and recycle.

Table 5-7 provides a brief description of the proposed waste management measures.

Table 5-7. **Waste Management Control Measures**

Number	Name	Pollutant	Description
WA1	Landfills	GHG, ROG, TACs	Propose amendments to Air District Rule 8-34 to increase stringency of emission limits, including fugitive leak standards, and improve consistency with federal rules.
WA2	Composting and Anaerobic Digesters	GHG, ROG, PM	Develop an Air District rule that includes emission limits based on best practices in other areas of the state.
WA3	Green Waste Diversion	All Pollutants	Develop model policies to facilitate local adoption of ordinances and programs to reduce the amount of green waste going to landfills.
WA4	Recycling and Waste Reduction	GHG	Develop or identify and promote model ordinances on community-wide zero waste goals and recycling of construction and demolition materials in commercial and public construction projects.

Water

Over 400 billion gallons of water are used in the Bay Area each year to support residential, commercial, agricultural and industrial activities.[17] Water use results in criteria air pollutant and toxic air contaminants emissions, as well as GHG emissions. Greenhouse gases are emitted from the water sector directly and indirectly. Sixty percent of GHGs in this sector (primarily methane) are *directly* emitted from the treatment of water and wastewater at publicly owned treatment works (POTWs). Forty percent of the GHG emissions associated with water use (primarily carbon dioxide) are generated *indirectly,* as a result of the energy used to pump, convey, recycle, and treat water and wastewater throughout the Bay Area.

Combustion of fossil fuels and digester gas for the operation of engines, boilers and turbines at POTWs emits criteria pollutants and TACs. The Air District regulates these sources through its permitting process and requires the implementation of Best Available Control Technology (BACT) to control these emissions. In addition, POTWs must comply with state water regulations that have reduced emissions of toxics, such as mercury and silver in recent decades. The expansion of anaerobic digester systems at POTWs in recent years helps to reduce GHG emissions, but may increase emissions of criteria pollutants and TACs.

The water sector accounts for a small portion, approximately 1 percent, of Bay Area GHG emissions. GHG emissions from the water sector are currently projected to slightly increase through 2030. However, the state is implementing policies to improve water-use efficiency and increase conservation that may achieve overall GHG emission reductions in the water sector when fully implemented.

The proposed control measures to reduce emissions from the water sector will reduce emissions of criteria pollutants, TACs, and GHGs by encouraging water conservation, limiting GHG emissions from POTWs, and promoting the use of biogas recovery systems.

Table 5-8 provides a brief description of the water sector measures.

Table 5-8. **Water Control Measures**

Number	Name	Pollutant	Description
WR1	Limit GHGs from POTWs	GHG, ROG, TACs	Initiate a process to better understand and quantify GHG emissions at POTWs. Explore rulemaking to reduce GHGs emitted directly within POTWs. Promote the use of biogas recovery systems at POTWs.
WR2	Support Water Conservation	GHG	Develop a list of best practices that reduce water consumption and increase on-site water recycling in new and existing buildings; incorporate into local planning guidance.

Super-GHGs

Super-GHGs include methane, black carbon and fluorinated gases (F-gases). The compounds are sometimes referred to as short-lived climate pollutants (SLCPs) because their lifetime in the atmosphere is generally fairly short. However, for the purpose of climate planning, their principal characteristic is that they have very high global warming potential on a per-unit basis, in comparison to CO_2. Reducing emissions of super-GHGs is a key priority for this control strategy, because this approach represents our best opportunity to slow the rate of global warming in the near term, as discussed in Chapter 3.

Methane: Methane accounts for the second largest share, after CO_2, of the Bay Area GHG inventory. Three source categories in the Bay Area GHG inventory are estimated to account for 90 percent of total methane emissions: landfills (50 percent), animal waste (27 percent), and natural gas production and distribution (13 percent). Recent research suggests that methane emissions from some source categories may be significantly

Methane accounts for the second largest share, after CO_2, of the Bay Area GHG inventory.

underestimated. Therefore, to inform its methane control efforts, the Air District is expanding its monitoring of Bay Area methane concentrations and working to improve its methane emissions inventory.

Bay Area methane emissions are currently projected to decrease slowly from 2015 through 2030. However, the projected decrease is far short of the amount that would be needed to reduce methane emissions commensurate with the GHG reduction goals for years 2030 and 2050.

Measures to reduce methane are addressed on a sector-by-sector basis in this Plan. Methane emissions from landfills are addressed in the waste management sector. Methane emissions from animal waste are discussed in the agricultural sector. Methane emissions from natural gas extraction and distribution are addressed in the stationary source sector. To reduce methane emissions from landfills and composting operations (waste management sector), the Air District will propose a rule for limiting emissions from composting facilities and propose amendments to Air District Rule 8-34 to strengthen requirements to reduce methane emissions at landfills. To reduce methane emissions from animal waste (agricultural sector), the Air District will promote the use of biogas recovery/anaerobic digester systems at farms. To reduce methane emissions from natural gas production and distribution, the Air District will collaborate with the California PUC and ARB to implement a natural gas “leak detection repair, rehabilitation and replacement” (LDAR) program (see SS13, SS14 and SS15).

WHOLE FOODS – CLIMATE FRIENDLY REFRIGERATION

Some of the most potent greenhouse gases—what we call super-GHGs—are used every day in refrigeration and air conditioning systems. Bay Area businesses are stepping up to take voluntary actions to find alternatives. For example, Whole Foods Markets is testing natural refrigerants—including CO_2, propane and ammonia—in several Bay Area grocery stores. Although CO_2 and propane are themselves greenhouse gases, they are thousands of times less potent than the hydrofluorocarbons that are the most commonly used refrigerants today. Not only are natural refrigerants significantly more climate-friendly, Whole Foods is also expecting the new systems to operate more efficiently and result in cost savings for the entire store. The newest system, in Santa Clara—the nation’s first propane/CO_2 “cascade” refrigeration system—uses heat recovered from the refrigeration system for space heating and to preheat water. Whole Foods is also testing climate-friendly systems in Berkeley, San Jose, Dublin and many other locations. The pilot test results will help Whole Foods determine the best type of system to use in different stores and climates. Innovation and leadership from the private sector is critical to moving the economy toward a climate-friendly future.

Black Carbon (BC): BC is a climate pollutant and a component of particulate matter that also harms public health. Diesel engines and wood burning devices (fireplaces and stoves) are the leading sources of BC in the Bay Area. BC emissions in the Bay Area decreased by 54 percent from 1990 through 2015 as a result of efforts by ARB and the Air District to reduce emissions from heavy-duty diesel engines, and the Air District's efforts to reduce wood burning during winter months. Bay Area BC emissions are projected to continue decreasing through 2020. However, in the absence of additional control measures, BC emissions are projected to increase beyond 2020 as Bay Area population increases and the number of diesel engines in service grows.

To further reduce BC emissions, the Air District will propose amendments to its general PM requirements (Rule 6-1) to place more stringent limits on PM emissions from stationary sources; continue to enforce ARB regulations to reduce PM emissions from diesel engines in the Bay Area communities most impacted by PM emissions; continue and enhance its program to reduce residential wood burning; and provide grants and incentives to reduce emissions of particulate matter and BC from heavy-duty vehicles.

Fluorinated gases: F-gases include a variety of compounds, most of which have a global warming potential (GWP) thousands of times greater than CO_2 on a per-unit basis. The 2017 Plan addresses hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6), which are generated by a variety of industrial processes and do not exist in nature. HFCs were introduced to replace chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), which were targeted for phase-out under the Montreal Protocol due to their ozone-depleting characteristics. Statewide, total F-gas emissions were reduced by 57 percent from 1990 through 2013, as CFCs and HCFCs began to be phased out to protect the stratospheric ozone layer. However, emissions of HFCs, which were introduced to replace CFCs and HCFCs in many refrigeration and air conditioning applications, have increased greatly over the past 20 years. To reduce future HFC emissions, in October 2016, international negotiators reached an important binding agreement, amending the 1987 Montreal Protocol, to phase out the production and use of HFCs. In addition, some 50 nations, including the U.S. and 50-plus partner organizations, have joined the *Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants.*

To reduce F-gas emissions, the Air District will continue to support regulations that restrict the production, purchase and sale of high-GWP refrigerants as new low-GWP refrigerants are brought to market. Current regulations for existing commercial and industrial refrigeration systems also need to be enforced and strengthened to further reduce leaks of F-gases. To that end, the Air District will continue to enforce ARB regulations to control HFC emissions from commercial refrigeration systems in the Bay Area.

Incentivizing early adoption of low-GWP refrigerants in new equipment and retrofits used in commercial, industrial and residential sectors can also play an important role. To eliminate high-GWP refrigerants in motor vehicle air conditioning systems, the Air District promotes measures such as accelerating the turnover of older vehicles through its vehicle buy back program. Low-GWP refrigerants for automobiles are available now and will be required in new cars sold in the U.S. starting in 2021. The Air District also encourages better recovery, reclamation and recycling of refrigerants from all mobile and stationary refrigeration and air conditioning systems. In addition, the Air District will provide technical assistance to encourage local agencies to include appropriate measures to reduce super-GHG emissions in their climate action plans.

Table 5-9 provides a brief description of the proposed super-GHG measures. Measures to reduce super-GHG emissions are also included in Table 5-1 (stationary source sector), Table 5-5 (agriculture sector), and Table 5-7 (waste management sector).

Table 5-9. **Super-GHG Control Measures**

Number	Name	Pollutant	Description
SL1	Short-Lived Climate Pollutants	GHG, including black carbon	Reduce methane from landfills and farming activities through various control measures listed under waste and agriculture sectors. Develop a rule to reduce methane emissions from natural gas pipelines and processing operations, and amend regulations to reduce emissions of methane and other organic gases from equipment leaks at oil refineries. Enforce applicable regulations on the servicing of existing air conditioning units in motor vehicles, support the adoption of more stringent regulations by CARB and/or U.S. EPA, and encourage better HFC disposal practices.
SL2	Guidance for Local Planners	GHG	Track progress in adoption and implementation of super-GHG reduction measures in local plans and programs.
SL3	GHG Monitoring and Emissions Measurement Network	GHG	Develop a GHG air monitoring plan for the Bay Area that includes strategic selection of measurement locations, selection of relevant measurement technologies and procurement of appropriate GHG instrumentation, calibration gas standards and sampling logistics. Establish, operate and maintain the GHG air monitoring network. Collaborate with the scientific community to use different methods to estimate methane emissions in the Bay Area and identify sectors and areas for focused measurement study.

Further Study Measures

In reviewing potential control measures for the 2017 Plan, the Air District identified a number of potential measures that appear to have merit but need further evaluation before they can be included as formal control measures. These measures have been included as further study measures (FSMs). Measures have been classified as FSMs for a variety of reasons, including insufficient emissions data for the targeted source, uncertainty as to the cost-effectiveness of a measure, or because the proposed control technology has not been adequately demonstrated. By designating measures as FSMs, the Air District commits to continue to evaluate these measures. However, the District makes no commitment to actually adopt or implement any FSM as a formal control measure unless and until the measure has been demonstrated to be feasible pursuant to the control measure evaluation criteria specified in the Health & Safety Code. Further study measures are briefly described in Table 5-10.

Table 5-10. **Further Study Measures**

Number	Name	Pollutant	Description
Stationary Source			
FSM_SS1	Internal Combustion Engines	NO_X	Consider lower NO_X emission limits for some categories of internal combustion (IC) engines.
FSM_SS2	Boilers, Steam Generator and Process Heaters	NO_X	Examine the possibility of further emission reductions from Boilers, Steam Generators and Process Heaters from 2MM to 5MM BTU/hr in size.
FSM_SS3	GHG Reductions from Non-Cap-and-Trade Sources	GHG	Use quantitative analysis to find greenhouse gas (GHG) reduction opportunities from stationary sources that are not covered under the ARB's Cap-and-Trade Program.
FSM_SS4	Methane Exemptions from Wastewater Regulation	GHG	Conduct research and testing to identify significant methane sources in the refinery wastewater collection systems and to determine how these sources may be minimized or controlled. In addition, investigate if non-refinery wastewater systems have significant methane emissions and quantify potential emission reductions for methane, as well as for ROG, in order to determine if Rule 8-8 should be expanded to additional non-refinery sources.
FSM_SS5	Controlling SSMM Emissions	NO_X, PM, SO_2, ROG, TAC	Reduce emissions by considering implementing requirements to minimize start-up, shutdown, maintenance, and malfunction (SSMM) emissions through abatement technology, equipment design considerations, revised activity scheduling or planned redundancy.
FSM_SS6	Carbon Pollution Fee	GHG	Explore options for placing a fee or tax on fossil fuels based on the carbon intensity of the fuel.
FSM_SS7	Vanishing Oils and Rust Inhibitors	ROG	Research ROG reductions from vanishing oils and rust inhibitors.
FSM_SS8	Dryers, Ovens and Kilns	NO_X	Seek further emission reductions of NO_X from combustion devices that are currently exempt from the requirements of Rule 9-7.
FSM_SS9	Omnibus Rulemaking to Achieve Continuous Improvement	GHG	This measure seeks to accelerate the pace of greenhouse gas (GHG) emission reductions in the Bay Area by exploring the feasibility of broad-sweeping, or "omnibus," rulemaking.

(continued)

Table 5-10. **Further Study Measures** *(continued)*

Number	Name	Pollutant	Description
		Buildings	
FSM_ BL1	Space Heating	NO_X	Research the viability of reducing NO_X emission from furnaces rated above 175,000 BTU/hr that are found in multi-family residential buildings and large commercial spaces.
		Agriculture	
FSM_ AG1	Wineries	ROG	Review emissions generated by fermentation at wineries and breweries to determine if reductions can be achieved.

What the 2017 Plan Will Accomplish

To achieve the goals of protecting public health and protecting the climate, the 2017 Plan proposes an integrated, multi-pollutant control strategy to reduce emissions of key air pollutants and greenhouse gases. While achieving the region's long-term air quality and climate protection goals will require aggressive and sustained action by all members of society and all sectors of the economy, the 2017 control strategy focuses on what the Air District can do over the next three to five years to reduce air pollution and to achieve GHG reductions needed by 2020 and to set the region on a path toward the longer-term goals. By addressing all economic sectors and emission source categories consistent with the Air Resources Board's 2014 Scoping Plan, and drawing upon the full range of tools and resources available to the Air District, this control strategy includes all feasible measures that the Air District can take, within its current statutory authority, to reduce emissions of air pollutants and greenhouse gases. The anticipated benefits of the Plan in protecting public health and protecting the climate are discussed below from both a qualitative and quantitative perspective.

Protecting Public Health

To protect public health, the 2017 Plan reinforces the Air District's commitment to focus our air quality efforts on reducing the air pollutants that pose the greatest health risk to Bay Area residents. As noted in Chapter 2, fine particulate matter ($PM_{2.5}$) poses the greatest health risk for Bay Area residents. The control strategy includes a comprehensive set of measures to reduce PM emissions from a wide

The 2017 Plan also represents a concerted effort to reduce multiple pollutants from the Bay Area's five oil refineries.

range of emission sources. For stationary sources alone, the control strategy includes the following measures that will help to reduce emissions of PM and/or PM precursors: SS1, SS4, SS7, SS8, SS11, SS18, SS19, SS24, SS31, SS32, SS33, SS34, SS35, SS36, SS37 and SS38.

The control strategy also focuses on reducing emissions and population exposure in the Bay Area communities that are most impacted by air pollution. For example, the proposed control measures to further reduce emissions of particulate matter and toxic air contaminants from key sources, such as oil refineries (see measures SS1 through SS12), diesel engines (see measures SS32, TR18 and TR19), and wood burning (see measure SS34), will all help to reduce population exposure to the most harmful air pollutants in the impacted communities. To protect these communities, the Air District will also prioritize implementation of measures to reduce toxics from new and existing facilities (SS20 and SS21). In addition to reducing disparities in health risks between communities, the control strategy also aims to advance equity in a broader sense. For example, as discussed above, by promoting urban tree-planting, control measure NW2 can help to clean the air, mitigate local heat island effects, and improve the overall quality of life in impacted communities.

The 2017 Plan also represents a concerted effort to reduce multiple pollutants from the Bay Area's five oil refineries. At least 12 control measures in this Plan are designed to reduce refinery emissions of particulate matter, ozone precursors, toxic air contaminants and GHGs. In addition to directly reducing emissions, the Air District's Refinery Emissions Reduction Strategy also addresses these emissions through monitoring, best practices and health risk assessments. Building upon previous refinery regulations, this set of measures, taken as a whole, constitutes one of the most aggressive strategies to reduce oil refinery emissions in the country.

Emissions of ROG, NO_X and $PM_{2.5}$ have been decreasing steadily over the past several decades, in response to existing regulations and policies, and turnover in the motor vehicle fleet. The 2017 control strategy will provide additional emission reductions, over and above any built-in emission reductions from the existing control program in future years. In aggregate, the proposed control measures are expected to reduce emissions of ROG by 11 tons per day, NO_X by 9.3 tons per day, and $PM_{2.5}$ by 3.1 tons per day in 2030. (Actual emission reductions are expected to be higher, because Air District staff has not yet been able to estimate the emission reduction for a number of measures.)

The estimated health benefits of the reductions in emissions of ozone precursors, particulate matter, and toxic air contaminants from the proposed control strategy as a whole, based on the multi-pollutant evaluation method (MPEM) described in Appendix C, are shown in the "Cases Avoided" column in Table 5-11. The table also provides the estimated dollar value of the health costs and premature mortality that will be avoided as a result of the reduction in emissions, based on the valuations described in Appendix C. The total estimated benefit in terms of reduced incidence of illness and premature mortality is on the order of $736 million per year. Because there is a high cost associated with premature mortality, and exposure to fine particulate matter ($PM_{2.5}$) accounts for nearly all the premature mortality, reductions in emissions of $PM_{2.5}$ and PM precursors (such as ammonia and sulfur dioxide) account for the majority of the estimated value of the health benefits.

Table 5-11. Estimated Health Benefits and Dollar Value of 2017 Control Strategy

Health Endpoint	Cases Avoided	Dollar Value
Premature Mortality	76	$700,232,000
Nonfatal Heart Attacks	44	$3,810,000
Hospital admissions	16	$840,000
Asthma Emergency Room Visits	29	$14,000
Chronic Bronchitis	47	$23,645,000
Acute Bronchitis	249	$156,000
Respiratory Symptoms	10,189	$412,000
Lost Work Days	9,128	$2,284,000
Minor Restricted Activity Days	51,403	$4,567,000
Total Estimated Dollar Value		**$735,960,000**

Protecting the Climate

The 2017 Plan expands and deepens the Air District's existing efforts to protect the climate by defining a comprehensive regional climate protection strategy. This strategy will reduce GHG emissions in the near term and serve as a roadmap toward the GHG reduction targets for 2030 and 2050. In addition to moving aggressively within the Air District's statutory authority to limit emissions from stationary sources, the economic sector framework used to develop the proposed control strategy broadens the scope of the Air District's climate protection activities into sectors in which the Air District may have limited authority to adopt regulations, but which are appropriate focuses for Air District policy intervention, such as transportation, energy, waste, agriculture, natural and working lands, buildings and water. In crafting the proposed control measures, Air District staff will apply technical and policy expertise in these sectors that should prove useful in encouraging other entities that have direct control or influence over these GHG emissions to adopt new technologies, policies and approaches needed to fully implement the control strategy.

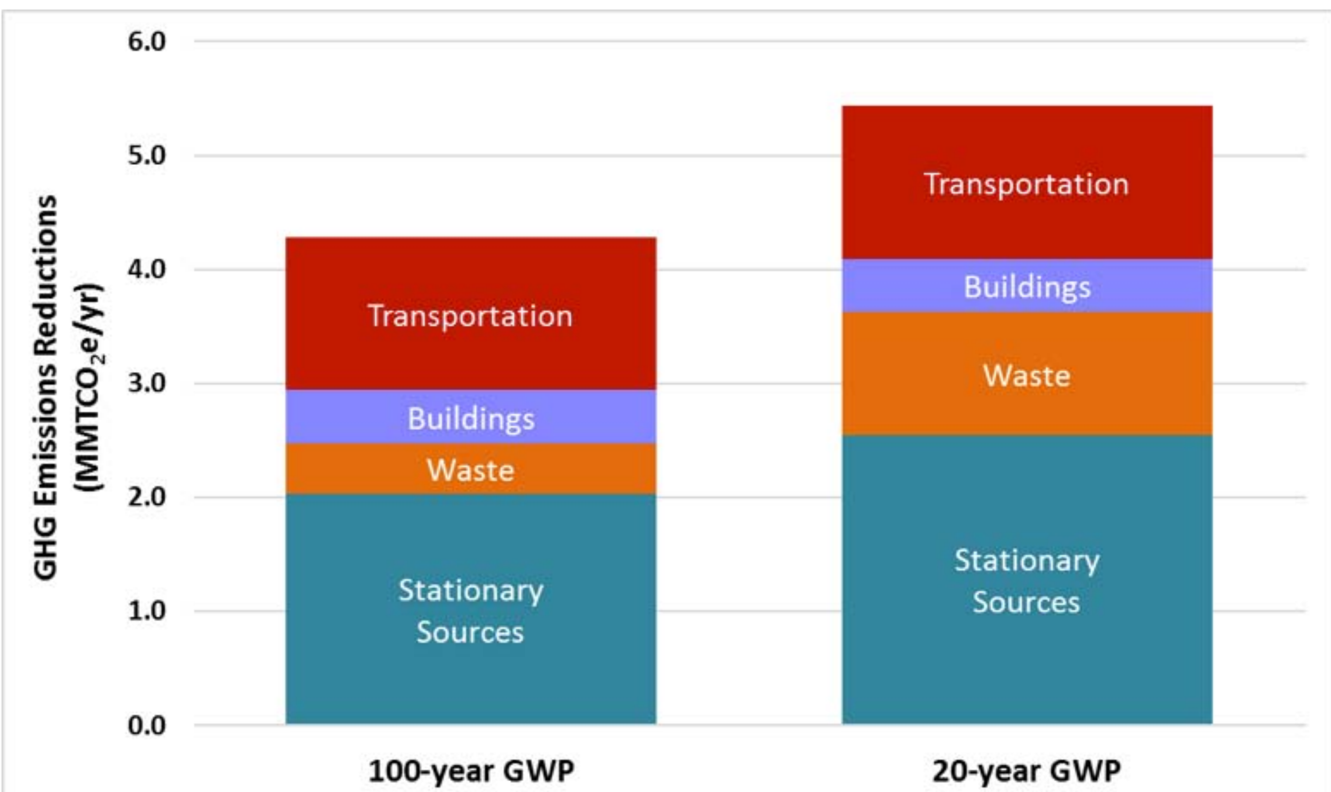
The Air District's GHG reduction efforts to date have primarily focused on reducing emissions of carbon dioxide. Although reducing CO_2 will continue to be a major focus of our climate protection strategy, the 2017 Plan also breaks new ground by emphasizing the importance of moving quickly to reduce emissions of super-GHGs such as methane, black carbon and fluorinated gases.

In the course of developing the 2017 Plan, the Air District collaborated with the UC Berkeley Cool Climate Network to prepare a consumption-based GHG emissions inventory for the region as a whole, as well as for each city and county in the Bay Area, as discussed in Chapter 3. The consumption-based inventory describes the magnitude and composition of GHG emissions embedded in the goods and services consumed by Bay Area residents. This information is already helping to inform local climate planning in the region, and can be used to educate Bay Area residents, agencies, and businesses about effective action they can take to reduce their own GHG footprint.

The estimated reductions in Bay Area GHG emissions from the proposed control strategy, broken down by economic sector, are shown in Figure 5-1. The GHG reduction measures in the proposed control strategy are estimated to reduce approximately 4.4 million metric tons (MMT) of CO_2e per year by 2030, based on 100-year GWP factors. The emissions reductions are estimated to be 5.6 MMT of CO_2e per year by 2030 if the emissions reductions are calculated based on 20-year GWP factors. Emission reductions estimates for individual control measures, for both criteria air pollutants and GHGs, and the approach used to generate those estimates, are described in Appendix H. Please note that, because emission reductions could not be estimated for a number of the control measures, the reductions shown in Figure 5-1 underestimate the total reductions that will eventually be achieved from the control strategy.

Air District staff expects the proposed control measures to provide important GHG reduction benefits, both by directly reducing emissions through their implementation, and also by supporting or stimulating action by others. However, the Air District expects that the full benefit of the proposed measures will ultimately be greater than quantified here. The emission reduction estimates provided here are deliberately conservative.

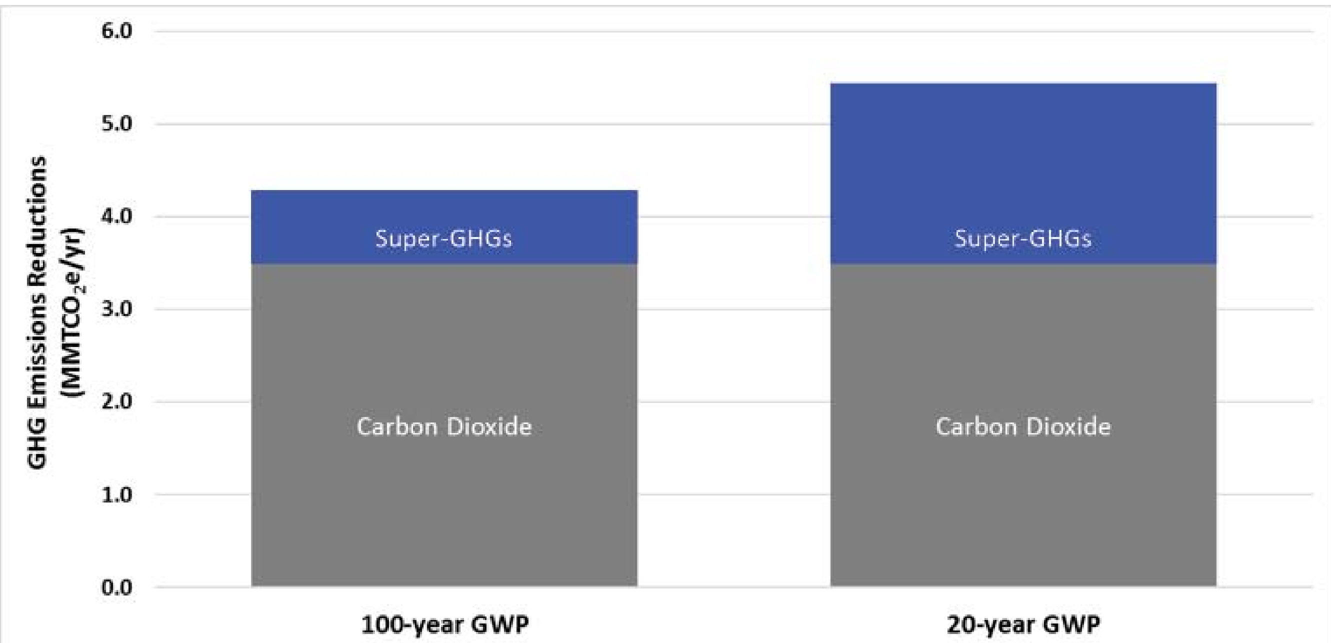
Figure 5-1. Estimated 2030 GHG Emission Reductions from Control Strategy by Economic Sector



The analysis uses cautious assumptions about the extent of the measures' direct impacts, and also does not quantify potential secondary effects in supporting activities by other entities. But we believe that the set of control measures proposed in this Plan represents a broad range of effective and appropriate actions that we can take to reduce GHG emissions and to support critical policies and programs implemented by other key actors.

Figure 5-2 shows the estimated Bay Area GHG emissions reductions by climate pollutant. The super-GHG emissions are primarily methane, along with a small amount of HFC emissions. Some control measures will also reduce black carbon (as a component of fine PM); however, black carbon emission reductions are not included in the super-GHG data in Figure 5-2.

Figure 5-2. **Estimated 2030 GHG Emissions Reductions from Control Strategy by Climate Pollutant**



Economists use a term called the "social cost of carbon" to estimate the monetary benefit of reducing GHG emissions...

Economists use a term called the "social cost of carbon" to estimate the monetary benefit of reducing GHG emissions in terms of avoiding or mitigating the global warming and climate change impacts that would otherwise occur. Using a social cost of \$62 per metric ton of CO_2e reduced, per U.S. EPA guidance, the anticipated GHG reductions from the 2017 Plan control strategy will have a value of approximately \$350 million per year (based on the 5.6 MMT per year of GHG reductions using the 20-year GWP values).[18]

The control strategy proposed in the 2017 Plan should be seen as a key element of a broader region-wide effort on the part of public agencies, academic institutions, the business community, and environmental and community groups, and the public to reduce Bay Area GHG emissions and protect the climate. As noted in Chapter 4, *Plan Bay Area,* which was adopted by MTC and ABAG in 2013 and is currently being updated, will play an important role in integrating land use and transportation planning so as to reduce motor vehicle travel. In addition, the local climate action plans that have been adopted by more than 60 cities and counties throughout the Bay Area are another critical element of the overall regional effort to reduce GHG emissions and protect the climate.

The control measures described in this Plan, in combination with the state, regional, and local efforts summarized in Chapter 4, will help to move the Bay Area closer to the trajectory needed to achieve the long-range GHG reduction targets for years 2030 and 2050. The Air Resources Board is also in the process of updating the AB 32 Scoping Plan and estimating the anticipated emissions reductions from that plan. The Air District will continue to work with ARB and other key partners in evaluating the impacts of climate protection programs.

The control strategy described in the 2017 Plan should serve as a solid foundation to guide our efforts to reduce emissions of air pollutants and GHGs over the next three to five years. However, achieving the long-range GHG reduction targets will require a collaborative effort on the part of government agencies, the business community, and Bay Area residents to make fundamental changes to our economy and energy systems, as described in the Vision for 2050 that introduces this document.

Implementation—Key Priorities

To implement the control measures in the 2017 Plan, the Air District will use the full range of its tools and resources. For the purpose of prioritizing the implementation of the control measures in the 2017 Plan, the Air District will consider the potential of each measure to:

- Improve air quality in impacted communities.
- Reduce GHG emissions, especially in the near term (e.g., measures to reduce super-GHG emissions).
- Reduce multiple pollutants on a cost-effective basis (see Table H-1 in Appendix H).
- Serve as a model or example that can be replicated in other regions.

Based upon these criteria, the Air District will prioritize the implementation of control measures so as to maximize progress toward four key themes:

- Reduce emissions of criteria air pollutants and toxic air contaminants from all key sources.
- Reduce emissions of super-GHGs with high global warming potential, such as methane.
- Reduce demand for fossil fuels.
    - Increase efficiency of energy, buildings, and transportation sectors.
    - Reduce demand for vehicle travel, and high-carbon goods and services.
- Decarbonize our energy system.
    - Make the electricity supply carbon-free.
    - Electrify the transportation and building sectors.

Reduce Criteria Air Pollutants and TACs

As indicated in the above section *Protecting Public Health,* the 2017 Plan includes a comprehensive set of measures to reduce criteria pollutants, particulate matter and toxic air contaminants. A dozen measures focus specifically on the Bay Area's five oil refineries and supporting operations. The refinery measures are part of a regional effort to reduce both criteria pollutants and health risks to local communities from TACs by 20 percent by 2020. To that end, over the next few years, the Air District will be prioritizing rules to reduce emissions at refineries and supporting operations. These include new rules on sulfur recovery units (SS5), sulfuric acid plants (SS7), refinery fuel gas (SS6) and fluid catalytic cracking units (SS1).

Reducing particulate matter, including diesel PM, will be prioritized through measures to reduce emissions from diesel engines (SS32, TR18 and TR19), measures that further limit and control a variety of sources of PM, including the handling of coke and coal (SS31, SS35, SS36 and SS37) and through further limits on wood burning (SS34). These measures will reduce population exposure to the most harmful air pollutants in the Bay Area's most impacted communities.

Additionally, over the next two years, two innovative measures in the control strategy will be implemented to target existing and new sources of TACs. These measures will ensure that existing facilities that emit TACs do not pose an unacceptable health risk to nearby residents, workers, and/or students (SS20) and that the Air District is using the most up-to-date scientific information and procedures to assess health impacts for new projects (SS21).

Reduce Emissions of Super-GHGs

As discussed in Chapter 3, reducing emissions of super-GHG with high global warming potential, including methane, black carbon and fluorinated gases (F-gases), provides an effective way to decrease GHG emissions and slow the rate of global warming in the near term.

Methane is the second largest climate pollutant in the regional GHG inventory. Key sources of methane in the Bay Area include landfills, the production and distribution of oil and natural gas and agriculture (animal husbandry). The Air District will prioritize implementation of control measures that address methane in stationary sources, including:

- Control measure SS16: 'Basin-Wide Methane Strategy,' which would serve as a stop-gap measure to prohibit methane leaks previously excluded as a regulated pollutant; and

- Control measure SS15: 'Natural Gas Processing and Distribution,' which involves working with the California Public Utilities Commission (CPUC) to reduce methane emissions from the natural gas processing, storage and distribution network in the Bay Area.

In addition, the Air District will target methane emissions from waste and agriculture by:

- Tightening rules on landfills and composting facilities (WA1, WA2);

- Working with local governments to limit organic materials from landfills (WA3); and

- Working with wastewater treatment facilities (WR1) and dairy farmers (AG2, AG4).

Black carbon, another potent climate pollutant, is a component of PM. Diesel engines and wood smoke are key sources of black carbon in the Bay Area. The Air District has been working hard over the past 10 to 15 years to reduce emissions of diesel PM and wood smoke through a combination of regulation, public education and incentives. The control strategy in this Plan will enhance these efforts through a variety of control measures to further reduce PM emissions, such as SS33 and SS34. To reduce emissions of F-gases, the Air District will continue to enforce statewide regulations limiting emissions of F-gases as discussed in Chapter 4.

Reduce Demand for Fossil Fuels

The most direct and cost-effective way to reduce fossil-fuel use is to increase the efficiency of our energy, transportation and distribution systems, and to reduce demand for vehicle travel, and high-carbon goods and services.

Control measure SS18 will limit combustion of fossil fuels at stationary sources (refineries, power plants, cement plants and other industries) by applying a “basin-wide combustion strategy” that will prioritize sources based on the magnitude of their emissions, analyze the efficiency of combustion processes, and optimize energy efficiency in the production process.

In addition, control measure SS12 is intended to limit facility-wide carbon intensity at Bay Area oil refineries by requiring each refinery to maintain its carbon intensity below an established baseline, based upon its current levels of production. Alternatively, refineries could meet an annual GHG emissions limit.

To reduce fossil-fuel emissions from electricity production, the Air District will work with local governments to promote energy-efficiency programs via best practices, model ordinances and technical support, as well as support efforts to decrease electricity use during periods of peak demand, as described in control measure EN2.

The transportation measures in this Plan describe a comprehensive strategy to decrease motor vehicle use by promoting the use of alternative modes of travel, including transit, bicycling, walking, ridesharing and carsharing; reducing emissions from heavy-duty vehicles such as freight trucks; and encouraging “smart driving” to improve fuel economy. These measures complement and support *Plan Bay Area,* adopted by MTC and ABAG, which lays out the region’s planning framework to reduce motor vehicle miles traveled (see Chapter 4).

In addition to reducing direct tailpipe emissions of CO_2, the measures to decrease motor vehicle travel will also reduce upstream emissions of criteria air pollutants, TACs, and GHGs from oil refining by reducing demand for gasoline and diesel. Therefore, the transportation measures can both directly and indirectly reduce population exposure to air pollutants in the Bay Area’s most vulnerable communities.

The Air District’s consumption-based GHG inventory (described in Chapter 3) also identifies opportunities to reduce GHG emissions by decreasing demand for GHG-intensive goods and services. For example, food production is a GHG-intensive sector, generating emissions of carbon dioxide, methane and nitrous oxides. Through its public education efforts, the Air District can encourage Bay Area residents to increase their consumption of low-carbon foods and reduce food waste, and work with local governments to ensure that all food waste is diverted from landfills to compost or other productive uses.

Decarbonize Our Energy System

To achieve long-range GHG reduction targets, it will be essential to decarbonize our energy systems by intensifying existing programs and policies to reduce the carbon content of our electricity supply. This, in turn, facilitates the transition from fossil fuels to low-carbon electricity for purposes of powering our vehicles and heating our homes.

The Air District will primarily focus on advancing decarbonization efforts through the following methods:

- Support switching fossil fuel end-uses to energy efficiency and renewable electricity in existing buildings.
- Incentivize electric vehicles and infrastructure.

Low-Carbon Electricity: To further reduce the carbon content of our electricity supply, the Air District will collaborate with energy providers to maximize the amount of renewable energy in the electricity produced and consumed in the Bay Area, as described in measure EN1.

Decarbonize Buildings: To achieve the long-range GHG reduction targets, existing residential and commercial buildings will need to switch from fossil fuels to low-carbon electricity (or ground-source heat pumps) for space heating and water heating. The Air District will help to accelerate this transition by implementing control measures BL1: Green Buildings, and BL2: Decarbonize Buildings, which prioritize energy efficiency and renewable energy sources through a combination of incentives and technical assistance to local governments, such as providing model ordinances, best practices and technical guidance.

Additionally, the Air District will continue its collaboration with the BayREN program to promote community-choice energy programs that purchase renewable power, and work with the agencies that set standards for energy use in buildings to promote ambitious standards. Two measures in the energy sector (EN1: Decarbonize Electricity Production and EN2: Decrease Electricity Demand) will also play a key role in this effort to reduce emissions from the buildings sector.

Electrify Vehicles: To achieve long-range GHG reduction targets, aggressive action is needed to electrify the motor vehicle fleet. To facilitate this transition, the Air District will continue to implement the Bay Area Plug-In Electric Vehicle (PEV) Readiness Plan through its grant and incentive programs, as described in control measures TR14: Cars and Light Trucks and TR19: Medium- and Heavy-Duty Trucks. As the state continues to push for further advancements in battery, hybrid and fuel cell technologies, the Air District will focus on securing new funding to help deploy more electric vehicles, as well as fund the infrastructure that supports these vehicles.

Table 5-12 shows the rule development schedule for proposed control measures described in the 2017 control strategy. The proposed control measures are also summarized in Table 5-13. Detailed descriptions of the control measures are provided in Volume 2.

Table 5-12. **Rule Development Schedule: 2015–2020**

CM #	Control Measure (Air District Regulation and Rule)
2015 Regulatory Schedule	
SS1	Fluid Catalytic Cracking in Refineries (Rule 6-5), Phase 1—adopted December 2015
SS2	Equipment Leaks (Rule 8-18)—adopted December 2015
SS3	Cooling Towers (Rule 11-10)—adopted December 2015
2016 Regulatory Schedule	
SS8	Sulfur Dioxide from Petroleum Coke Calcining (Rule 9-14)—adopted April 2016
SS10	Petroleum Refining Emissions Tracking (Rule 12-15)—adopted April 2016
SS19	Portland Cement (Rule 9-13), Phase 1—adopted October 2016
SS21	New Source Review for Toxics (Rule 2-5)—adopted December 2016
2017 Regulatory Schedule	
SS31	General PM Emissions Limits (Rule 6-1)
SS35	PM from Bulk Materials, Including Coke and Coal (Rule 6-8)
SS36	PM from Trackout (Rule 6-6)
SS37	PM from Asphalt Operations (Rule 6-7)
SS5	Sulfur Recovery Units (Rule 9-1)
SS6	Refinery Fuel Gas (Rule 9-1)
SS7	Sulfuric Acid Plants (Rule 9-1)
SS9	Enhanced NSR Enforcement for Changes in Crude Slate (Rule 2-2)
SS11	Petroleum Refining Facility-Wide Emission Limits (Rule 12-16)

Table 5-12. **Rule Development Schedule: 2015–2020** *(continued)*

2017 Regulatory Schedule *(continued)*	
SS12	Petroleum Refining Climate Impacts Limit
SS16	Basin-Wide Methane Strategy[1]
SS17	GHG BACT Threshold (Rule 2-2)
SS20	Air Toxics Risk Reduction from Existing Facilities (Rule 11-18)
SS22	Stationary Gas Turbines (Rule 9-9)
2018 Regulatory Schedule	
SS13	Oil and Gas Production (Rule 8-37)
SS18	Basin-Wide Combustion Strategy[1]
SS19	Portland Cement (Rule 9-13), Phase 2
SS1	Fluid Catalytic Cracking in Refineries (Rule 6-5), Phase 2
SS15	Natural Gas Processing and Distribution
SS40	Odors
TR16	Indirect Source Review
WA1	Landfills
WA2	Composting Operations
2019 Regulatory Schedule	
SS4	Refinery Flares (Rules 12-11 and 12-12)
SS24	Sulfur Limits Liquid Fuels (Rule 9-1)
SS25	Coatings, Solvents and Lubricants
SS30	Residential Fan Type Furnaces
SS33	Commercial Cooking
SS34	Wood Smoke
2020 Regulatory Schedule	
SS14	Methane and Other Fugitive Emissions from Capped Wells (Rule 8-37)
SS23	Biogas Flares
SS26	Surface Prep and Cleaning Solvent
SS27	Digital Printing
SS28	LPG, Propane, Butane
SS32	Emergency Back Up Generators[2]

Notes

[1] This timeline is given for the planning portion of these strategies, not for their implementation.

[2] Emissions from emergency back-up generators will be addressed by the new Rule 11-18 (see SS20: Air Toxics Risk Reduction from Existing Facilities). It is added as a separate item in the schedule for the sake of completeness.

Conclusion

We have made great progress in improving Bay Area air quality in recent decades, but more work is needed. Air pollution still has negative effects on public health, there are still disparities in health risk from air pollution among Bay Area communities, and climate change represents a major threat to air quality and to the health and well-being of Bay Area residents. To address these challenges, the 2017 Plan describes a comprehensive multi-pollutant control strategy to protect public health and to protect the climate by reducing emissions of criteria air pollutants, TACs, and GHGs in all economic sectors. The control strategy builds on the success of Air District's existing regulatory, incentive and public outreach programs, and makes use of the full range of the Air District's tools and resources. The Plan will continue to reduce emissions and ambient concentrations of ozone and PM, and to decrease population exposure to the most harmful air pollutants, such as fine PM and TACs, in impacted communities.

Recognizing that the Bay Area is highly vulnerable to the impacts of climate change, the 2017 Plan describes a comprehensive strategy to reduce GHG emissions in the near term, and a vision of how a "post-carbon" Bay Area may look in 2050 to guide our actions over the longer term. The 2017 Plan represents the Air District's best effort to use its tools and resources to directly reduce Bay Area GHG emissions, while also working to support and enhance the GHG reduction efforts that are being implemented by partner agencies at the state, regional and local levels. We hope that the impact of this Plan can be magnified by providing a model that will inspire action in other regions and metropolitan areas across the nation and around the world.

No single agency or plan can solve the problem of climate change on its own. Achieving the critical transformation to a post-carbon economy will require a collaborative effort on the part of governmental agencies at all levels, business and industry, community and environmental groups, educational institutions and Bay Area residents. The Bay Area has all the necessary attributes that we need to tackle the climate challenge. We are one of the most socially and technologically innovative regions in the world, with a strong environmental ethos, world-class academic institutions, and progressive leadership in business and government. By rising to the challenge, we can not only protect the environment and quality of life that makes the Bay Area a great place to live, but also ensure that the Bay Area leads the way in developing and adopting the new technologies and innovations needed to address the climate challenge.

Table 5-13. **Control Measures in the 2017 Plan**

Number	Title	Ozone Precursors, PM, and TAC Reduced	GHGs Reduced	Primary Implementation Tools				
				Rule-making	Funding	Facilitate Best Policies	Outreach and Education	Advocacy
Stationary Source								
SS1	Fluid Catalytic Cracking in Refineries	PM		X				
SS2	Equipment Leaks	ROG	Methane	X				
SS3	Cooling Towers	ROG, TACs		X				
SS4	Refinery Flares	ROG, SO_2, PM	Black Carbon	X				
SS5	Sulfur Recovery Units	SO_2		X				
SS6	Refinery Fuel Gas	SO_2		X				
SS7	Sulfuric Acid Plants	SO_2		X				
SS8	Sulfur Dioxide from Coke Calcining	PM, SO_2		X				
SS9	Enhanced NSR Enforcement for Changes in Crude Slate	All Pollutants	CO_2	X				
SS10	Petroleum Refining Emissions Tracking	All Pollutants	CO_2	X				
SS11	Petroleum Refining Facility-Wide Emission Limits	All Pollutants	CO_2	X				
SS12	Petroleum Refining Climate Impacts Limit		CO_2	X				
SS13	Oil and Gas Production, Processing and Storage	TAC, ROG	Methane	X				
SS14	Methane from Capped Wells	ROG, TAC	Methane	X				
SS15	Natural Gas Processing and Distribution		Methane	X				
SS16	Basin-Wide Methane Strategy		Methane	X				
SS17	GHG BACT Threshold		CO_2	X				
SS18	Basin-Wide Combustion Strategy	PM, TACs	CO_2	X				
SS19	Portland Cement	SO_2, PM	CO_2	X				
SS20	Air Toxics Risk Cap and Reduction from Existing Facilities	TAC		X				

Table 5-13. Control Measures in the 2017 Plan *(continued)*

Number	Title	Ozone Precursors, PM, and TAC Reduced	GHGs Reduced	Primary Implementation Tools				
				Rule-making	Funding	Facilitate Best Policies	Outreach and Education	Advocacy
***Stationary Source** (continued)*								
SS21	New Source Review for Toxics	TAC		X				
SS22	Stationary Gas Turbines	NO_X		X				
SS23	Biogas Flares	NO_X		X				
SS24	Sulfur Content Limits of Liquid Fuels	SO_2, PM		X				
SS25	Coatings, Solvents, Lubricants, Sealants and Adhesives	ROG		X				
SS26	Surface Prep and Cleaning Solvent	ROG		X				
SS27	Digital Printing	ROG		X				
SS28	LPG, Propane, Butane	ROG		X				
SS29	Asphaltic Concrete	ROG		X				
SS30	Residential Fan Type Furnaces	NO_X, CO		X				
SS31	General PM Emission Limitation	$PM_{2.5}$		X				
SS32	Emergency Backup Generators	DPM, TAC	Black Carbon	X				
SS33	Commercial Cooking Equipment	PM_{10}, TAC		X				
SS34	Wood Smoke	$PM_{2.5}$	Black Carbon	X				
SS35	PM from Bulk Material Storage, Handling and Transport, Including Coke and Coal	PM_{10}, $PM_{2.5}$		X				
SS36	PM from Trackout	$PM_{2.5}$		X				
SS37	PM from Asphalt Operations	$PM_{2.5}$		X				
SS38	Fugitive Dust	PM_{10}, $PM_{2.5}$		X				
SS39	Enhanced Air Quality Monitoring	All Pollutants		X		X		
SS40	Odors	Odors		X				

Table 5-13. Control Measures in the 2017 Plan *(continued)*

Number	Title	Ozone Precursors, PM, and TAC Reduced	GHGs Reduced	Primary Implementation Tools				
				Rule-making	Funding	Facilitate Best Policies	Outreach and Education	Advocacy
Transportation Sector								
TR1	Clean Air Teleworking Initiative	All Pollutants	CO_2	X	X	X		
TR2	Trip Reduction Programs	All Pollutants	CO_2	X	X	X		X
TR3	Local and Regional Bus Service	All Pollutants	CO_2		X			
TR4	Local and Regional Rail Service	All Pollutants	CO_2		X			
TR5	Transit Efficiency and Use	All Pollutants	CO_2		X			
TR6	Freeway and Arterial Operations	All Pollutants	CO_2		X			
TR7	Safe Routes to Schools and Transit	All Pollutants	CO_2		X			
TR8	Ridesharing, Last-Mile Connection	All Pollutants	CO_2		X		X	
TR9	Bicycle and Pedestrian Access and Facilities	All Pollutants	CO_2		X	X		
TR10	Land Use Strategies	All Pollutants	CO_2		X	X		
TR11	Value Pricing	All Pollutants	CO_2			X		X
TR12	Smart Driving	All Pollutants	CO_2		X		X	
TR13	Parking Policies	All Pollutants	CO_2		X		X	
TR14	Cars and Light Trucks	All Pollutants	CO_2		X	X	X	
TR15	Public Outreach and Education	All Pollutants	CO_2		X		X	
TR16	Indirect Source Review	All Pollutants	CO_2	X				
TR17	Planes	NO_X	CO_2					X

Table 5-13. **Control Measures in the 2017 Plan** *(continued)*

Number	Title	Ozone Precursors, PM, and TAC Reduced	GHGs Reduced	Primary Implementation Tools				
				Rule-making	Funding	Facilitate Best Policies	Outreach and Education	Advocacy
***Transportation Sector** (continued)*								
TR18	Goods Movement	All Pollutants	CO_2, Black Carbon					
TR19	Medium and Heavy Duty Trucks	All Pollutants	CO_2, Black Carbon		X		X	
TR20	Ocean Going Vessels	All Pollutants	CO_2, Black Carbon		X			
TR21	Commercial Harbor Craft	All Pollutants	CO_2, Black Carbon			X	X	
TR22	Construction and Farming Equipment	All Pollutants	CO_2, Black Carbon		X			
TR23	Lawn Care Equipment	All Pollutants	CO_2		X			
Buildings Sector								
BL1	Green Buildings	All Pollutants	CO_2			X		
BL2	Decarbonize Buildings	All Pollutants	CO_2			X	X	
BL3	Market-Based Solutions	All Pollutants	CO_2			X		
BL4	Urban Heat Island Mitigation	All Pollutants	CO_2			X		
Energy Sector								
EN1	Decarbonize Electricity Production	All Pollutants	CO_2		X	X	X	
EN2	Decrease Electricity Demand	All Pollutants	CO_2			X	X	

Table 5-13. **Control Measures in the 2017 Plan** *(continued)*

Number	Title	Ozone Precursors, PM, and TAC Reduced	GHGs Reduced	Primary Implementation Tools				
				Rule-making	Funding	Facilitate Best Policies	Outreach and Education	Advocacy
Agriculture Sector								
AG1	Agricultural Guidance and Leadership	All Pollutants	Methane			X		
AG2	Dairy Digesters		Methane			X	X	
AG3	Enteric Fermentation		Methane			X	X	
AG4	Livestock Waste	PM, ROG, ammonia	Methane	X				
Natural and Working Lands								
NW1	Carbon Sequestration in Rangelands		CO_2			X		
NW2	Urban Tree Planting	Criteria pollutants	CO_2			X		
NW3	Carbon Sequestration in Wetlands		CO_2			X		
Waste Sector								
WA1	Landfills	ROG, TAC	Methane	X				
WA2	Composting and Anaerobic Digesters	ROG, PM	Methane	X				
WA3	Green Waste Diversion	All Pollutants	Methane	X		X		
WA4	Recycling and Waste Reduction	TAC	CO_2, Methane			X		
Water Sector								
WR1	Limit GHGs from POTWs	All Pollutants	CO_2, Methane	X		X		
WR2	Support Water Conservation	All Pollutants	CO_2			X	X	
Super-GHG Pollutants								
SL1	Short-Lived Climate Pollutants	PM	Methane, BC, HFC	X		X	X	
SL2	Guidance for Local Planners		Methane, BC, HFC			X		
SL3	GHG Monitoring and Emissions Measurement Network		Methane			X		

FOOTNOTES

[1] Volume 2 of the 2017 Plan

[2] The Air District does not normally include off-road equipment in the transportation sector for the Bay Area emissions inventory. However, we do so here to be consistent with the way off-road equipment is categorized in the ARB Scoping Plan.

[3] GHG emissions from Bay Area power plants are addressed in the energy sector (rather than stationary sources) for purposes of this analysis. GHG emissions from electricity are attributed to the energy sector, rather than the end users in sectors such as buildings, stationary sources, transportation and water. However, natural gas production, transmission or distribution are addressed in the stationary source sector rather than the energy sector.

[4] BAAQMD, 2015, *Bay Area Emissions Inventory Summary Report: Greenhouse Gases Base Year 2011.*

[5] California Public Utilities Commission, California Renewables Portfolio Standard (RPS): http://www.cpuc.ca.gov/PUC/energy/Renewables/

[6] Center for Climate and Energy Solutions, California Cap-and-Trade Program Summary: https://www.c2es.org/us-states-regions/key-legislation/california-cap-trade

[7] This standard requires that any new long-term financial investment in “baseload” generation resources - the workhorse power plants that supply electricity around the clock - made on behalf of California customers must be in clean energy sources that meet the standard of 1,100 lbs CO2/MWh. http://www.energy.ca.gov/emission_standards/.

[8] The “Buildings” slice of the pie chart shown in Figure 3-6 reflects only the direct GHG emissions related to combustion of natural gas and other fuels for space heating, water heating, and cooking. This buildings sector portion of the GHG inventory would be larger if emissions were included from indirect sources such as building materials and from power plants that generate the electricity consumed in buildings.

[9] https://escholarship.org/uc/item/2sn7m83z

[10] http://www.sagecenter.org/publications/sustaining-our-agricultural-bounty-an-assessment-of-the-current-state-of-farming-and-ranching-in-the-san-francisco-bay-area-2011-0/

[11] Bay Area Open Space Council. 2014. *The Conservation Lands Network 1.0 Progress Report.* Berkeley, CA.

[12] Estimate from California Rangeland Trust as indicated in Bay Area Open Space Council (2014).

[13] “Ecosystem services and urban heat riskscape moderation: water, green spaces, and social inequality in Phoenix, USA,” by G. Darrel Jenerette, Sharon L. Harlan, William L. Stefanov, and Chris A. Martin. Ecological Applications, Vol. 21 No. 7, October 2011.

[14] For example, requiring the use of aerated static piles for the composting method in order to limit particulate matter, odors, and organic compounds that are ozone precursors will have the co-benefit of reducing methane emissions as well.

[15] Brown et al. *Greenhouse Gas Balance for Composting Operations.* J. Environ. Qual. 37:1396–1410. 2008.

[16] Lifecycle emissions are not included in this sector’s quantitative analysis, but the potential to use the resulting compost for various local purposes is a clear benefit over importing other products from outside the region (e.g., artificial fertilizers made from hydrocarbons such as natural gas).

[17] http://bairwmp.org/docs/2013-bairwm-plan-update/2013-final-plan/San%20Francisco%20Bay%20Area%20IRWMP%20Final_September%202013.pdf

[18] The social cost of carbon attempts to capture the full range of future impacts from climate change, including direct and indirect impacts to public health, and to express those costs or savings in current dollars. Estimating the social cost of carbon is a complex endeavor, with a wide range of uncertainty. Because the methodology cannot fully capture all the potential impacts of climate change, it is likely that the $62 per metric ton of CO_2e used in our estimate underestimates the actual social benefits of reducing GHG emissions. For additional information: https://www3.epa.gov/climatechange/Downloads/EPAactivities/social-cost-carbon.pdf

ACRONYMS AND TERMS

ABAG................Association of Bay Area Governments

ARB ....(California) Air Resources Board

ATCM................Airborne Toxic Control Measure

BAAQMD ....Bay Area Air Quality Management District

BACM ....Best Available Control Measure

BACT ....Best Available Control Technology

BAR ....Bureau of Automotive Repair

BARCT ....Best Available Retrofit Control Technology

BART ....Bay Area Rapid Transit District

BCDC ....Bay Conservation and Development Commission

BC.....................Black Carbon

CAP ....Clean Air Plan (for state ozone standard)

CAPCOA...........California Air Pollution Control Officers Association

CARB................California Air Resources Board

CARE................Community Air Risk Evaluation Program

CCAA................California Clean Air Act

CEQA................California Environmental Quality Act

CH_4 ....Methane

CMA..................Congestion Management Agency

CMAQ............... Congestion Management and Air Quality (Improvement Program)

CMP................. Congestion Management Program

CO.................... Carbon Monoxide

CO_2.................. Carbon Dioxide

CO_2e................ CO_2-equivalent (a metric to express the various GHGs in comparison to CO_2)

EIR.................... Environmental Impact Report

EMFAC............. Emission Factors (CARB model to calculate motor vehicle emissions)

EPA................... (United States) Environmental Protection Agency

EPDC................ Expected Peak Day Concentration

FSM.................. Further Study Measure

GHG................. Greenhouse Gas

HOV.................. High-Occupancy Vehicle

GWP................. Global Warming Potential

I & M................ (Motor Vehicle) Inspection and Maintenance Program (“Smog Check”)

ISR.................... Indirect Source Review

LEV................... Low Emission Vehicle

MTC.................. Metropolitan Transportation Commission

MMT................. Million Metric Tons

NAAQS............. National Ambient Air Quality Standards

NH_3.................. Ammonia

NO_x.................. Oxides of Nitrogen

NSR.................. New Source Review

O_3 .... Ozone

$PM_{2.5}$ .... Particulate Matter less than 2.5 microns in diameter

PM_{10} .... Particulate Matter less than 10 microns in diameter

ppb.................. Parts per billion

pphm................ Parts per hundred million

ppm.................. Parts per million

RACM .... Reasonably Available Control Measure

RFP .... Reasonable Further Progress

ROG .... Reactive Organic Gases

RTP .... Regional Transportation Plan

Super-GHGs..... Methane, black carbon, and other potent climate-forcing pollutants

TAC.................. Toxic air contaminant

TFCA .... (BAAQMD) Transportation Fund for Clean Air

TIP................... Transportation Improvement Program

TLC.................. (MTC) Transportation for Livable Communities Program

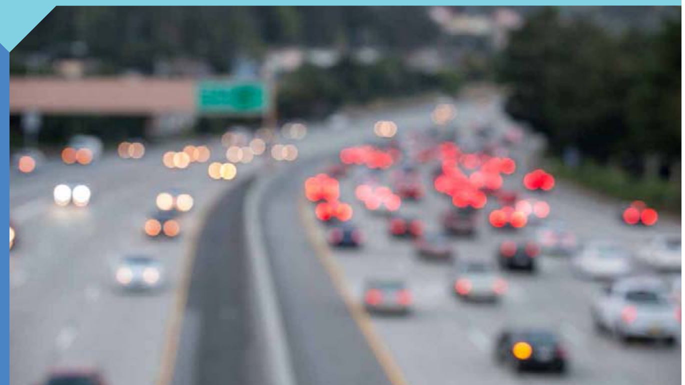
tpd.................... Tons per day

VMT .... Vehicle Miles Traveled

VOC................. Volatile organic compound

ZEV.................. Zero-emission vehicle

APPENDIX A



STATE AIR QUALITY PLANNING REQUIREMENTS

For the past 28 years, the 1988 California Clean Air Act (CCAA), along with subsequent amendments, as codified in the California Health & Safety Code, has guided efforts throughout California to achieve state ambient air quality standards. This appendix describes CCAA air quality planning requirements and how the 2017 Plan fulfills all requirements.

The basic goal of the CCAA is to achieve health-based state ambient air quality standards by the earliest practicable date. The CCAA requires regions that violate the state ozone standard to prepare attainment plans that identify a strategy to attain the standard. California classifies ozone nonattainment areas based on their "expected peak day concentration." An analysis of Bay Area "expected peak day concentration" values is provided in Appendix E. Legal requirements vary according to the severity of a region's ozone problem. The Air District is subject to CCAA requirements for "serious" areas [Secs. 40921.5(a)(2), 40919].[1]

Regional air quality plans are required to achieve a reduction in district-wide emissions of 5 percent per year for ozone precursors (California Health & Safety Code Section 40914). However, if an air district is unable to achieve a 5 percent annual reduction, then the air district is required to adopt a control strategy to implement "all feasible measures" on an expeditious basis [Sec. 40914(b)(2)].

All Feasible Measures

No non-attainment area in the state has been able to demonstrate a 5 percent reduction in ozone precursor pollutants each year. Consequently, air districts throughout the state, including the Bay Area, have opted to adopt "all feasible measures" as expeditiously as possible to meet the requirements of the CCAA. The CCAA does not define "feasible," but the Health and Safety Code provides some direction to assist the Air District in making this determination. Section 40406 defines a related term, Best Available Retrofit Control Technology (BARCT), as "an emission limitation that is based on the maximum degree of reduction achievable, taking into account environmental, energy and economic impacts by each class or category of source." The California Air Resources Board (ARB) defines "all feasible measures" in the Transport Mitigation Regulation, Section 70600 *et seq,* Title 17 California Code of Regulations, as "air pollution control measures, including but not limited to emissions standards and limitations, applicable to all air pollution source categories under a district's authority that are based on the maximum degree of reductions achievable for emissions of ozone precursors, taking into account technological, social, environmental, energy and economic factors, including cost-effectiveness." Section 40922(a) requires an assessment of the cost-effectiveness of each proposed control measure, including a ranking of measures from the least cost-effective to the most cost-effective. Section 40922(b) lists additional criteria that air districts should consider in reviewing potential control measures, including technological feasibility, total emission reduction potential, the rate of reductions, public acceptability and enforceability.

The process that the Air District used to review and evaluate potential control measures in relation to these criteria is described in Appendix G. An overview of the 2017 Plan control strategy is provided in Volume I, Chapter 5; detailed descriptions of control measures are provided in Volume II of the 2017 Plan.

Transport Mitigation Requirements

The CCAA requires ARB to periodically assess transport of ozone and ozone precursors from upwind to downwind regions and to establish mitigation requirements for upwind districts (Sec. 39610). The CCAA also requires air districts to address transport mitigation requirements in their clean air plans to include strategies to assist downwind air districts in achieving the State ozone standard (Sec. 40912).

ARB first adopted transport mitigation requirements in 1990, amended them in 1993, and further strengthened them in 2003. ARB's 2003 amended Transport Mitigation Requirements are in Title 17, California Code of Regulations, Sections 70600 and 70601. The requirements for transport mitigation state that upwind districts "shall include sufficient emission control measures in their attainment plans for ozone…to mitigate the impact of pollution sources within their jurisdictions on ozone concentrations in downwind areas commensurate with the level of contribution." Specifically, the Air District is required to:

1) adopt and implement all feasible measures as expeditiously as practicable;

2) adopt and implement Best Available Retrofit Control Technology (BARCT) on all existing stationary sources of ozone precursor emissions as expeditiously as practicable;

3) maintain a stationary source permitting program designed to achieve no net increase in the emissions of ozone precursors from new or modified stationary sources that emit or have the potential to emit 10 tons or greater per year of an ozone precursor; and

4) include measures sufficient to attain the State ambient air quality standard for ozone by the earliest practicable date within the North Central Coast Air Basin, that portion of Solano County within the Broader Sacramento Area, that portion of Sonoma County within the North Coast Air Basin, and that portion of Stanislaus County west of Highway 33 during air pollution episodes, provided that:

    a) the areas are likely to violate the State ozone standard,

    b) the areas are dominated by transport from the Bay Area, and,

    c) the areas are not affected by emissions of ozone precursors within their borders.

The 2017 Plan addresses all of the above requirements. The control strategy defined in the 2017 Plan, together with the Air District rule development and permitting processes, addresses the requirement to adopt all feasible measures, including measures sufficient to attain the state ozone standard in specified transport areas, and to implement BARCT on all existing stationary sources. With respect to the "no net increase" requirement, the Air District adopted a 10 ton per year no net increase requirement for ozone precursors in Regulation 2, Rule 2: New Source Review on December 21, 2004.

In addition, the Air District is required to consult with downwind districts on development of the 2017 Plan, review the list of control measures in the most recently approved attainment plan (in this case, the Bay Area 2010 Clean Air Plan), make a finding as to whether the proposed list of control measures meets the requirements of Section 70600 (b), and include the finding in the proposed 2017 Plan.

To fulfill these consultation requirements, the Air District hosted a conference call with downwind air districts in January 2017 to update them on the implementation of the 2010 Clean Air Plan and to solicit comments and suggestions on the 2017 Plan draft control strategy.

Other Requirements

In addition to requirements concerning all feasible measures and transport mitigation, the CCAA requires that strategies to attain the State ozone standard contain other elements, including the following:

Emissions inventory system [Sec. 40918(a)(5)]: The Air District maintains an emissions inventory system. The emission inventory is included in the "Sources of Air Pollution—Emission Inventory" section of the 2017 Plan.

A permitting program [Sec. 40919(a)(2)] designed to achieve no net increase in emissions from permitted sources with a potential to emit greater than 10 tons per year of a non-attainment pollutant or their precursors and to require the use of Best Available Control Technology (BACT) on new and modified sources with a potential to emit greater than 10 pounds per day. The Air District's permitting program, as spelled out in Regulation 2, Rule 2: New Source Review, complies with the requirements of Health and Safety Code Section 40919(a)(2). Sufficient offsets have been provided for all permits that have been issued by the Air District. Furthermore, the Small Facility Banking account has sufficient credits to sustain withdrawals into the foreseeable future at the current withdrawal rate. The Air District's no net increase threshold was reduced to 10 tons per year to comply with transport mitigation requirements in December, 2004.

Best Available Retrofit Control Technology (BARCT) on all existing permitted stationary sources [Sec. 40919(a)(3)]: BARCT is implemented through the Air District's rule development, enforcement and permit review programs. Air District staff performs an assessment of BARCT requirements when proposing new rules or rule amendments and ARB reviews Air District rules and proposed rule amendments to insure that BARCT standards are implemented. Additionally, the Air District evaluates existing sources during the annual permit review process to ensure BARCT requirements are being met. Finally, the Air District issues facility advisories, and implements compliance assistance and enforcement programs help to ensure compliance with BARCT standards in rules.

Measures to achieve use of a significant number of low-emission vehicles in motor vehicle fleets [Sec. 40919(a)(4)]: Transportation control measures TR14 and TR19 promote the use of low-emission vehicles and trucks to reduce motor vehicle fleet emissions. The Air District's Transportation Fund for Clean Air, Carl Moyer and Low Emission School Bus programs provide funding for projects to promote the purchase and use of low-emission vehicles.

Transportation Control Measures (TCMs) to substantially reduce the rate of increase in passenger vehicle trips and miles traveled per trip [Sec. 40918(a)(3)]: Pursuant to Sections 40233 and 40717, each transportation control measure must include the following:

- A schedule for implementation
- Identification of potential implementing agencies
- Procedures for monitoring the effectiveness of and compliance with the measures in the Plan

In addition, Section 40233 directs the Air District to estimate the quantity of emission reductions from transportation sources necessary to attain and maintain state and national ambient air quality standards. Section 40233 requires the Metropolitan Transportation Commission (MTC) to prepare and adopt a TCM plan to achieve the specified quantity of emission reductions. The TCM plan is then incorporated into the overall strategy for achieving the state ozone standard. The statute also requires MTC to develop and adopt a revised TCM plan whenever the Air District revises the emission reduction target.

The Air District and MTC complied with the requirements of Section 40233 when preparing the 1991 Clean Air Plan, the Air District's first plan for the state ozone standard, by adopting a TCM emission reduction target and plan in 1990. Section 40233 allows the Air District's discretion as to whether and when to revise the emission reduction target for transportation sources set in 1990. This update to the strategy to attain the state ozone standard does not include a revised emission reduction target for transportation sources, and therefore does not trigger a TCM plan revision. The Air District and

MTC have, however, comprehensively reviewed and augmented the TCMs during preparation of the 2017 Plan to maximize their effectiveness.

Indirect source and area source programs [Section 40918(a)(4)]: Several measures in the 2017 Plan are intended to reduce emissions from indirect sources. TR16 calls for the Air District to develop an indirect source review regulation pursuant to Section 40716. TR10 describes updated CEQA guidelines that should also help to reduce emissions from new indirect sources of emissions. TR10 also includes actions by the Air District and partner agencies to promote infill development that should also reduce emissions from indirect sources. Management of area source emissions is addressed through existing Air District regulations for ROG in Regulation 8 and NO_X in Regulation 9. In addition, PM is addressed by Regulation 6, including the Air District's wood smoke rule (Reg. 6, Rule 3, adopted in July 2008) and complementary wood smoke public education program.

Regional public education programs [Section 40918(a)(6)]: The Air District administers several public education programs that encourage the public to reduce air pollution both year round and on an episodic basis. The Air District's *Spare the Air* public education program, described in TR15, is aimed at curbing emissions from motor vehicles and other ozone precursor sources on days when weather conditions are conducive to high ozone levels. The *Winter Spare the Air* program complements the regulatory wood burning program that reduces emissions of particulate matter from wood burning. Other ongoing educational programs include grassroots resource teams located throughout the Bay Area, a Smoking Vehicle Assistance Program, outreach and presence at public events throughout the year, a suite of youth education programs including the Spare the Air Youth and Protect Your Climate Curriculum, and a Speakers Bureau that delivers talks on air quality to a variety of audiences throughout the region.

An assessment of cost-effectiveness of proposed control measures (Section 40922): Information regarding the cost-effectiveness of proposed control measures is provided in Chapter 5 of the 2017 Plan.

Periodic requirements of the CCAA include the following:

An annual regulatory schedule (Section 40923): The Air District produces a regulatory schedule each December, listing regulatory measures that may be scheduled for adoption or amendment during the following year. A proposed regulatory schedule for years 2017 through 2019 is provided in Chapter 5 of the 2017 Plan.

An annual progress report on control measure implementation and, every third year, an assessment of the overall effectiveness of the program (Section 40924): The latest assessment is provided in Chapter 4, as well as Appendix F of the 2017 Plan.

A review and update of the Plan every three years to correct for deficiencies and to incorporate new data and projections (Section 40925): The 2017 Plan incorporates new data and projections and updates the 2010 Clean Air Plan control strategy.

FOOTNOTES

[1] All references to Section numbers are for the California Health and Safety Code unless otherwise noted.

APPENDIX B

PUBLIC OUTREACH

Air District staff reached out to inform and engage the general public, as well as key stakeholders, about the 2017 Plan throughout the Plan development process. At the outset of the process, staff designed a public outreach strategy to foster sustained engagement and dialogue with a wide range of stakeholders in developing the Plan. Staff identified the following goals to guide public outreach and engagement:

- ***Inform*** a wide range of stakeholders and members of the public about the scope and schedule of the Plan and opportunities for comment.
- ***Provide opportunities*** for members of the public and stakeholders to offer input on the Plan and outreach process.
- ***Educate*** the public about air quality and why the Air District and the 2017 Plan are relevant, and why greenhouse gases and climate protection have become an integral part of the Plan.
- ***Engage impacted communities and multilingual communities*** in developing the Plan.
- ***Promote transparency*** throughout the strategy and Plan development process.
- ***Foster buy-in, ownership, and acceptance*** of the Plan.

Public outreach for the 2017 Plan took place in three phases: introduction to the 2017 Plan and the planning process, development of the control measures and climate strategies, and presentation of the draft Plan and the final Plan. Primary outreach mechanisms utilized include the 2017 Plan website; news releases and advisories; notices sent to the Plan e-mail list serve; and Plan public workshops, open houses, community meetings and the associated materials that staff prepared. Additionally, in the interests of implementing the goals above, staff developed materials and outreach mechanisms to support education and outreach to Air District constituents for whom English is not the primary language, with a focus on Chinese, Vietnamese, Tagalog, and Spanish speakers. Additional outreach took place for the environmental review process and consultation with other air districts. A description of the full range of outreach mechanisms employed over the course of the 2017 Plan development process is provided below.

Open Air Forum: The Air District recently launched a new online civic engagement tool, Open Air Forum. Open Air Forum is an online resource that offers the public a new opportunity to interact with the Air District and provide feedback on specific Air District topics. Open Air Forum was used for public discussion on the 2017 Plan. The forum gave visitors access to draft control measures and informational material distributed at each open house—to review and provide comment at their leisure. Open Air Forum can be accessed through the Air District website homepage at www.baaqmd.gov or directly at http://www.baaqmd.gov/in-your-community/open-air.

Web pages: The 2017 Plan webpage on the Air District's website features a description of the Plan goals and purpose, regulatory framework, meeting schedule, meeting notices and materials and key technical documents. The website has been used primarily to alert the public to meetings and workshops and to post meeting materials and Plan documents for public review prior to each workshop. The main 2017 Plan web page is located on the Air District's website, in the air quality plans section: http://www.baaqmd.gov/plans-and-climate/air-quality-plans.

E-mail and paper mail database: An email database was compiled from an existing outreach database, updated to reflect the most current information for contacts, augmented with additional health, non-government organizations and regulatory agency contacts, and converted to the extent possible from U.S. mail addresses to e-mail in keeping with the Air District's interest in reducing waste. The database consists of approximately 1,650 e-mail contacts with an additional 185 U.S. mail contacts, representing regional and state regulatory agencies, staff from other air districts, transportation agencies, environmental and health advocates and professionals, community members, representatives from regulated industries, local governments and others. The list is refreshed and added to based upon meeting attendance lists and requests received via e-mail and the 2017 Plan website. The database was used to notify the public of meetings dates and locations, and to alert the public to meeting materials and planning and CEQA documents posted on the 2017 Plan website.

News advisories and releases: The Air District used both news advisories and news releases to inform the wider community about the 2017 Plan and opportunities to comment. News advisories were sent before each open house and public meeting. News releases were used both when a new topic on the Plan was opened on Open Air Forum and when the draft 2017 Plan was released for the 45-day public review period.

Outreach to multilingual communities: Air District staff held six open houses on the draft 2017 Plan. Information regarding these open houses was translated into Spanish, Chinese, Vietnamese and Tagalog languages, and posted on the 2017 Plan website. At the open houses, Spanish and Chinese interpreters were available to translate questions and answers and printed material regarding the open houses was available.

Public workshops and community meetings: The Air District held public workshops, open houses and other meetings at locations throughout the Bay Area during the planning process to facilitate dialogue and collect input on the proposed control measures and climate strategies. All meetings were held at accessible locations and in close proximity to transit whenever possible. Notice of public workshops and open houses was provided at least three weeks in advance on the Air District website and by e-mail to the Plan contact database. Open-house flyers in multiple languages were posted in key community spaces (e.g., community centers, libraries) in the cities where the open houses took place. As of April 2017, 35 public workshops, open houses, community meetings, and stakeholder meetings were held at key intervals throughout the planning process. A summary of these meetings is provided in Table B-1.

Sector-based working groups: Early in the 2017 Plan planning process, the Air District convened small groups of experts in each economic sector. These experts were convened to discuss GHG emission inventories and projected trends in GHG emissions. Air District staff also solicited suggestions for potential measures to reduce emissions of GHGs and other air pollutants. The Air District later expanded the initial group of technical experts into multi-stakeholder working groups to further inform the 2017 Plan development. The working groups focused on specific economic sectors; members were asked to provide input, based on their expertise in a particular economic sector, on potential control measures and actions the Air District could take to reduce emissions.

Table B-1. **Public meetings on 2017 Plan**

	Description and Purpose	Date and Location	Attendance
Introduction to the 2017 Plan Planning Process	**Kick-off Workshop**	February 28, 2014 – Oakland*	35
	Winter 2014 County Stakeholder Meetings	February 12, 2014 – Sunnyvale February 24, 2014 – Oakland*, Napa February 26, 2014 – Marin March 5, 2014 – Saratoga March 6, 2014 – Santa Clara* March 10, 2014 – Martinez* March 12, 2014 – San Francisco*	11 14 9 8 12 8 5
Control Strategy Development	**Open Houses:** • Control Measure Implementation Actions Review • Call for additional control measure ideas	January 28, 2016 – Redwood City February 2, 2016 – San Jose* February 3, 2016 – Santa Rosa February 4, 2016 – Richmond* February 8, 2016 – Pleasanton February 9, 2016 – Oakland*	13 21 14 28 12 33
	Working Group Sessions Round One: • Development/review of economic sector analyses	December 16, 2014 – Super GHGs December 17, 2014 – Natural & Working Lands December 19, 2014 – Agriculture December 22, 2014 – Transportation January 13, 2015 – Buildings January 29, 2015 – Stationary Source February 5, 2015 – Energy February 25, 2015 – Waste April 6, 2015 – Water	4 13 7 9 7 10 13 4 6
	Working Group Sessions Round Two: • Revised sector analyses and preliminary control measures	April 12, 2016 – Agriculture/Natural & Working Lands April 13, 2016 – Energy/Stationary Source April 19, 2016 – Transportation April 22, 2016 – Buildings/Waste/Water	11 19 21 27
	Open Houses: Draft Plan	January 30, 2017 – Cupertino January 31, 2017 – San Francisco* February 1, 2017 – San Rafael* February 2, 2017 – Yountville February 6, 2017 – Walnut Creek February 6, 2017 – Dublin* February 7, 2017 – San Jose* February 8, 2017 – Oakland*	

*These meetings were held in Community Air Risk Evaluation (CARE) impacted communities to address the District's CARE program and the 2017 Plan, with the aim of soliciting input on the 2017 Plan planning process from communities most directly impacted by air pollution.

In addition to formal workshops and community meetings, staff made presentations about the Plan to interested stakeholders to solicit feedback on various aspects of the Plan. These included:

- Contra Costa County Industrial Association, April 2016
- BayREN, March 2016
- Clean Air Professionals (Lung Association), January 2016
- California Air Pollution Control Officers Association, December 2015
- California Climate Planning Conference, August 2015
- California Council for Environmental and Economic Balance, July 2015, February 2016, February 2017 and July 2016
- Air and Waste Management Association, March 2017, June 2016 and June 2014
- San Francisco Planning and Urban Research, March 2017

Consultation with neighboring air districts: Air District staff held a conference call with downwind air districts on January 11, 2017, to discuss the implementation of 2010 Clean Air Plan control measures and to receive input on proposed 2017 Plan control measures.

Collaboration with regional agencies: The 2017 Plan was developed in collaboration and consultation with the Air District's regional agency partners, the Metropolitan Transportation Commission (MTC), Association of Bay Area Governments (ABAG), and the Bay Conservation and Development Commission (BCDC). MTC and ABAG staff provided important input to the transportation sector measures, and MTC staff played a key role in developing emission reduction and cost estimates for the transportation measures. In addition, the 2017 Plan was informed by regional agency plans, including *Plan Bay Area.*

Air District Staff made presentations about the 2017 Plan at the following regional agency meeting:

- Bay Area Regional Collaborative
  - July 17, 2015
  - February 17, 2017

Reports to Air District Board of Directors and Board Committees: District staff provided several briefings to the Board of Directors and Board Committees in the course of developing the 2017 Plan.

- Board of Directors:
  - July 29, 2015
  - January 18, 2017
  - March 1, 2017
- Climate Protection Committee
  - September 29, 2014
  - March 16, 2016
  - September 15, 2016
- Executive Committee
  - March 2, 2016
- Stationary Source Committee
  - March 20, 2017
- Advisory Council
  - October 3, 2016
  - February 6, 2017
  - July 19, 2016

CEQA Review: Pursuant to the California Environmental Quality Act (CEQA), Air District staff prepared and released a Notice of Preparation and Initial Study on June 15, 2016, for a 30-day public review period. Air District staff released a Draft Programmatic Environmental Impact Report for a 45-day review period on February 17, 2017.

APPENDIX C

AIR POLLUTION HEALTH BURDEN

Reducing emissions of criteria air pollutants, toxic air contaminants (TACs) and greenhouse gases (GHGs) will provide public health, environmental and economic benefits. The Air District developed a multi-pollutant evaluation method (MPEM) as an analytical tool that was initially used in developing the Bay Area 2010 Clean Air Plan. The MPEM provides a means to quantify the estimated benefits of individual control measures and the control strategy as a whole in protecting public health, extending the average lifespan of Bay Area residents and protecting the climate. This information can be used to compare the estimated costs and benefits of individual control measures, to help prioritize implementation of control measures in the 2017 Plan, and to estimate the magnitude of benefits to the region from the control strategy as a whole. MPEM input values have been updated for use of the method in the 2017 Plan. The MPEM was a key tool used in preparing the Health Burden Analysis, as described below.

The MPEM estimates the benefits from reductions in pollutant emissions that result from a given control measure, as described below. The MPEM includes a set of well-documented health effects, as shown in Table C-1. For estimated reductions in $PM_{2.5}$ and ozone, a range of health benefits are estimated based upon U.S. EPA's BenMAP methodology. For toxic air contaminants, we estimate the reduction in cancer incidence and mortality for a set of carcinogens (benzene, 1,3-butadiene, formaldehyde, and acetaldehyde). It should be noted that the MPEM does not capture the full range of health impacts from air pollution. For example, studies have found a correlation between exposure to air pollution and health effects such as birth defects, autism and diabetes. However, these health effects are not included in the MPEM analysis. In addition to estimating the health benefit of reductions in air pollutants, monetary values are also estimated for the social benefit of GHG reductions.

The MPEM consists of four basic steps:

1. Estimating the change in pollutant concetrations from changes in emissions: For a given control measure, the resulting daily mass emissions reductions in various pollutants are input to MPEM. The pollutants include both direct emissions of $PM_{2.5}$, toxics and GHGs, but also ozone and $PM_{2.5}$ precursors—VOCs, NO_X, SO_2 and ammonia. MPEM takes these changes and estimates the change in pollutant concentrations for a four sq. kilometer grid covering the Bay Area. This includes estimating the changes of ozone and $PM_{2.5}$ concentrations resulting from changes in precursors.

2. Estimating the change in population exposure: MPEM multiplies the change in pollutant concentration times the population and computes a population-weighted average for each grid square.

3. Estimating the change in various health endpoints: MPEM then applies a set of concentration-response functions that estimate the change in health endpoints for a given change in pollutant concentration, multiplying by the size of the susceptible population. For example, a reduction in $PM_{2.5}$ of 1 µg/m^3 has been found to reduce hospital admissions for chronic obstructive pulmonary disease (COPD) for those 65 and older by 0.15 percent. The rate of COPD admissions in Alameda County for 2011–13 was 7.2 per thousand. Alameda had an estimated 213,879 at 65+ years of age, so a 1 µg/m^3 reduction in $PM_{2.5}$ would be estimated to reduce the number of emissions by 0.0015 x 0.0072 x 213,879 = 2.3 cases per year.

4. Estimating the monetary value of the changes: MPEM takes the health endpoints and multiplies by the dollar valuations listed in the Valuation of Health Effects section below. It adds the estimated societal value of tonnage reductions in GHGs expressed in CO_2-equivalent.

The MPEM provides a tool that integrates the 2017 Plan goals of improving air quality, protecting public health and protecting the climate. For purposes of the 2017 Plan, the MPEM has been used to:

- Estimate the health and climate protection benefits, expressed in dollar terms, for individual control measures;
- Analyze trade-offs in the case of control measures that would increase one or more pollutants while reducing others;
- Estimate the aggregate benefit for the proposed 2017 Plan control strategy as a whole; and
- Evaluate the health burden associated with pollution levels in years past and compare that to the health burden in more recent years.

The MPEM relies upon various assumptions and approximations.[1] For example, for purposes of estimating population exposure to pollutants, the MPEM assumes "backyard" exposure, i.e., that people are at home and outside in their yards 24 hours a day, seven days a week. Because the MPEM is a complex methodology, the estimates of social benefits that it generates are subject to considerable uncertainty. To address this uncertainty, Air District staff performed a probability analysis of MPEM results.[2]

Valuation of Health Effects

Negative health effects related to air pollution impose direct costs to treat illness and disease, as well as indirect costs such as lost work days and diminished productivity. Table C-1 shows the values used for key health endpoints in the current analysis.[3]

Table C-1: Valuation of Key Health Endpoints (in 2015 dollars)

Health Endpoint	Valuation
Mortality	$8,800,000
New cancer case	$3,700,000
New chronic bronchitis case	$476,117
Non-fatal heart attack	$82,580
Hospitalization for respiratory illness	$49,000–$55,000 per admission
Hospitalization for cardiovascular illness	$56,000–$65,000 per admission
Asthma emergency room visits	$478 per incident
Acute bronchitis episodes	$598 for a 6-day illness period
Upper respiratory symptom days	$40 per day
Lower respiratory symptom days	$25 per day
Work loss days: daily median wage by county	$186–$278
School absence days	$103 per day
Minor restricted activity days	$85 per day

Valuation of Greenhouse Gas Reductions

The MPEM also considers the value of reducing greenhouse gas emissions. Assigning a value to GHG reductions is problematic, given that 1) climate change will have impacts both locally and at the global scale, 2) potential climate change impacts are very broad, including a wide array of health, ecosystem, social and economic impacts, and 3) the full range and force of climate change impacts from GHGs emitted today will not be experienced until decades, or even centuries, into the future. For purposes of the MPEM, Air District staff selected a value of $62 per metric ton of GHG reduced (expressed in CO_2-equivalent). This value was chosen from a range of potential values suggested by U.S. EPA in its *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 document.*

Relative Value of Emission Reductions Based on MPEM

The MPEM can be used to compare the benefit of reducing the various air pollutants, as shown in Table C-2. For this exercise, the MPEM was used to calculate the value of reducing one ton of each pollutant or precursor that is included in the methodology. The relative weight for each pollutant was then determined using ROG as the unit of comparison. Since studies show that PM is the predominant cause of air pollution-related mortality, as discussed below, and mortality has by far the highest value ($8.8 million) among the health endpoints used in the MPEM, it is not surprising that the MPEM-derived weighting factor for PM reductions is much higher than for the other pollutants analyzed. These weighting factors are instructive for purposes of comparing the value of reducing the various pollutants.

Table C-2. Dollar Value of Reducing Pollutant 1 Ton/Year

Pollutant	Benefit: Reducing One Ton Per Year	Weighting Factor[1]
ROG	$3,400	1.0
NO_X	$6,000	1.8
Diesel $PM_{2.5}$	$562,600	167.5
Direct $PM_{2.5}$ (no diesel)	$558,400	166.3
SO_2	$18,700	5.5
Ammonia	$109,800	32.7
Acetaldehyde	$4,000 ($600 plus $3,400 as ROG)	1.2
Benzene	$12,600 ($9,200 plus $3,400 as ROG)	3.8
1,3-Butadiene	$35,700 ($32,400 plus $3,400 as ROG)	10.6
Formaldehyde	$4,700 ($1,400 plus $3,400 as ROG)	1.4
CO_2 equivalent	$62	0.02

[1]Weighting factor: ROG = 1.0. The dollar benefit/ton is divided by the ROG value of $3,400/ton to calculate weighting factor for each pollutant. For example, the value of SO_2 reductions is $18,700; dividing this by $3,400 yields a weighting factor of 5.5 for SO_2. The weighting for benzene, butadiene, formaldehyde and acetaldehyde includes their effects both as air toxics, as well as components of ROG that contribute to formation of ozone and PM.

Health Burden Analysis

The Air District analyzed the health burden from air pollution for the Bay Area 2010 Clean Air Plan. That analysis has been updated in this appendix based upon air quality data for year 2015 and valuations of health endpoints expressed in 2015 dollars.

Analysis of trends in monitoring data shows that in recent decades, Bay Area air quality has improved dramatically. This has been accomplished even as regional population, the number of motor vehicles and miles driven, and the value of the region's economic production have grown significantly. Our progress in improving air quality is due to comprehensive federal, state and local programs to reduce emissions from both stationary and mobile sources of air pollutants.

The purpose of this analysis is to estimate the health and social impacts of air pollution in the Bay Area today compared with the earliest period for which reliable ambient air quality measurements are available. To facilitate comparison between earlier years and today, we have calculated the benefit of pollutant reductions based upon the current Bay Area population. That is, the health burden is analyzed as if today's population were exposed to the pollution levels that prevailed in earlier years, and then compared to the health burden associated with current air pollution levels.

The good news is that exposure to unhealthy concentrations of local air pollutants in the Bay Area—ozone, particulate matter (PM), and air toxics—and hence their health effects, have been reduced by more than half since the 1970 Clean Air Act was enacted. Despite this progress, a variety of health effects, including premature deaths, are still associated with exposure to air pollution. These health effects result in direct and indirect economic impacts to the region that are valued in billions of dollars per year.

Methodology

The analysis presented here is based upon the Multi-Pollutant Evaluation Method. The MPEM, which draws upon U.S. EPA's BenMAP methodology,[4] is based upon various assumptions and approximations described in the *MPEM Technical Document.*[5]

Air Toxics

The air toxic health effects considered in this appendix are limited to cancer. The Air District and ARB began regular air toxics monitoring in the late 1980s. However, some toxics such as formaldehyde and acetaldehyde were not monitored until several years later. Except for diesel PM, estimates were made of the annual mean for the earliest year available and for 2015.

Diesel PM, the air toxic with the greatest health impact, cannot presently be measured directly. Indirect estimates were made for recent years using elemental carbon (EC) measurements for various Air District sites. For earlier years, estimates were made using Coefficient of Haze measurements[6], along with PM_{10} and its constituents.

Ozone

The Air District has monitored ozone since the 1950s, and since 1968 has had a spatially dense set of ozone measurements. These measurements were used to estimate population exposure for 2015 and what the exposure would have been if the ozone levels had not been reduced since 1970. For purposes of this analysis, we estimated the health impact of population exposure to the anthropogenic (man-made) portion of ozone, i.e., ozone in excess of natural background levels. The average background level of ozone in the Bay Area is on the order of 45 parts per billion (ppb), so the analysis focused on estimating the health effects related to exposure to hourly ozone concentrations above 45 ppb.[7]

$PM_{2.5}$

$PM_{2.5}$ consists of many components, some anthropogenic (man-made), some biogenic (naturally occurring). The health burden of $PM_{2.5}$ was based on the amount of anthropogenic $PM_{2.5}$, subtracting natural background $PM_{2.5}$ (sea salt, windblown dust, etc.) which is estimated to average about 3 micrograms per cubic meter (μg/m³).

$PM_{2.5}$ has been measured routinely only since 1999. To estimate $PM_{2.5}$ concentrations prior to 1999, other PM measurements made since the late 1980s and early 1990s were used to approximate $PM_{2.5}$ concentrations in 1990. The MPEM Technical Document provides details of how this was done.

Diesel PM is a key component of $PM_{2.5}$ and warrants separate treatment because it is also identified by the State of California as a carcinogen. Therefore, anthropogenic $PM_{2.5}$ is divided into diesel PM and non-diesel PM. Diesel PM cannot be measured directly, but is approximated from other measurements. See the MPEM Technical Document for details.

Health Summary

Figure C-1 shows the number of cases of selected health effects that are related to population exposure to current Bay Area air pollution levels (2015, labeled "now") compared with the estimated number of cases that would have occurred if the quantifiable air quality improvements had not been made (labeled "then"). The "then" data is based on the earliest data available—1970 for ozone, and the late 1980s for toxics and PM.

Figure C-1. Estimated incidence of health effects on today's Bay Area residents vs. effects without air quality improvements (using 1970 data for ozone, and 1980s data for toxics and PM)

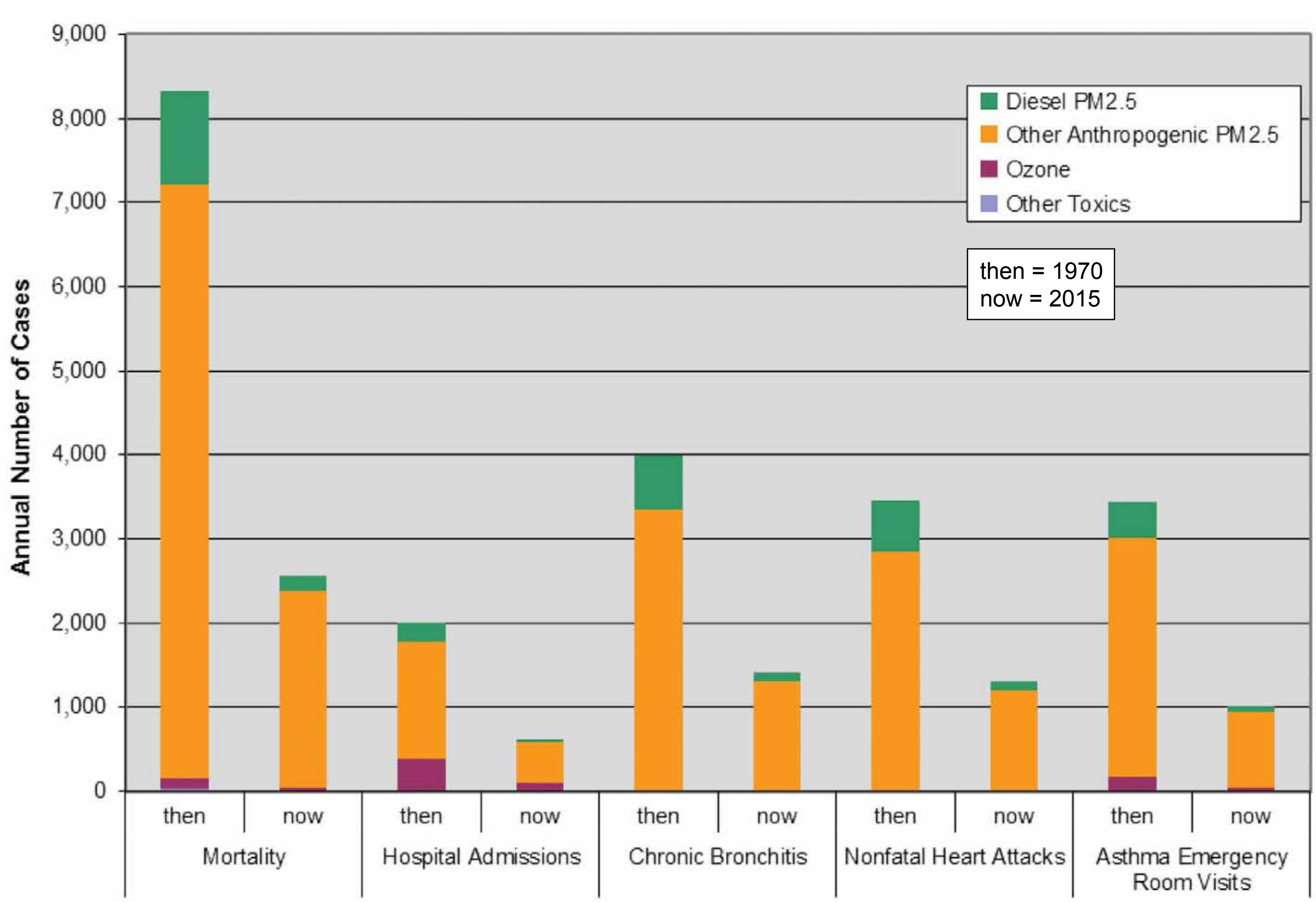


Table C-3 shows the reduction in the estimated number of annual cases; i.e., the difference between "then" and "now" for each of the health effects shown in Figure C 1. Table C-3 provides the "best estimate" as well as the lower bound (10th percentile) and upper bound (90th percentile) for an 80 percent confidence interval. The range of values is provided in Table C-3 in order to emphasize that all the health effects figures provided in this analysis are estimates. The numbers in this analysis are intended to convey a sense of overall trends and relative magnitudes, but they are not precise figures.

Figure C-1 shows that the annual numbers of health effects associated with exposure to air pollutants in the Bay Area has dropped dramatically by more than half. Of particular interest, premature deaths related to air pollution has decreased from an estimated 8,300 per year to an estimated 2,500 per year. For comparison, the total number of annual deaths in the Bay Area is about 45,000, and the annual number of transportation-related deaths in the Bay Area is 400 to 500.

Life expectancy is widely regarded as an indicator of the overall health of a given population. Life expectancy measures the average number of years a baby born today would live given the present distribution of age-specific probabilities of death. Premature mortality is a measure of unfulfilled life expectancy. The reduction in mortality risk as shown in Figure C-1 can be expressed in terms of increased life expectancy. Bay Area life expectancy increased by 6 years, from 75.7 in 1990 to 81.8 in 2012, due to a variety of factors. Of the overall increase in life expectancy during this period, improvements in air quality can be credited with extending average life expectancy in the Bay Area by about one year. Thus, approximately one-sixth of the improvement in Bay Area average life expectancy since 1990 may be attributable to cleaner air. (See MPEM Technical Document for further details.)

The vast majority of the mortality risk related to air pollution is due to exposure to fine particulate matter ($PM_{2.5}$), shown as the combination of diesel $PM_{2.5}$ and other anthropogenic $PM_{2.5}$ in Figure C-1. Several robust epidemiological studies have shown that $PM_{2.5}$ concentrations in a given area affect the death rate. The studies are based on data sets where the health and health-relevant information for a set of people from different areas has been collected for an extended period. These records allow the estimation of mortality rates for various areas, where the rates are adjusted for key factors such as age, gender, smoking, and obesity. The studies compared the adjusted death rate for each area with the average PM concentrations in the area. These showed clear correlations, with higher average $PM_{2.5}$ correlated with lower life expectancy.[8]

After reviewing the literature, a risk factor is used based on the assumption that every 1.0 μg/m^3 reduction in $PM_{2.5}$ concentration results in a one percent reduction in mortality rate for individuals

Table C-3. Reductions in annual cases, "then" to "now" including an 80 percent confidence interval.

	Mortality	Cancer Onset	Respiratory Hospital Admissions	Cardiovascular Hospital Admissions	Chronic Bronchitis	Nonfatal Heart Attacks	Asthma Emergency Room Visits
Best Estimate	5,500	120	240	900	2,900	2,600	2,200
10th Percentile	2,200	50	120	700	1,100	1,300	1,500
90th Percentile	10,100	230	420	1,100	4,400	3,600	2,900

over 30 years old.[9] For the MPEM, the change in premature mortality from $PM_{2.5}$ was calculated by estimating the percentage change in mortality from a given change in $PM_{2.5}$ concentration and applying that to the annual deaths to persons over 30 years old. Currently, Bay Area $PM_{2.5}$ concentrations average about 8.7 μg/m^3, or about 5.7 μg/m^3 above natural background levels. Thus, total elimination of anthropogenic $PM_{2.5}$ is estimated to reduce the death rate by about 5.7 percent for those over 30, or about 2,500 deaths per year.

Although research is still on-going to determine the precise biological mechanisms through which $PM_{2.5}$ is associated with increased mortality, it appears that cardiovascular problems, such as heart attacks, are the leading cause (U.S. EPA 2009). Although diesel PM is the leading air toxic in the Bay Area, it should be noted that perhaps only about 10 percent of these PM-related deaths are linked to diesel exhaust. Other sources of PM, such as wood smoke, cooking, and secondary formation of PM from precursors such as NO_X, SO_2, and ammonia, collectively account for most of the ambient PM, and PM-related mortality, in the Bay Area. To the extent that diesel PM does contribute to premature deaths, it appears to be primarily due to the mechanisms mentioned above. Cancer accounts for a smaller number of total deaths related to air pollution. The total annual number of cancer deaths, including lung cancer, related to exposure to diesel PM in the Bay Area, is approximately 20-25 per year. Thus, mortality related to exposure to fine PM (including diesel particles) appears to be associated much more with cardiovascular problems than with cancer.

Summary of Costs and Disbenefits

Air pollution imposes costs on society in terms of public health, the environment, and the economy. Approximations can be made for the direct costs of treatment for pollution-related health effects, as well as indirect costs based upon people's willingness to pay to avoid those health effects. Table C-4 presents a list of health effects and the estimated dollar value of these effects on a per-case basis. For GHGs, a value of $62 metric ton of CO_2-equivalent emitted is used for the overall social cost related to the anticipated impacts of

Table C-4. Estimated dollar value per case for key health effects related to Bay Area air pollution.

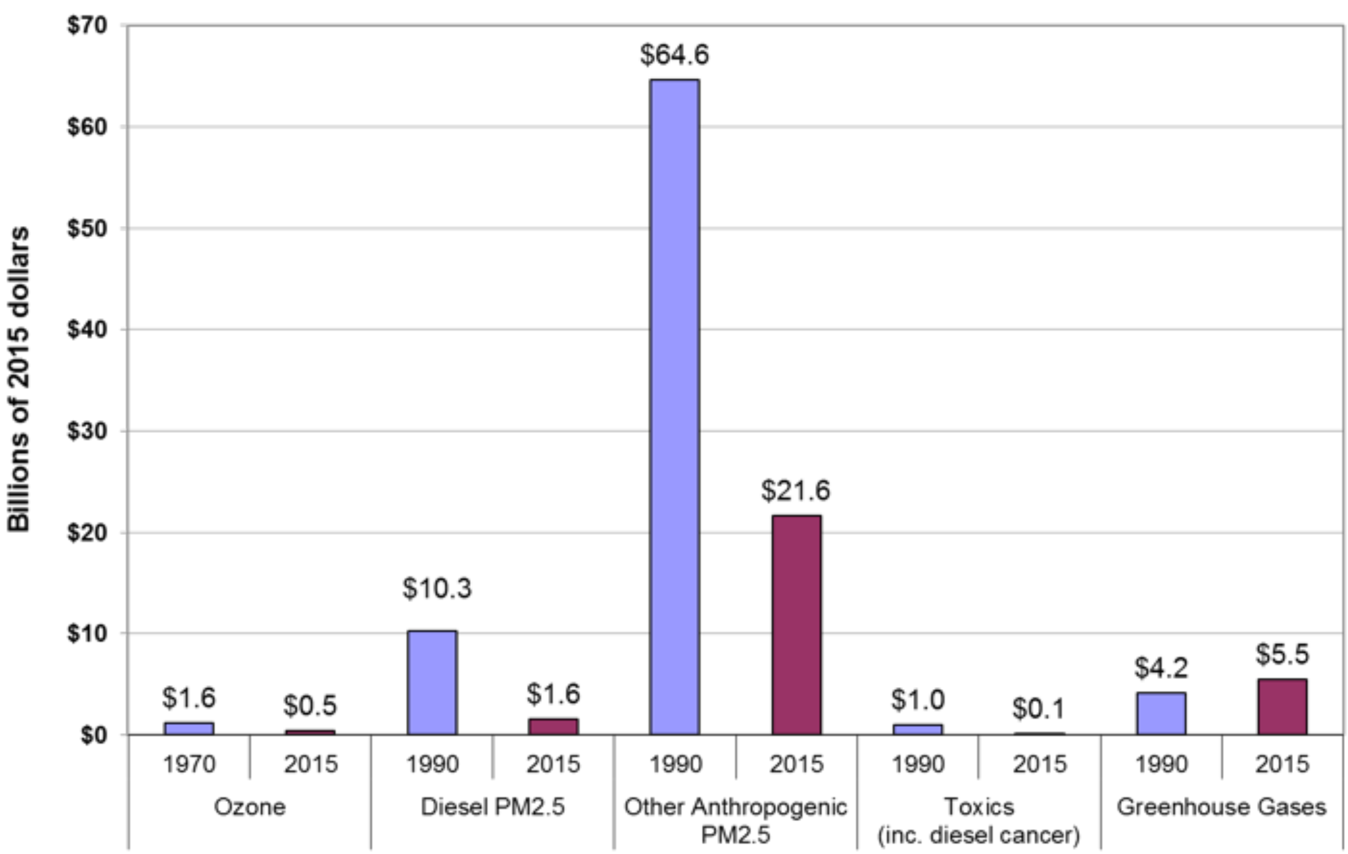
Health Effect	Unit Value (Cost per Incident, 2015 dollars)
Mortality (all ages)	$8,800,000
Chronic Bronchitis Onset	$476,117
Respiratory Hospital Admissions	Age 65 < : $55,305 Age 65 > : $48,901
Cardiovascular Hospital Admissions	Age 65 < : $65,178 Age 65 > : $56,060
Non-Fatal Heart Attacks	$82,580
Asthma Emergency Room Visits	$478
Acute Bronchitis Episodes	$598 for a 6-day illness period
Upper Respiratory Symptom Days	$40
Lower Respiratory Symptom Days	$25
Work Loss Days	Daily Median Wage by County ($186 to $278)
School Absence Days	$103
Minor Restricted Activity Days	$85
Cancer	$3,700,000
Social Cost of GHG Emissions	$62 per metric ton ($CO_2$ equivalent)

climate change. This value was chosen from a range of potential values suggested by U.S. EPA in its *Social Cost of Carbon* fact sheet.[10]

Figure C-2 summarizes the figures for health burden associated with exposure to ozone, $PM_{2.5}$, and air toxics, and also the social cost of GHG emissions. The cost estimates in Figure C-2 are based upon individual case values shown in Table C-4. Note that the data in Figure C-2 are based upon a wider range of health effects than the subset of health effects portrayed in Figure C-1. In each case, estimates for the earliest reliable period are compared with the present. The data in Figure C-2 indicate that, in aggregate, annual health and social costs have declined by more than 60 percent, from approximately $83 billion to approximately $32 billion per year. It should be emphasized that the numbers in Figure C-2 are estimates only; they should not be seen as precise values. Nonetheless, we can conclude with a high degree of confidence that the benefits of air pollution reductions run in the billions of dollars annually.

In contrast to ozone, PM, and air toxics, emissions of GHGs have risen steadily since 1990. The estimated costs presented in Figure C-2 are a few billion dollars a year, but this represents a median estimate, not an upper bound. The potential effects from global warming could be catastrophic.

Figure C-2. Estimated current annual health and other social costs of Bay Area air pollution: prior years compared with 2015.



Summary of Key Findings

The analysis described in this appendix indicates that due to improved air quality in the Bay Area, annual health effects, and the related social and economic cost of these health effects, have declined by more than 60 percent over the past several decades. The estimated number of premature deaths related to air pollution in the Bay Area decreased from approximately 8,300 per year in 1990 to about 2,500 per year in 2015. The reduction in premature deaths related to air pollution over the past two and a half decades has contributed to an increase in average life expectancy. Improved air quality is estimated to have extended average life expectancy on the order of one year per Bay Area resident. Despite this substantial progress, Bay Area residents continue to experience significant health effects from exposure to air pollution. These health effects impose on-going costs to the individuals who experience these impacts and to the region as a whole.

FOOTNOTES

[1] The various assumptions and approximations embedded in the method are described in the MPEM Technical Document, available on the Air District's website.

[2] District staff performed an uncertainty analysis using the Monte Carlo method to evaluate the MPEM calculations for each control measure.

[3] Valuations of health effects are explained in Section 5 in the MPEM Technical Document: http://www.baaqmd.gov/research-and-data/research-and-modeling.

[4] https://www.epa.gov/benmap

[5] MPEM Technical Document: http://www.baaqmd.gov/research-and-data/research-and-modeling.

[6] Coefficient of Haze (COH) is a measurement of PM that is highly correlated with elemental carbon (EC).

[7] For further discussion of this approach, see *The Health Benefits of Reduced Tropospheric Ozone in California,* by Bart Ostro, Tran Hien, and Jonathan I Levy, JAWMA July 2006.

[8] See Pope et al. *Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults,* American Journal of Respiratory and Critical Care Medicine, Vol. 151, No. 3_pt_1 (1995), pp. 669-674. Also see Krewski et al. *Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality.* Health Effects Institute, Number 140, May 2009.

[9] The key study serving as the basis of our estimate is the *Expanded expert judgment assessment of the concentration-response relationship between $PM_{2.5}$ exposure and mortality,* prepared for OAQPS-EPA by Industrial Economics Inc, September 21, 2006. A summary of this study is provided in Roman et al. 2008.

[10] https://www3.epa.gov/climatechange/Downloads/EPAactivities/social-cost-carbon.pdf.

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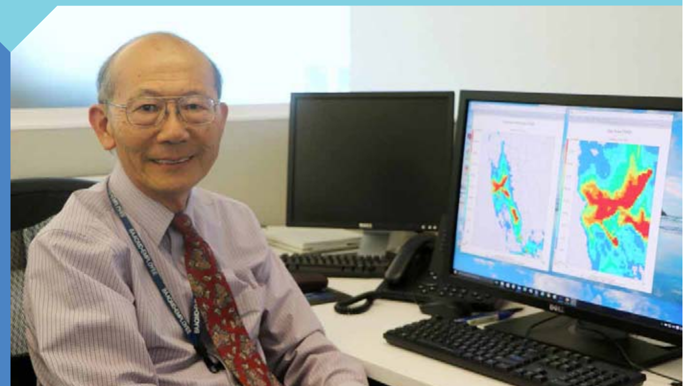
APPENDIX D



AIR QUALITY MODELING

Although there is no regulatory requirement to perform air quality modeling for the 2017 Plan, results of recent modeling help to inform the Air District's air quality planning. This appendix describes the Air District's recent air quality modeling work.

BAAQMD Modeling History and Scope

From 1989 to 2006, the Air District's air quality modeling effort primarily focused on ozone. PM and toxic air contaminants (TACs) have since been added to the modeling program. Because of the Bay Area's relatively low current PM and ozone levels, the Air District is not required to use air quality models to demonstrate attainment of federal air quality standards. Nor does the Health & Safety Code require the use of air quality models in meeting state air quality standards. However, the Air District is committed to continue working with neighboring districts and ARB to study regional ozone and PM formation and transport through air quality modeling and data analysis.

In summary, the goals of modeling at the Air District include:

- better understanding of ozone and particulate matter formation in the Bay Area;
- assessing the benefits of various proposed and adopted emissions control measures;
- weighing alternative emissions control strategies for future planning;
- estimating human exposure to pollutants and associated health impacts;
- analyzing potential impacts of land use and development; and
- providing modeling support to Air District programs and functions such as planning, permit evaluation, rule development, grants and incentives, climate protection, and the CARE Program.

The Air District also participates in collaborative regional air quality studies such as the Central California Ozone Study (CCOS) and the California Regional Particulate Air Quality Study (CRPAQS). Collaborators include the U.S. EPA, ARB, the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), universities and neighboring districts, especially the San Joaquin Valley Air Pollution Control District and the Sacramento Metropolitan Air Quality Management District.

Modeling Methodology

An air quality model estimates pollutant concentrations by accounting for pollutant emission, transport, mixing, chemical transformation in the atmosphere, and removal through deposition to the ground. The Air District uses two state-of-the-science air quality models that are publicly available: U.S. EPA's Community Multiscale Air Quality (CMAQ) model and Ramboll Environ US Corporation's Comprehensive Air Quality Model with extensions (CAMx). Both are capable of handling multiple pollutants, including ozone, toxics and PM. Currently, the Air District uses CAMx for simulating air toxics, and CMAQ for simulating ozone and $PM_{2.5}$ simultaneously.

Emissions inventory and meteorological inputs to these models are prepared using several specialized computer programs. The U.S. EPA's Sparse Matrix Operator Kernel Emissions (SMOKE) program is used to prepare anthropogenic emissions as inputs to air quality models. Biogenic emissions from ARB's Biogenic Emissions Inventory—Geographic Information System (BEIGIS) program are also processed using SMOKE. The meteorological inputs to SMOKE, CAMx and CMAQ are created using NOAA's Weather Research and Forecasting (WRF) model. This newer, more capable model replaced the Penn State University/National Center for Atmospheric Research Mesoscale Model version 5 (MM5) used in the past. SMOKE and CMAQ, along with their documentations, are available from the U.S. EPA and WRF, from NOAA. BEIGIS and its documentation is available from ARB. CAMx, with its documentation, is available from Ramboll Environ US Corporation.

To prepare the anthropogenic emissions inputs, county-level, source-specific annual (or average daily) total emissions are allocated spatially within a predefined grid covering the modeling domain. Emissions are then further distributed to each day of the week and hour of the day and chemically speciated for modeling. Biogenic (vegetation) emissions are estimated based on leaf area index, solar radiation and ambient temperatures within each grid cell at each hour.

WRF is applied to estimate hourly wind speed and direction, temperature, humidity, cloud cover, rain and solar radiation amounts needed by the air quality model. Observations are injected into the model during the simulations to minimize the difference between simulations and real-world measurements.

Both meteorological and photochemical models are applied over a relatively large domain to capture the regional features of meteorology and air quality. For the Air District's ozone and PM modeling, the domain covers all of Central California and portions of northern California, from Redding in the north to the Mojave Desert in the south, and from the Pacific Ocean in the west to the Sierra Nevada in the east (Figure E-1). For toxics and wood-burning modeling, a subset of the photochemical modeling domain was selected, shown as the red box in Figure D-1. While toxics and wood burning emissions were from Bay Area counties only, meteorological inputs covered the entire inner domain.

The Air District follows U.S. EPA and ARB guidelines in applying WRF, CMAQ and CAMx. These guidelines call for the air quality and meteorological models to be evaluated with observation data, in accordance with established model evaluation criteria. In addition, the Air District continually evaluates various physics and chemistry options within the models and other critical elements, which are not set within the models (such as initial and boundary conditions), to improve model performance.

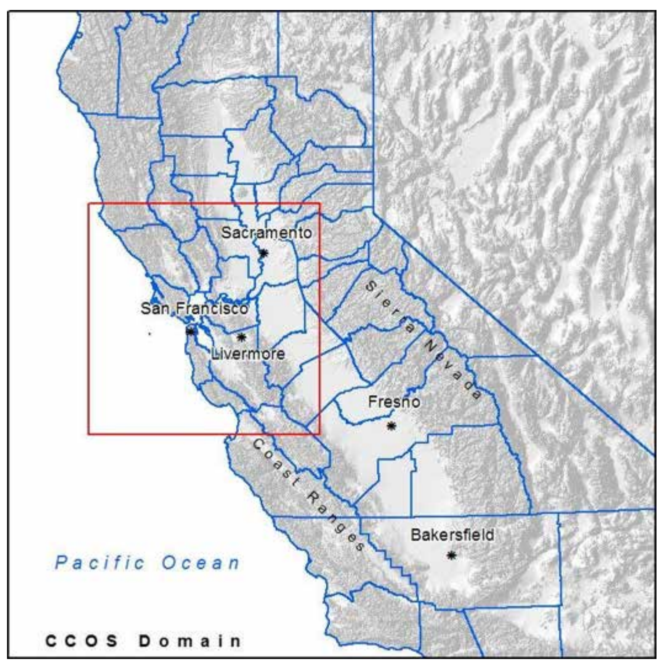


Figure D-1. Ozone and $PM_{2.5}$ modeling domain (entire figure); toxics and wood smoke modeling domain outlined in red.

Once model performance is deemed satisfactory, the models are used to simulate pollutants with the base-year emissions and to conduct sensitivity simulations to determine model response to changes in emissions. These model responses are also compared to trends in emissions and ambient pollutant concentrations. These rigorous steps are taken to improve confidence in model estimates for regulatory applications.

Model Application

A) Preparing model for base-case simulation

Initially, WRF and CMAQ were applied from Jan. 1–15, 2012, and Aug. 1–15, 2012, to simulate elevated winter PM and summer ozone concentrations, respectively. Outputs from both models were analyzed and compared to observations. Key meteorological parameters affecting air quality model performance were identified.

To improve performance for both models, a number of investigative simulations were conducted and key model options were tested. Specific areas of investigation included:

- ***Planetary Boundary Layer (PBL) processes and time-based evaluation of mixing height:*** The PBL schemes tested were Pleim-Xiu, YSU, MRF and TKE. The final version of the model utilized the Pleim-Xiu scheme.

- ***Input database for WRF:*** Input databases tested were North American Regional Reanalysis (NARR) and Ensemble Data Assimilation System (EDAS). The final version of the model utilized the NARR database. Other databases were also considered, but not selected because continuous data for the entire 2012 calendar year were unavailable.

- ***Four-Dimensional Data Assimilation (FDDA) strategy for WRF:*** WRF was tested with and without analysis and observational nudging. For the FDDA case, nudging time interval, radius of influence of observations, and the magnitude of nudging coefficients were tested. The final version of the model utilized 3-D analysis nudging with a twelve-hour interval (when upper air observations are available) and surface analysis nudging with one-hour interval for the 36 and 12 km domains. Observational nudging was applied to the 4km domain only. The radii of influence selected were about 200km, 100km, and 60km for the 36km, 12km, and 4km domains, respectively. The default nudging coefficients were kept.

- ***Horizontal and vertical diffusion:*** Horizontal and vertical diffusion coefficients were adjusted in both models. The final version of the model utilized a minimum horizontal diffusivity of 2000m^2/sec in WRF and 200m^2/sec in CMAQ. The default minimum vertical diffusivity (0.01m^2/sec) was kept in WRF, but minimum vertical diffusivity was increased from 0.01m^2/sec to 0.1m^2/sec in CMAQ.

- ***Advection scheme:*** Both WRF and Yamartino advection schemes were tested in CMAQ. The final version of the model utilized the Yamartino advection scheme.

- ***Initial and boundary conditions:*** Several strategies for specifying initial and boundary conditions were tested including interpolation from a previously prepared profile, from aircraft measurements and from MOZART (a global model). The final version of the model utilized initial and boundary conditions from interpolation of MOZART's output for all species except ozone. Ozone initial and boundary conditions were specified from a monthly average of the ozone profile measurements at Trinidad Head, Calif.

For each of the investigations, model performance was evaluated and results were assessed as to whether improvements were achieved. The final selected options and datasets provided the best performance for both models.

After the best performance was obtained for the 2-week winter and 2-week summer periods, the entire period from January 1 to December 31, 2012, was simulated. Model performance was qualitatively evaluated for key parameters and species such as wind speed and direction, temperature, ozone, PM, NO_2, VOC, SO_2, OC (organic carbon), EC (elemental carbon), and other pollutants for the entire year. Graphical displays of the simulated fields (such as wind, temperature and key pollutant concentration fields) were generated and evaluated for reasonableness. Emissions spatial distributions were also evaluated graphically. Diurnal and seasonal differences for all of these parameters and species were checked and evaluated qualitatively.

Figures D-2 and D-3 show examples of simulated ozone and $PM_{2.5}$ concentrations in the region on days when ozone and $PM_{2.5}$ concentrations were high.

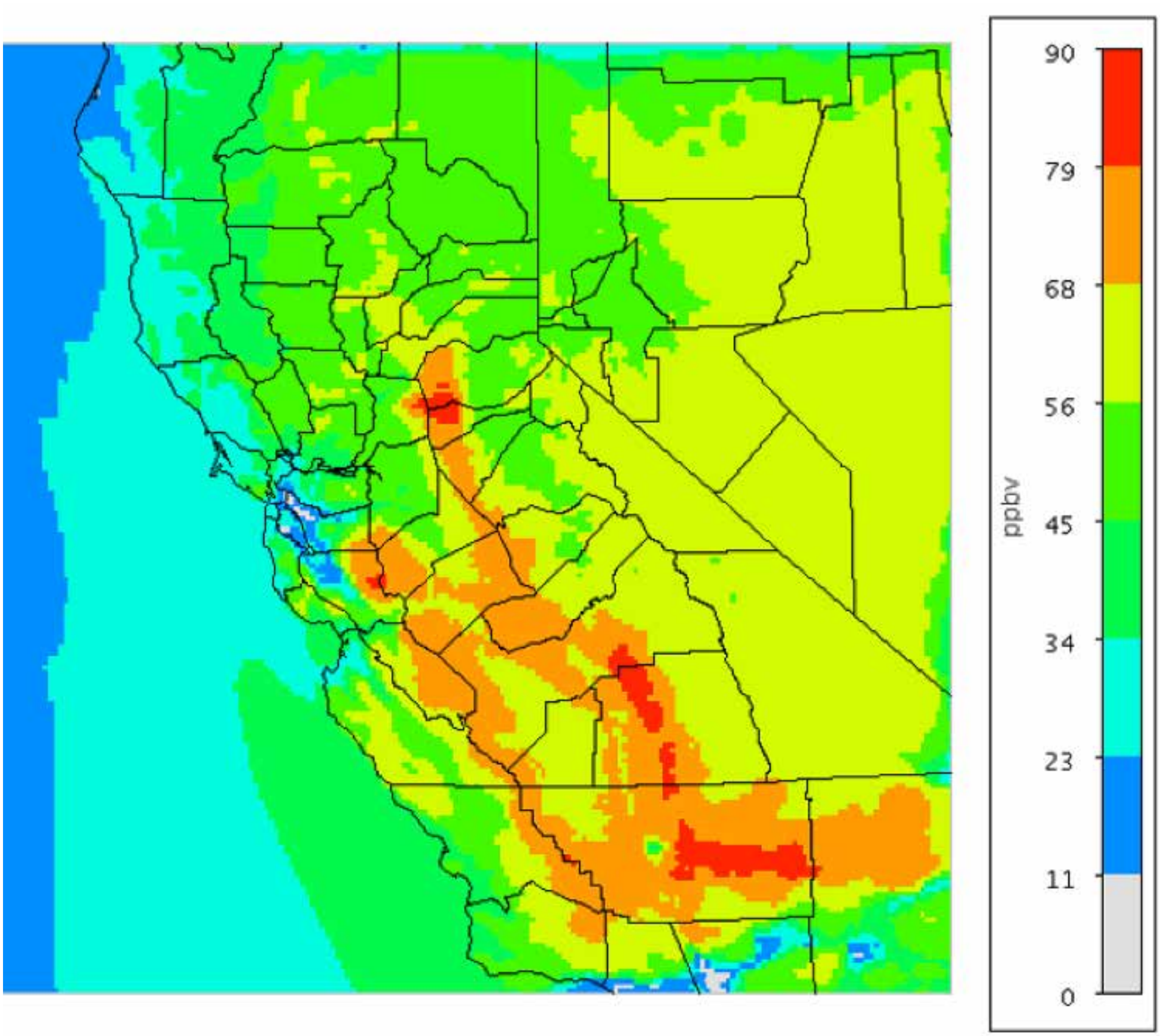


Figure D-2. Simulated 8-hour ozone concentrations on August 11, 2012, a typical ozone pattern during a high ozone day in the modeling domain

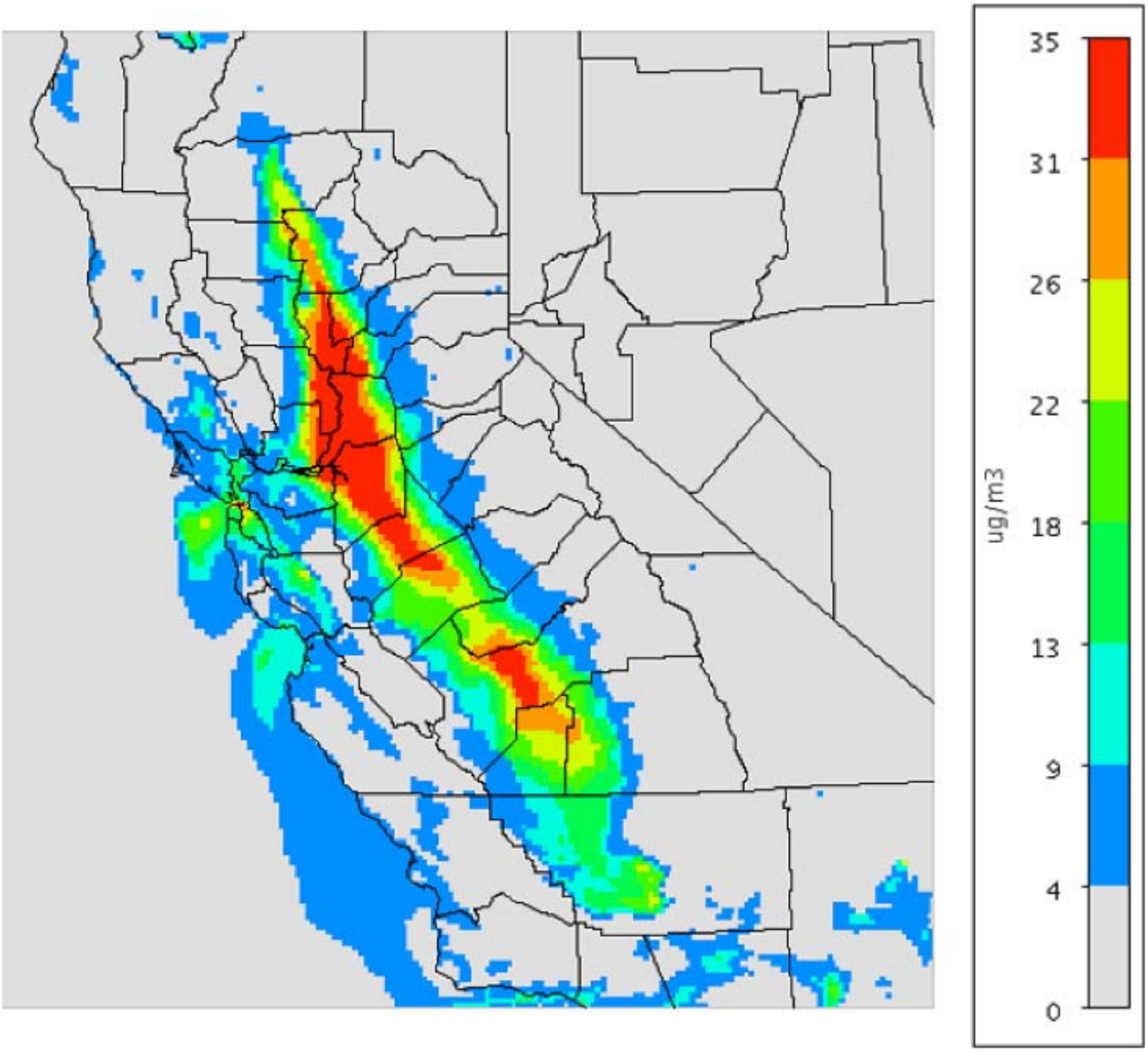


Figure D-3. **Simulated $PM_{2.5}$ concentrations on January 11, 2012 at noon, a typical $PM_{2.5}$ pattern on a high $PM_{2.5}$ day in the modeling domain**

B) Ozone base-case validation

To prepare for the sensitivity simulations, the base-case simulation for August 2–15, 2012 was more thoroughly validated using actual measurements to ensure that results adequately represented real-world ozone levels. First, the simulated hourly ozone levels were compared to observed hourly ozone for every measurement station in the modeling domain. Then a similar comparison was made for maximum 8-hour average concentrations on a day-by-day basis for the two-week period. Additionally, simulated values and observations, each averaged within selected subdomains, were compared. The selected subdomains were the Bay Area, San Joaquin Valley and Sacramento. Graphical displays of evaluated fields and statistical measures such as bias, error, root mean square error and index of agreements were generated. Overall, the model performance was reasonable.

The discussion below focuses on detailed results for the Bay Area and Delta region. Figures D-4a through D-4d compare simulated and observed maximum 8-hour average ozone for four Bay Area stations: Livermore, Concord, Los Gatos and San Martin. These stations have historically high ozone concentrations during summer months.

The day-to-day variance in ozone is captured well by the model at all four locations, indicating that the modeled meteorological conditions that impacted ozone formation during this period are generally accurate. Livermore (Figure D-4a) has mixed results, overestimating ozone concentrations for most of the August 2–15, 2012 period but slightly underestimating on the highest day, August 11. Concord (Figure D-4b) also has mixed results, but overestimates the peak day (also August 11) by over 10 ppb. Los Gatos (Figure D-4c) consistently overestimates ozone throughout the period. San Martin (Figure D-4d) mostly overestimates ozone, but does quite well for the highest observation days—August 12–13. With the exception of San Martin, the highest observations occurred on August 11. The model does quite well in identifying the day with the highest observed ozone for Livermore, Concord and Los Gatos, but incorrectly models August 11 as the highest day at San Martin.

The model was also evaluated with respect to key precursor concentrations such as NO_X and VOCs. The model performance for these species was also reasonable (not shown).

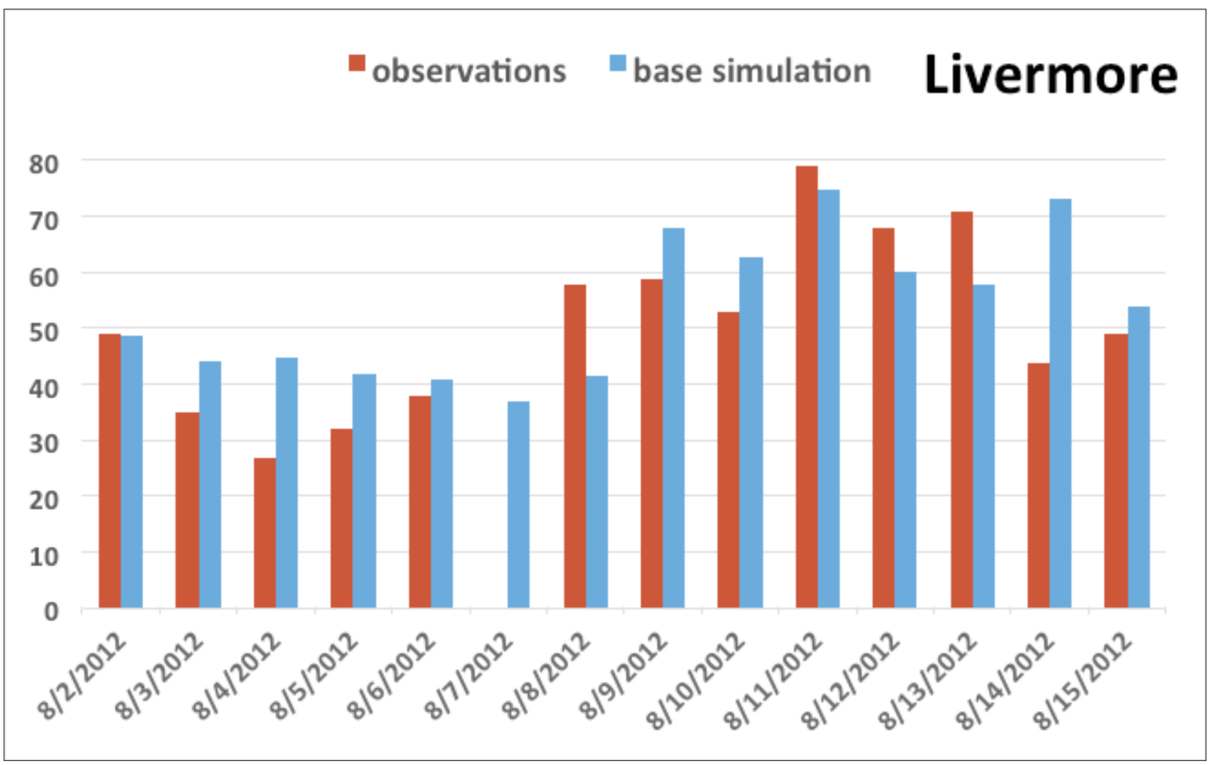


Figure D-4a. **Observed and simulated maximum 8-hour average ozone concentrations (ppb) at the Livermore air monitoring station for August 2–15, 2012**

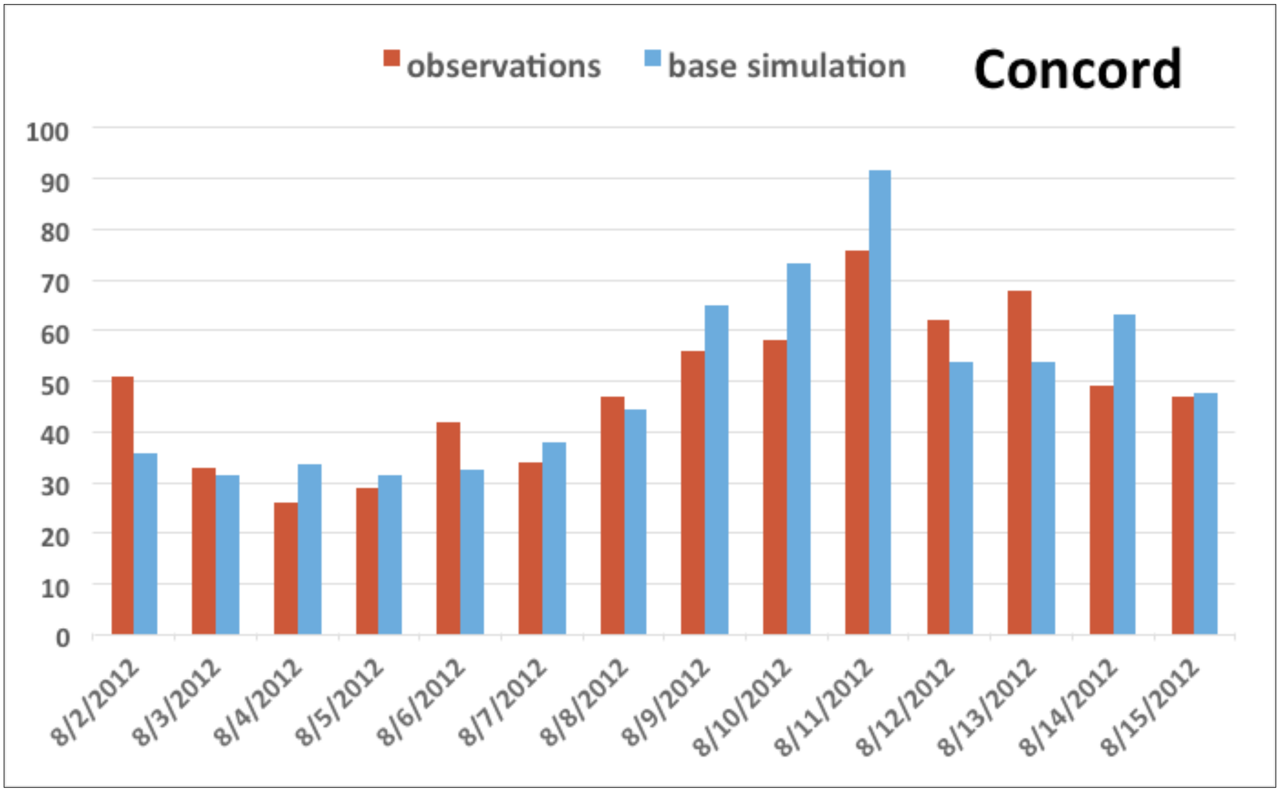


Figure D-4b. **Observed and simulated maximum 8-hour average ozone concentrations (ppb) at the Concord air monitoring station for August 2–15, 2012**

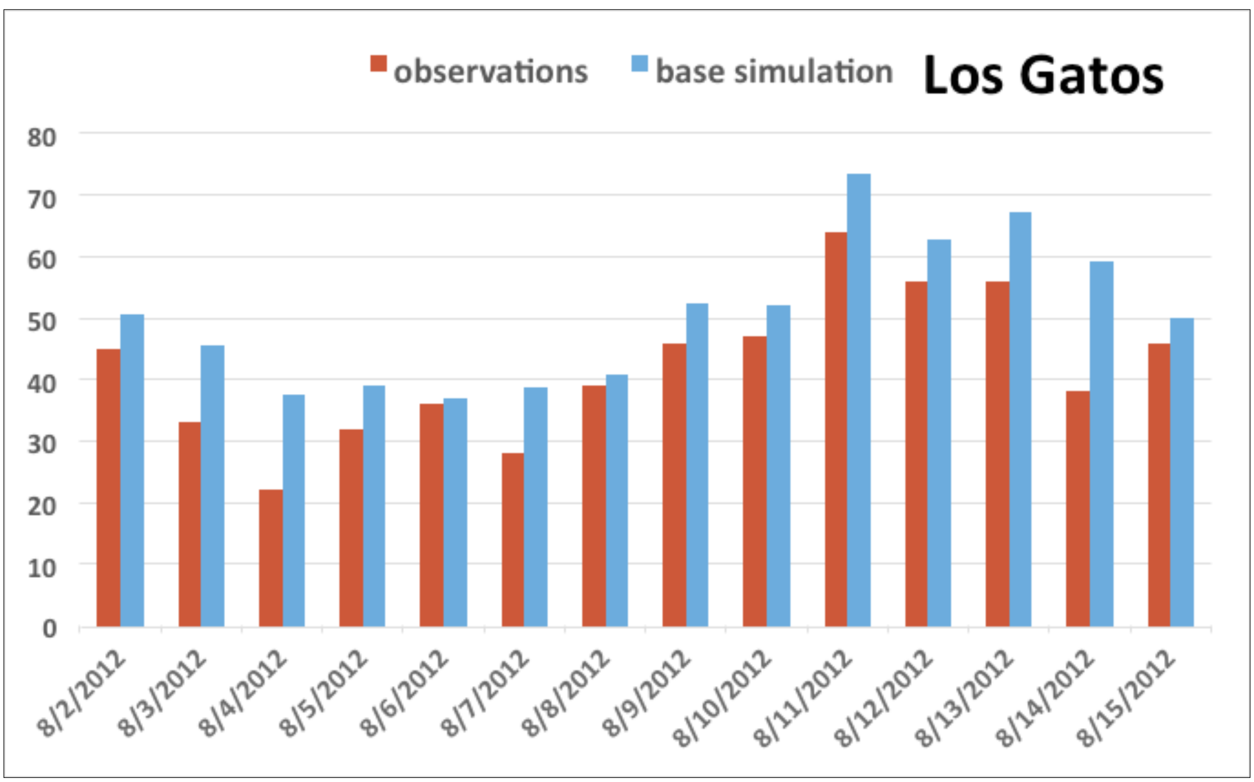


Figure D-4c. **Observed and simulated maximum 8-hour average ozone concentrations (ppb) at the Los Gatos air monitoring station for August 2–15, 2012**

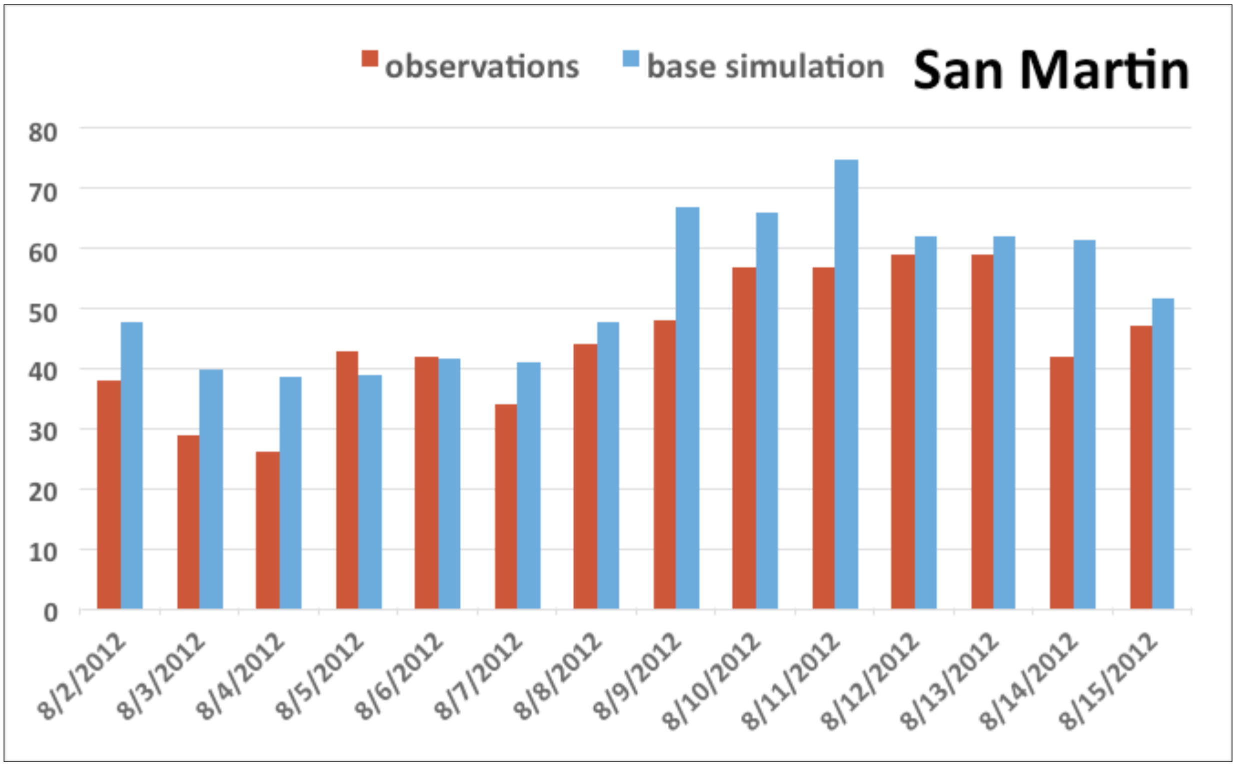


Figure D-4d. **Observed and simulated maximum 8-hour average ozone concentrations (ppb) at the San Martin air monitoring station for August 2–15, 2012**

C) Ozone sensitivity simulations

Two sensitivity simulations were conducted for August 2–15, 2012, with 20 percent across-the-board reduced anthropogenic NO_X and VOC emissions in the Bay Area. Results from these sensitivity simulations were compared to the base-case simulation over the entire Bay Area, but the following discussion is limited to the selected four Bay Area stations with historically high ozone discussed above.

Figures D-5a through D-5d show ozone concentrations for the base and control cases. NOx and VOC emission reductions each has less than 2 percent impacts on ozone at most Bay Area stations on most summer days.

A 20 percent reduction in anthropogenic VOC emissions reduces ozone 1–2 percent on most simulation days at all four stations. A 20 percent reduction in anthropogenic NO_X emissions, however, increases ozone 1–2 percent. This is because core urban areas of the Bay Area are still considered to be NO_X rich despite the fact that both anthropogenic NO_X and VOC emissions have been significantly reduced in the region over the last 20 years.

Recall that ozone chemistry is involved with conversion of NO to NO_2. Two path ways are significant: (1) $NO+O_3$->NO_2+O_2 and (2) $NO+RO_2$->NO_2+RO. Here RO and RO_2 represent VOC species from both anthropogenic and biogenic emissions. In a NO_X rich area, reducing NO_X emissions slows down ozone titration in reaction (1) and as a result NO_X emission reductions show ozone disbenefits. However, reducing NO_X emissions until ambient NO_X concentrations are below a threshold will slow down NO to NO_2 conversion in reaction (2) and as a result ozone production will also slow down. Under this condition, reducing NO_X or VOC emissions will also reduce ozone.

Outside of core urban areas of the Bay Area, the threshold value has already been reached. As Bay Area emissions are further reduced, it is expected that the threshold value will also be reached in core urban areas. That is when reducing NO_X or VOC will reduce ozone concentrations anywhere in the Bay Area.

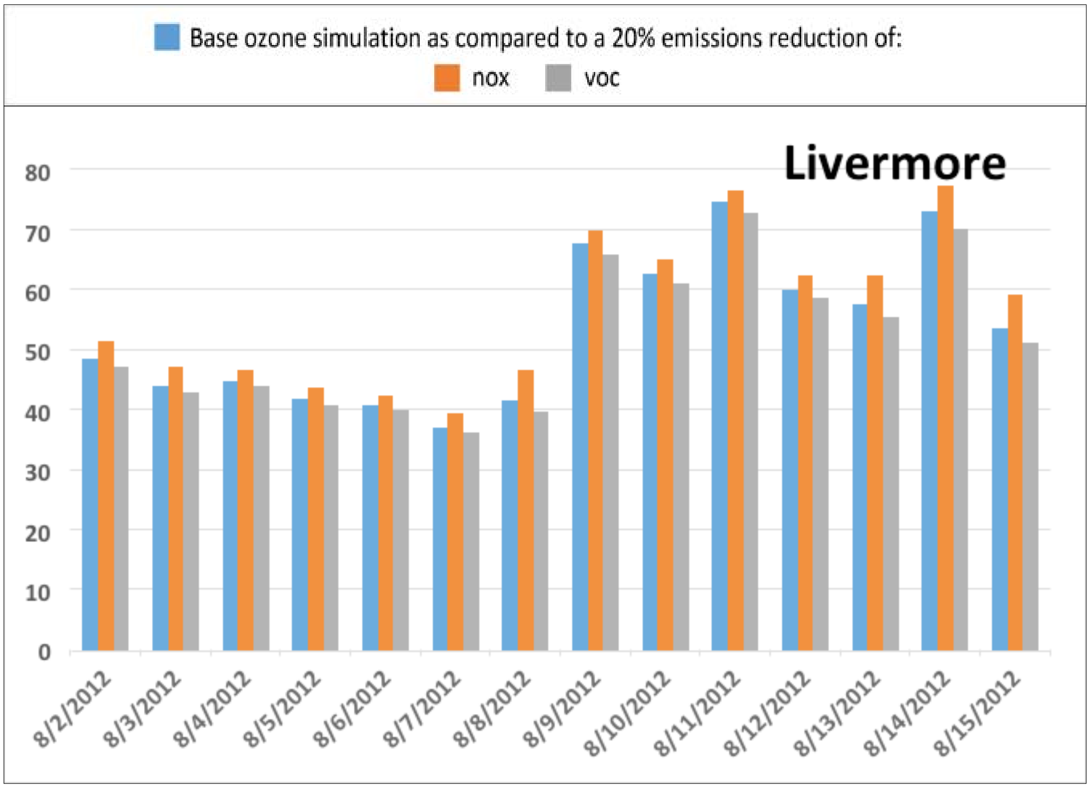


Figure D-5a. **Simulated maximum 8-hour average ozone concentrations (ppb) at the Livermore air monitoring station for August 2–15, 2012, for the base-case and two control cases**

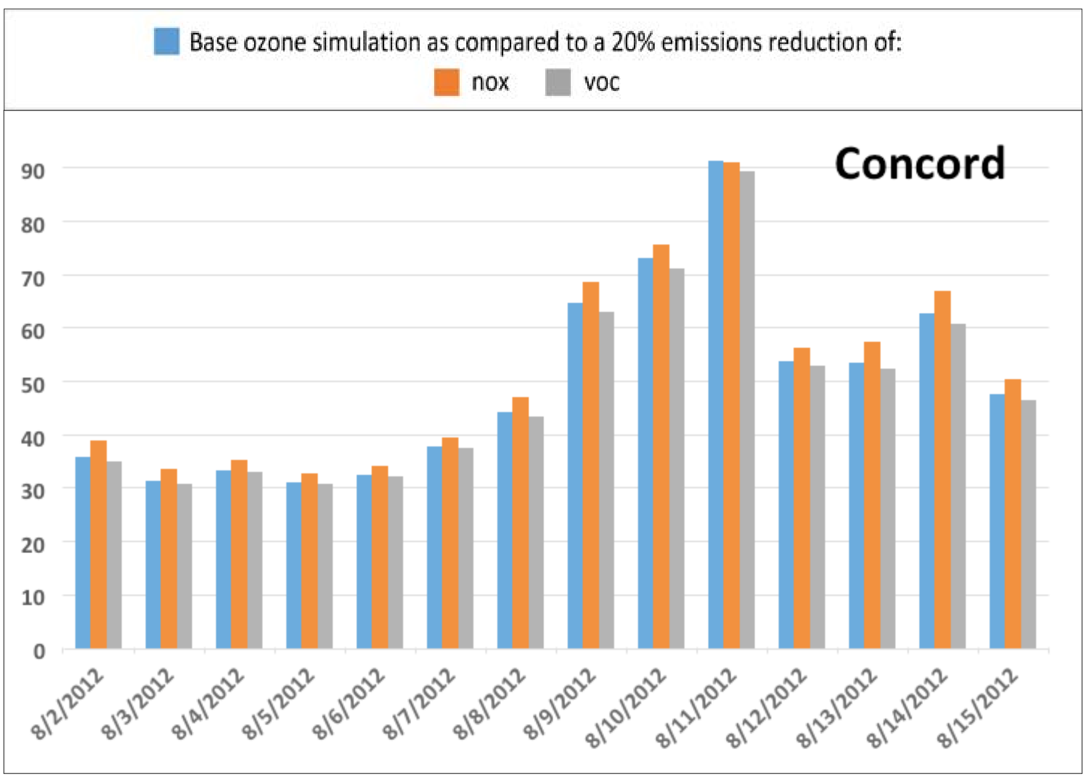


Figure D-5b. **Simulated maximum 8-hour average ozone concentrations (ppb) at the Concord air monitoring station for August 2–15, 2012, for the base-case and two control cases**

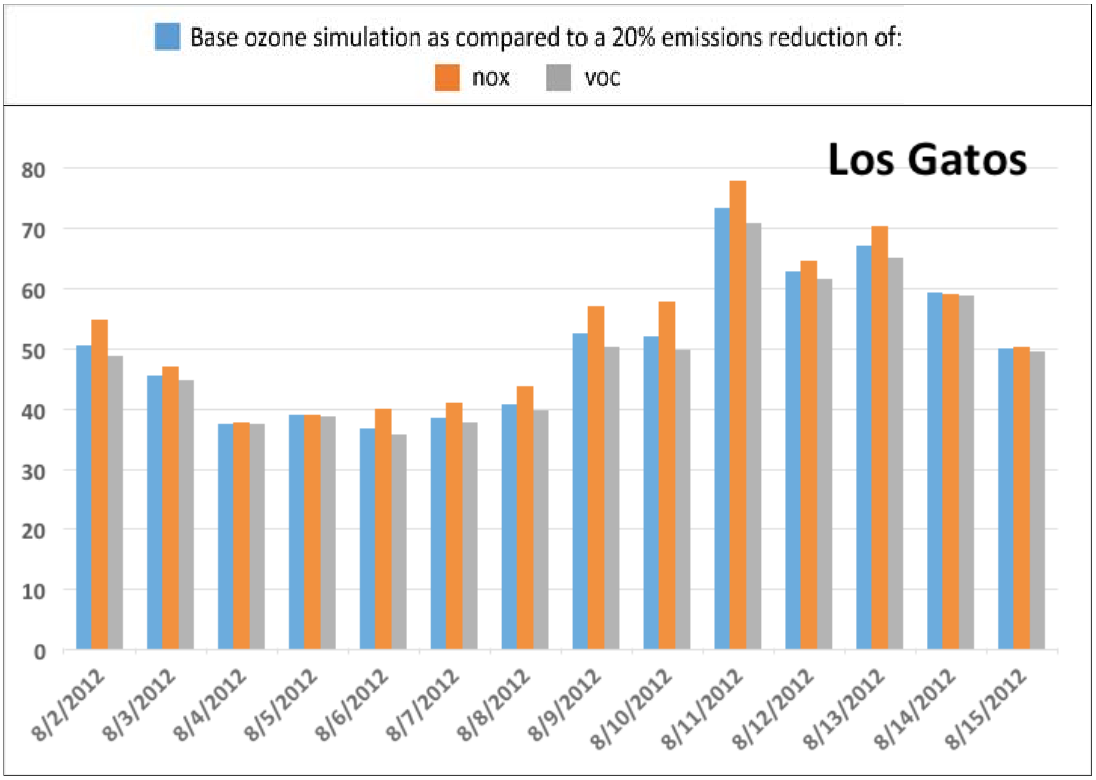


Figure D-5c. **Simulated maximum 8-hour average ozone concentrations (ppb) at the Los Gatos air monitoring station for August 2–15, 2012, for the base-case and two control cases**

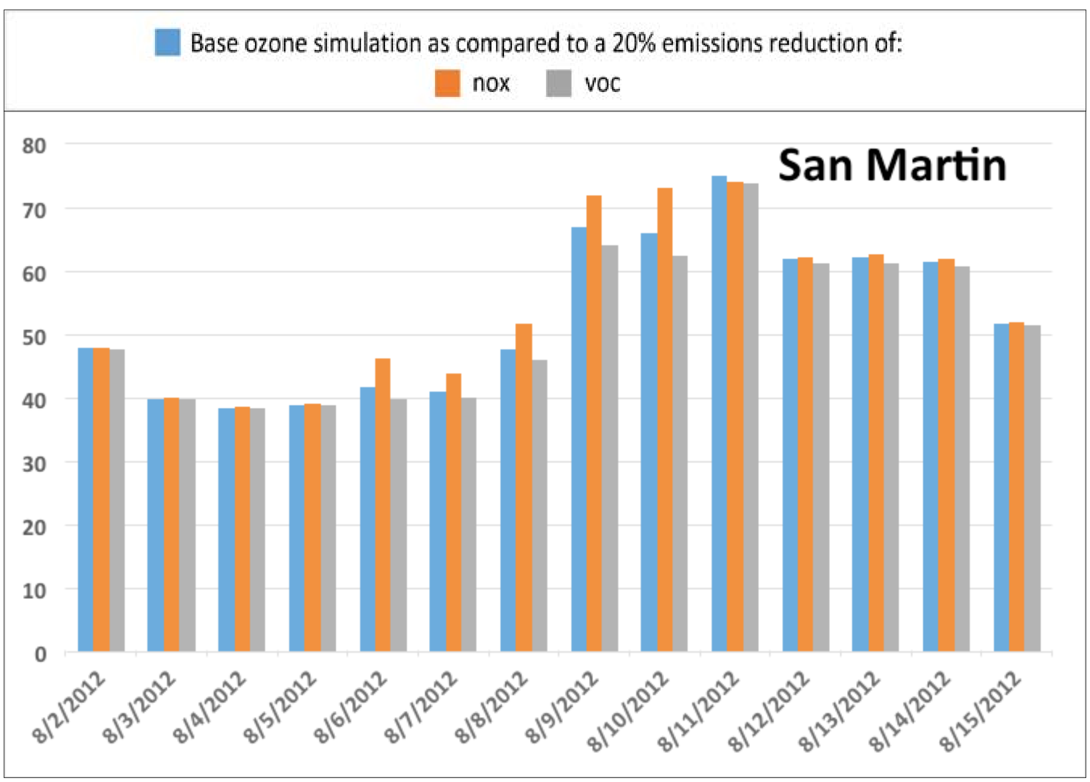


Figure D-5d. **Simulated maximum 8-hour average ozone concentrations (ppb) at the San Martin air monitoring station for August 2–15, 2012, for the base-case and two control cases**

D) $PM_{2.5}$ base-case validation

As with ozone, the $PM_{2.5}$ base-case simulation was validated using measurements to ensure that results adequately represented observed levels. Simulated 24-hour average $PM_{2.5}$ levels were compared against observed 24-hour average $PM_{2.5}$ at every observation station in the modeling domain, day by day, for January 2–15, 2012. Once again the average of simulated values at observation station locations for selected subdomains such as the Bay Area, San Joaquin Valley and Sacramento were compared to the average of observations for the respective subdomains. Finally, the simulated annual average was compared to the observed annual average for the stations within each subdomain. Graphical displays of evaluated fields and statistical measures such as bias, error, root mean square error and index of agreements were generated.

Generally, model performance is reasonable. Again, special attention is given to the Bay Area and Delta region. Station-by-station comparisons are shown in Figures D-6a through D-6d for four selected Bay Area stations: San Jose, San Francisco, Oakland and Vallejo for January 2–15, 2012. These stations historically experience high $PM_{2.5}$ concentrations during winter months.

The observed day-to-day variance in PM was effectively simulated by the model at all four locations, indicating that the meteorological conditions that impacted PM formation during this period were generally captured well. The magnitudes of peak simulated $PM_{2.5}$ were close to peak observations at San Jose and Vallejo, but were overestimated in San Francisco and underestimated in Oakland during the January 9–12 episode. This could be due to the inherent uncertainty in comparing a point measurement to a 4x4 km grid volume estimate at urban locations with complex emission patterns.

The model was also evaluated using observed concentrations of key precursors such as NO_X, VOCs, ammonia, organic and inorganic PM species and SO_X. The performance of the model for these species was also reasonable (not shown).

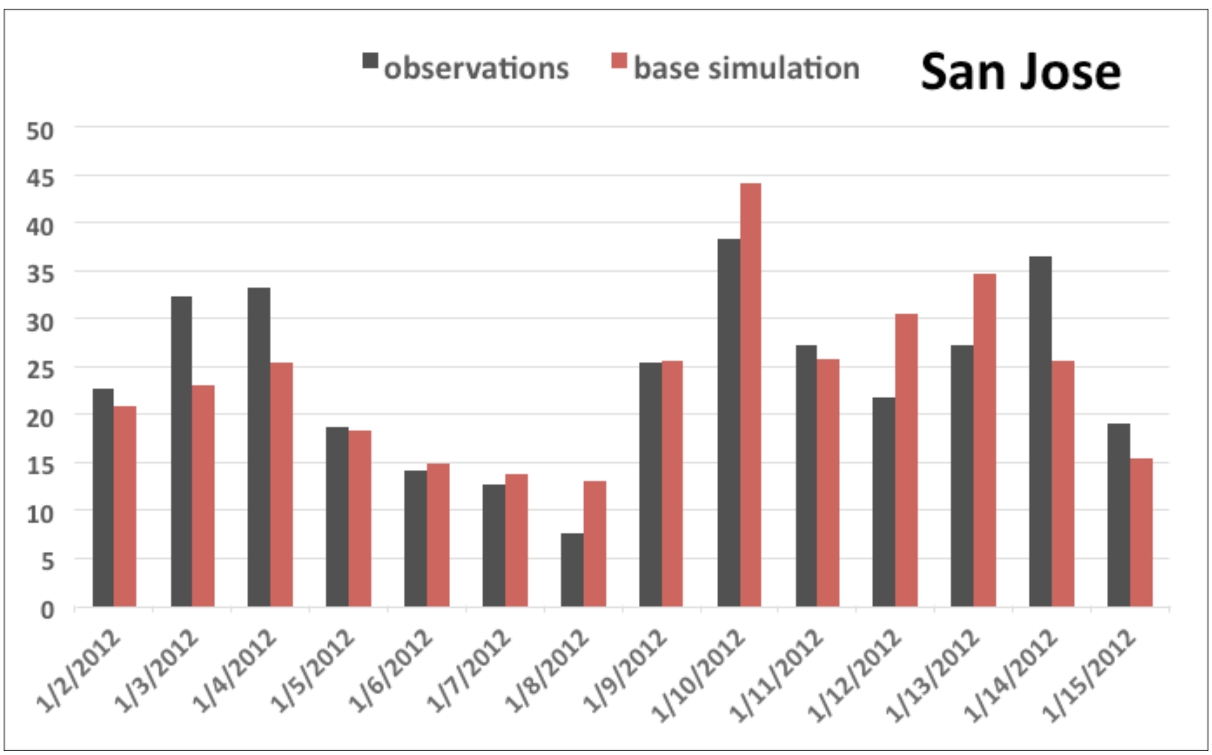


Figure D-6a. Simulated and observed 24-hour average $PM_{2.5}$ concentrations (μg/m³) at the San Jose air monitoring station for January 2–15, 2012

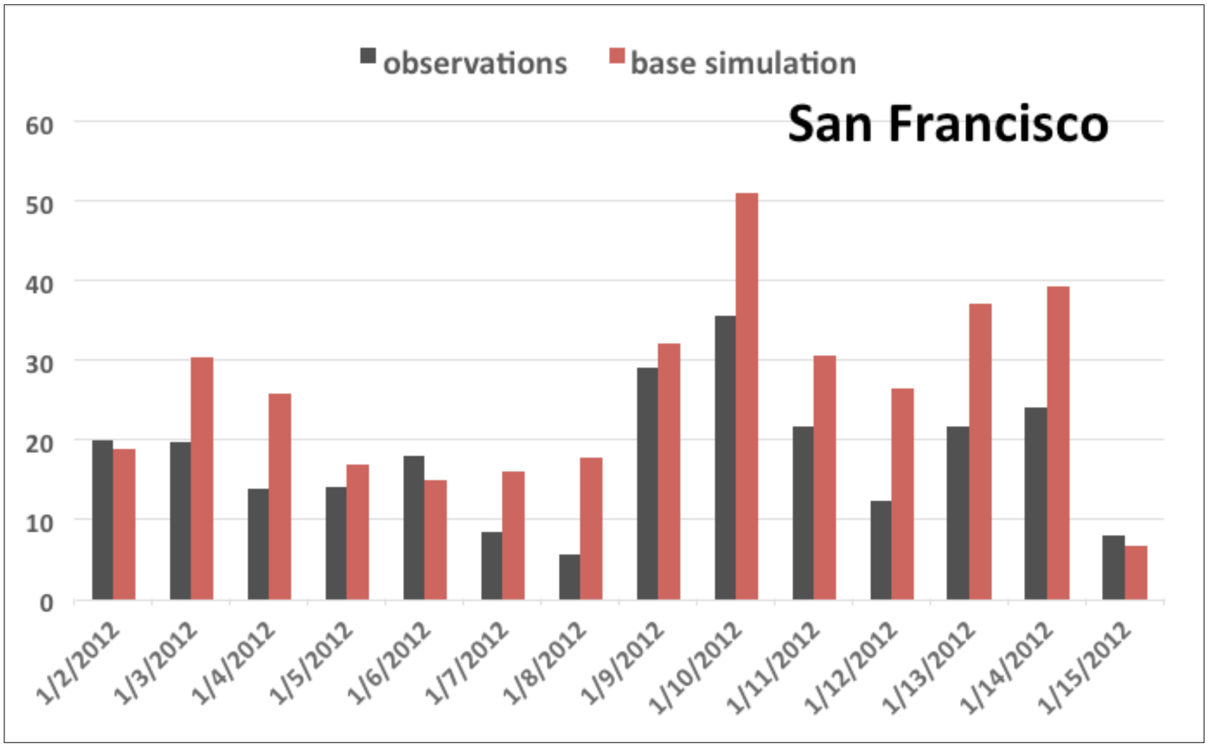


Figure D-6b. **Simulated and observed 24-hour average $PM_{2.5}$ concentrations (µg/m^3) at the San Francisco air monitoring station for January 2–15, 2012**

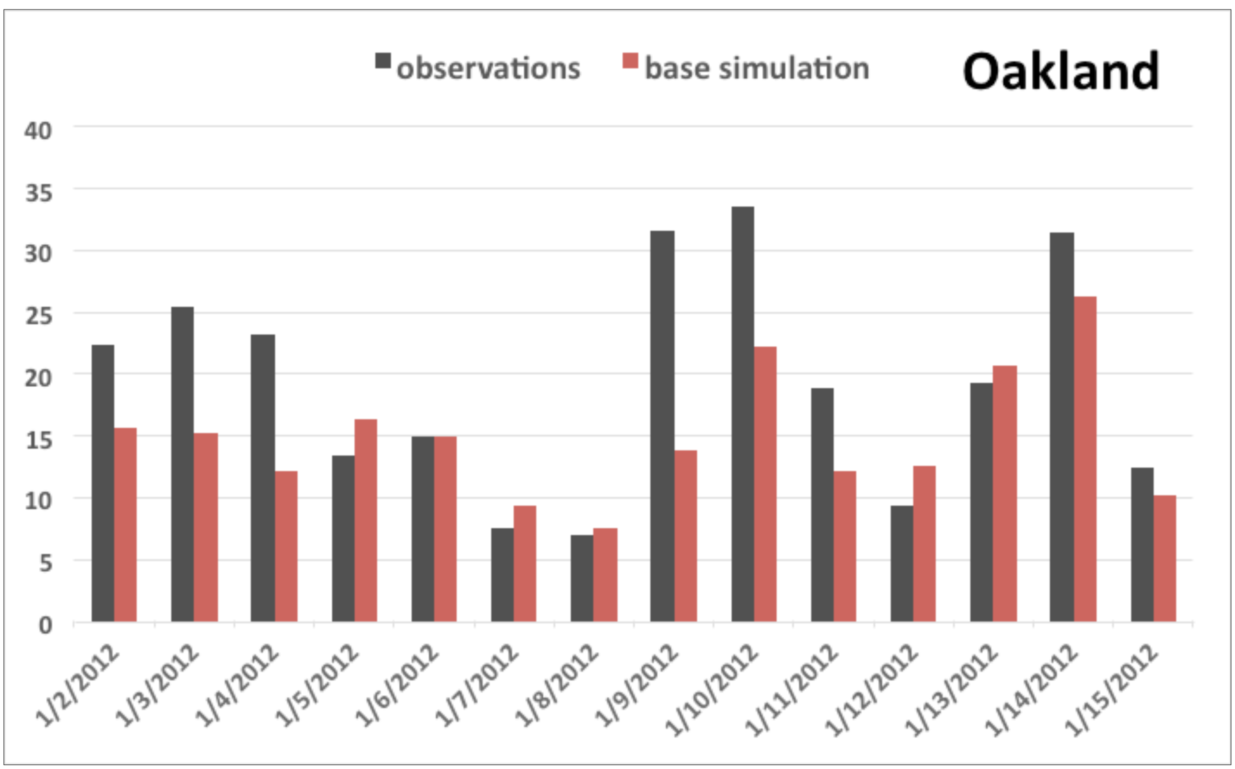


Figure D-6c. **Simulated and observed 24-hour average $PM_{2.5}$ concentrations (µg/m^3) at the Oakland air monitoring station for January 2–15, 2012**

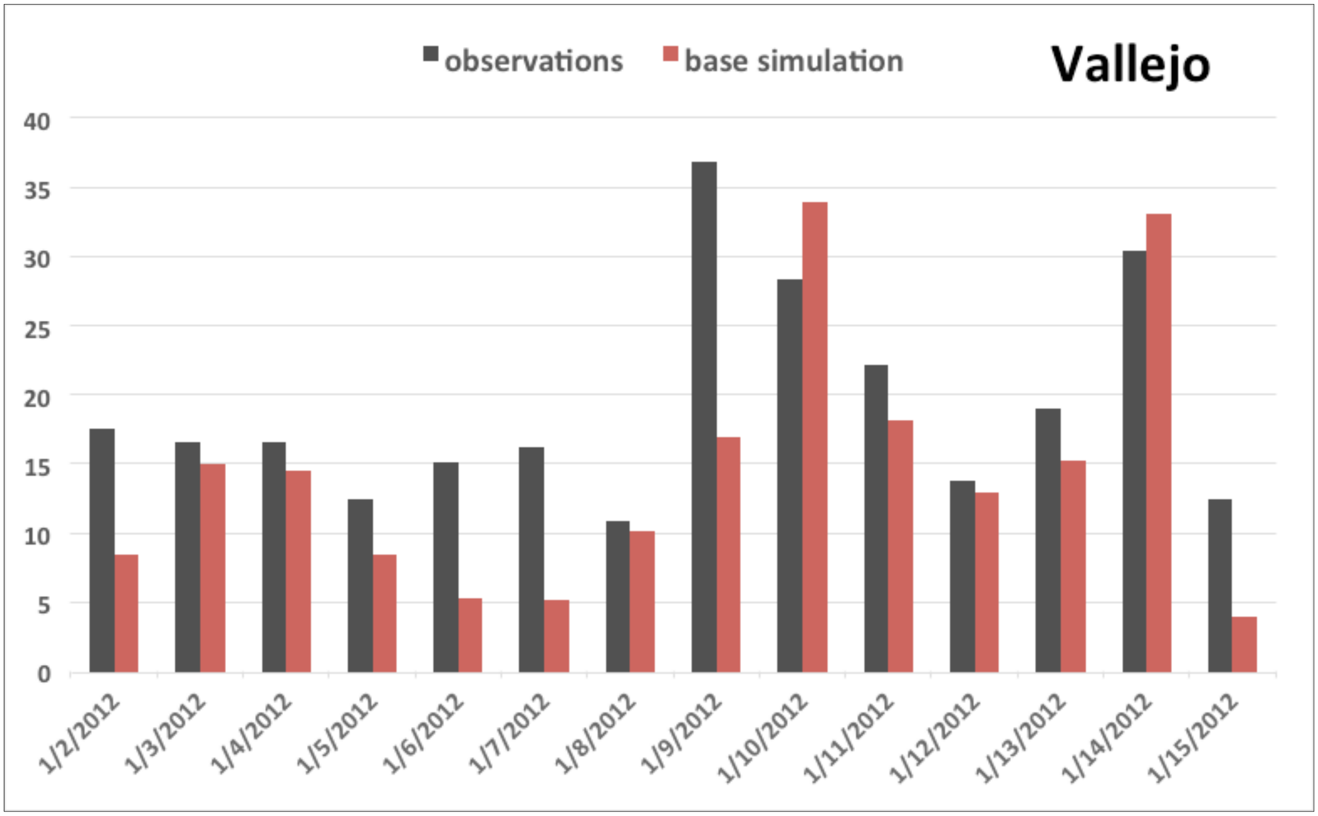


Figure D-6d. **Simulated and observed 24-hour average $PM_{2.5}$ concentrations (μg/m^3) at the Vallejo air monitoring station for January 2–15, 2012**

E) $PM_{2.5}$ sensitivity simulations

Six sensitivity simulations were conducted for 2–15 January 2012, with 20 percent across-the-board reductions in Bay Area anthropogenic NO_X, VOC, ammonia, SO_X, directly emitted PM and all these combined. Results from these sensitivity simulations were compared to the base-case simulation over the entire Bay Area, but the following discussion is limited to the four Bay Area stations with historically high PM mentioned above.

Among the five anthropogenic species selected, a reduction in directly emitted $PM_{2.5}$ is the most effective in reducing ambient $PM_{2.5}$ concentrations, with a 20 percent reduction in PM emissions resulting in 4–12 percent reductions in $PM_{2.5}$ concentrations at most Bay Area stations on most winter simulation days (Figures D-7a through D-7d). While reductions at San Francisco, Oakland and San Jose are at the upper range of this interval, the reduction at Vallejo is at the lower range because of its proximity to the heavily polluted Central Valley and the influence of transported pollutants from the Valley, evident in Figure D-3.

NO_X, VOC, ammonia and SO_X reductions have small influences as they are precursors of secondary $PM_{2.5}$ (chemically produced in the atmosphere), which requires favorable meteorological conditions, ideal concentrations, and time to form. A 20 percent reduction in emissions of these species each results in less than a 1 percent reduction in $PM_{2.5}$ concentrations at most Bay Area stations on most winter days.

A 20 percent reduction in total anthropogenic emissions results in the highest $PM_{2.5}$ reductions, higher than the 20 percent direct PM-only reduction case because of the contribution of reductions in secondary PM.

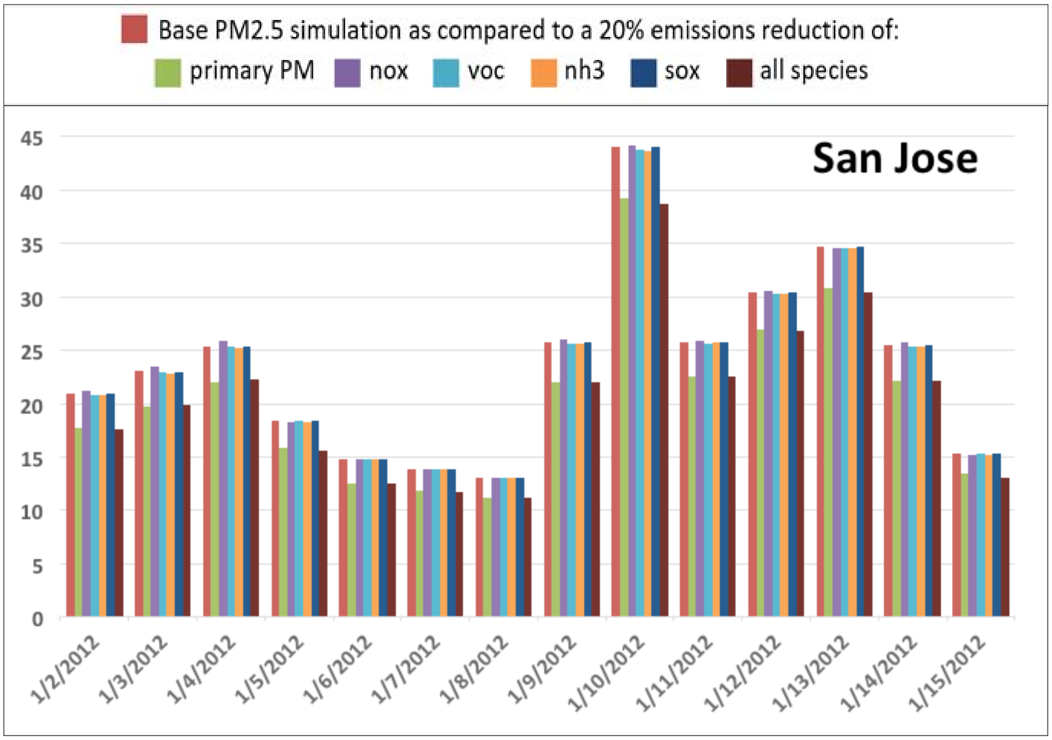


Figure D-7a. **Simulated 24-hour average $PM_{2.5}$ concentrations (μg/m³) at the San Jose air monitoring station for January 2–15, 2012, for the base case and six control cases; control cases include 20% across-the-board anthropogenic emission reductions for directly emitted PM, NO_x, VOC, ammonia, SO_x and all these combined.**

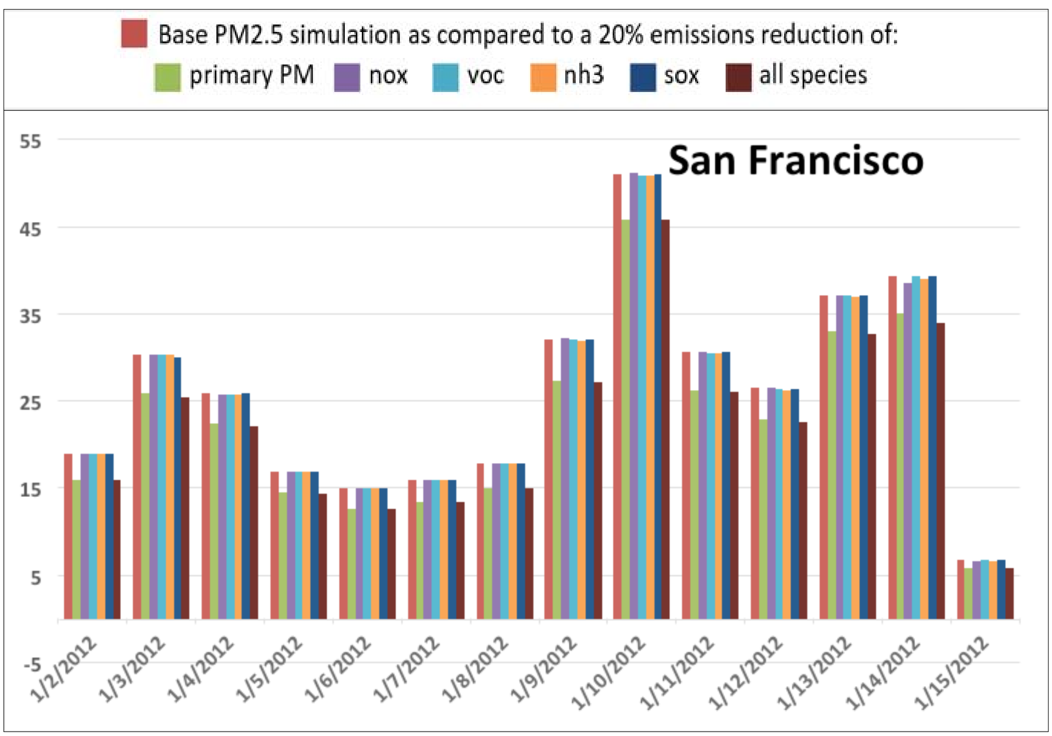


Figure D-7b. **Simulated 24-hour average $PM_{2.5}$ concentrations (μg/m³) at the San Francisco air monitoring station for January 2–15, 2012, for the base case and six control cases; control cases include 20% across-the-board anthropogenic emission reductions for directly emitted PM, NO_x, VOC, ammonia, SO_x and all these combined.**

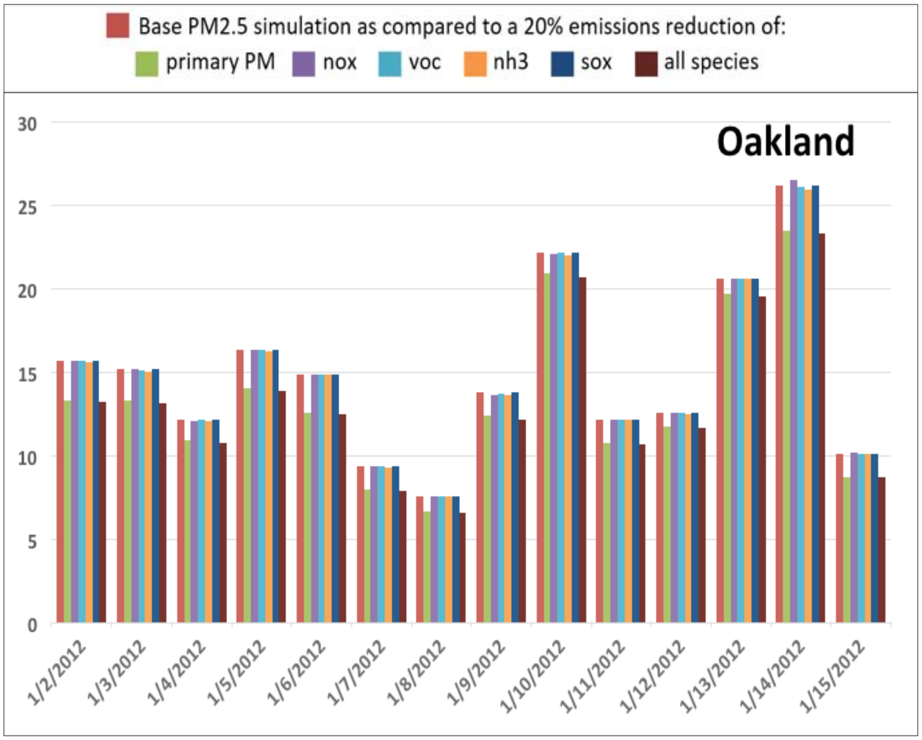


Figure D-7c. **Simulated 24-hour average $PM_{2.5}$ concentrations (μg/m^3) at the Oakland air monitoring station for January 2–15, 2012, ,for the base case and six control cases; control cases include 20% across-the-board anthropogenic emission reductions for directly emitted PM, NO_x, VOC, ammonia, SO_x and all these combined.**

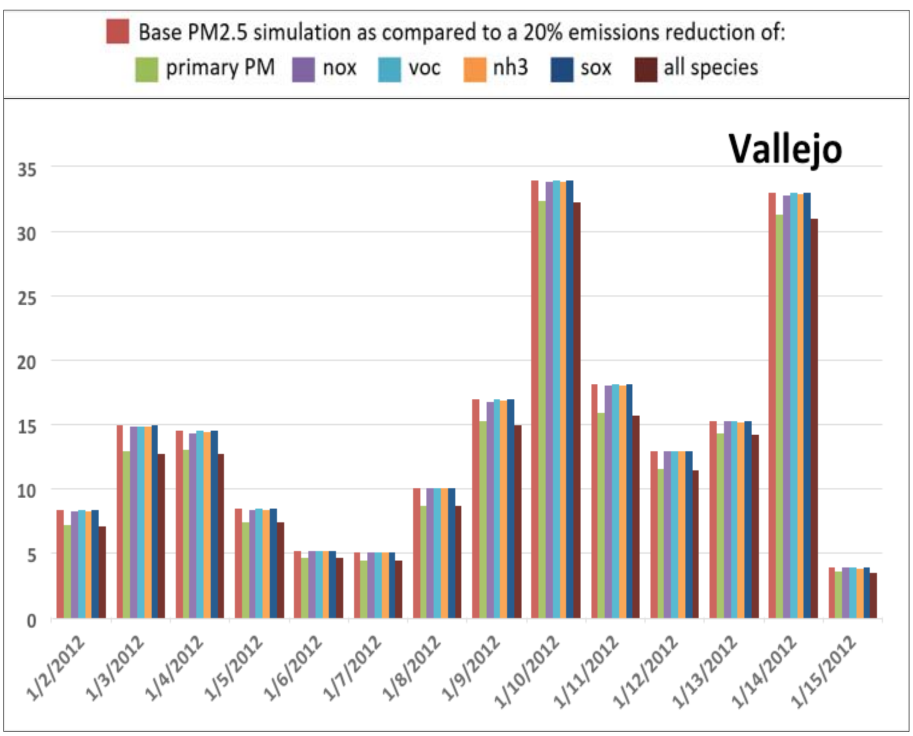


Figure D-7d. **Simulated 24-hour average $PM_{2.5}$ concentrations (μg/m^3) at the Vallejo air monitoring station for January 2–15, 2012, for the base case and six control cases; control cases include 20% across-the-board anthropogenic emission reductions for directly emitted PM, NO_x, VOC, ammonia, SO_x and all these combined.**

Summary and Discussion

Using the U.S. EPA's CMAQ model, ozone and PM were simulated for 1–15 August and 1–15 January, 2012, respectively. Ozone sensitivity simulations were conducted assuming 20 percent across-the-board reductions in Bay Area anthropogenic emissions of NO_X and of VOC. Analogous simulations with separate 20 percent reductions of NO_X, VOC, directly emitted PM, ammonia, SO_X and total anthropogenic emissions were conducted for PM. While VOC reductions showed 1–2 percent reductions in ozone concentrations, NO_X reductions showed 1–2 percent increase in ozone in core urban areas of the Bay Area. Model findings imply that core urban areas of the Bay Area are still NO_X-rich despite the fact that Bay Area emissions have been reduced significantly over the last 20 years. The PM simulations showed that in the Bay Area, reducing directly emitted PM is more effective than reducing secondary PM's precursor emissions.

While these sensitivity simulations are useful in understanding ozone and PM responses to reductions in Bay Area emissions, they may not perfectly replicate the true response in ambient ozone and PM concentrations to changes in emissions of pollutants or their precursors. The true response in real world conditions involves the influence of Bay Area emissions, transport of pollutants from surrounding areas such as the Central Valley, and intercontinental transport from Asia. ARB has characterized ozone transport within California. The U.S. EPA, NOAA and NASA have studied ozone transport from Asia for selected periods, but available information is not yet suitable for year-round photochemical modeling. The Air District has refined the available Asian transport information for 1–15 August, 2012, simulation period and estimated 2–6 ppb ozone transport from Asian to the Bay Area.

The Air District also characterized and quantified PM transport during winter Bay Area PM episodes. Preliminary findings show that up to 30 percent of Bay Area PM is transported from the Sacramento Valley and surrounding areas at the beginning and during a PM episode and up to 60 percent of Bay Area PM is transported from the San Joaquin Valley and surrounding areas toward the end of a PM episode. This switch occurs due to repositioning of the high pressure system from the beginning to the end of a PM episode. There has not been any significant effort to characterize or quantify PM transport from Asia.

APPENDIX E

PROGRESS TOWARD ATTAINMENT OF OZONE STANDARDS

This appendix provides additional information regarding ozone dynamics and trends in ambient ozone concentrations and population exposure to ozone to supplement the discussion of ozone in Chapter 2 of the 2017 Plan.

Ozone Dynamics

Ozone is not emitted directly from pollution sources. Instead, ozone is formed in the atmosphere through complex chemical reactions in the presence of sunlight between two types of precursor chemicals: reactive organic gases (ROG), and nitrogen oxides (NO_X).

Weather conditions have a strong impact on ozone formation. Due to variations in weather, ozone levels can vary dramatically day to day and from one summer to the next. As the air temperature rises, ground-level ozone forms at an accelerated rate. Ozone levels are usually highest on hot, windless summer afternoons, especially in inland valleys. Exceedances of state or national ozone standards in the Bay Area typically occur on hot, relatively stagnant days.

Climate change may increase ozone levels in future years. Longer and more severe heat waves expected as a result of climate change may cause more ozone formation, resulting in more frequent exceedances of ozone standards. Climate change could erode decades of progress in reducing ozone levels, as described in greater detail in Chapter 3. Ozone is a regional pollutant. Emissions of ROG and NO_X throughout the Bay Area contribute to ozone formation. Because emissions in one part of the region can impact air quality miles away, efforts to reduce ozone levels focus on reducing emissions of ROG and NO_X throughout the region.

The relative amounts of the precursor pollutants, or the ROG to NO_X ratio, strongly affects the ozone formation rate. The Air District's ozone modeling indicates that the Bay Area is "ROG-limited" for ozone formation. This means that reducing ROG emissions will be more productive in reducing ozone, at least in the near term. However, modeling also suggests that large reductions in NO_X emissions will be needed to achieve the reduction in ozone concentrations required to attain state and national ozone standards which have become progressively more stringent in recent decades.

A certain amount of ozone formation occurs naturally, even in the absence of anthropogenic emissions of ROG and NO_X. This natural ozone is referred to as the *background* level. Locally, background ozone appears to have increased, perhaps due to reductions in other pollutants. However, there are instances when some air pollutants react with and eliminate ozone, therefore reducing ambient concentrations.[1] Increasing emissions of methane at the global scale may be increasing background levels of ozone. In the recent past, ozone standards were roughly three times higher than background levels. Because ozone standards have been tightened, the standards are now less than twice the estimated background level, and may be reduced to even more stringent levels in the future. Ozone formation in the Bay Area is strongly influenced by the location and strength of the Eastern Pacific High Pressure System. During the summer months, this system normally develops over the Pacific Ocean and travels towards the east. From time to time, depending upon its strength and route of travel, it blocks westerly airflow exiting the Bay Area into the Central Valley and develops meteorological conditions conducive to ozone production: light winds, high temperatures, sunny and clear sky conditions and a shallow mixing layer. When these conditions occur in mid-summer, typically airflow from the core Bay Area penetrates into the Livermore Valley through the Interstate 680 corridor from the north and various gaps along the East Bay ridge from the west, carrying polluted air and causing increased ozone levels. At other times, especially in early or late summer, airflow with a weaker westerly push that is unable to cross the East Bay ridge flows southward, causing increased ozone levels in the Santa Clara Valley. San Martin is frequently the exceedance site in the Santa Clara Valley under these conditions.

See the air quality modeling discussion in Appendix D for additional information regarding ozone formation and ozone dynamics.

Peak Ozone Concentrations and Exposure

For the purpose of complying with Health & Safety Code ozone planning requirements, ARB guidance requires the calculation of three air quality indicators to assess the extent of air quality improvements within an air basin: (1) Expected Peak Day Concentration (EPDC), which is an estimate of the ozone concentration that would be exceeded once per year on average, (2) population-weighted exposure to ozone levels that exceed the state standard, and (3) area-weighted exposure to levels that exceed the state standard.

Expected Peak Day Ozone Concentrations

The EPDC for the state 1-hour ozone standard at Bay Area monitoring sites are listed in Table E-1 for 1986–1988, 2006–2008 and 2012–2014. Also shown are annual percentage reductions. Table E-2 presents these data for the 8-hour ozone standard. There was an average annual reduction in 1-hour ozone of 0.9 percent per year across all Bay Area sites between 1986–1988 and 2012–2014, and a reduction of 0.8 percent per year for the 8-hour ozone standard, with total reductions of 25 percent and 23 percent respectively. No site shows an increase in ozone over this period, indicating that progress is region-wide. During the period from 2008 through 2013, the reduction was 1.6 percent per year in 1-hour ozone and 0.5 percent per year in 8-hour ozone, indicating that progress has continued in recent years.

The progress has not been uniform, however. As the tables show, there were substantial reductions in the southern areas, including Los Gatos and San Jose, monitoring sites that once registered some of the Air District's highest values. In the central area, the progress is mixed, but at locations where there has been little reduction since late 2008, ozone values actually meet the standard. In the northern and eastern areas there have also been reductions, but long-term progress has been slower than in the south. At the Air District's design value site in Livermore, reductions have averaged 0.8 percent per year, which is on the order of 1 ppb per year, since the late 1990s.

EPDC values are, effectively, the design values for the California standards. Thus, a site whose 1-hour EPDC is less than 95 ppb meets the 1-hour standard, and a site whose 8-hour EPDC is less than 71 ppb meets the state 8-hour standard. Between 1986–1988 and 2012–2014, the number of long-running sites meeting the 1-hour standard increased from 5 to 18, and the number meeting the 8-hour standard increased from 3 to 10.

Table E-1. **1-hour Max Ozone Expected Peak Day Concentrations at Bay Area Sites: 1986–2014**

	Expected Peak Day			Annual Percentage[1]	
Monitoring Site:	**1986–1988**	**2006–2008**	**2012–2014**	**2006–2008 to 2012–2014**	**1986–1988 to 2012–2014**
Northern					
Napa	107	88	79	-1.7	-0.9
San Rafael	93	74	76	0.5	-0.7
Santa Rosa	87	72	66	-1.4	-0.9
Vallejo	109	83	81	-0.4	-0.9
Central					
Hayward	129	96	88	-1.4	-1.1
Oakland	82	73	69	-0.9	-0.6
Oakland West	-	-	60	-	-
Redwood City	97	74	76	0.5	-0.8
Richmond/ San Pablo[2]	83	68	70	0.5	-0.6
San Francisco	74	59	61	0.6	-0.6
Eastern					
Bethel Island	111	108	87	-3.2	-0.8
Concord	128	109	86	-3.5	-1.2
Fairfield	111	103	85	-2.9	-0.8
Livermore	145	123	107	-2.2	-0.9
San Ramon	-	-	97	-	-
Southern					
Cupertino	-	-	85	-	-
Gilroy	142	101	85	-2.6	-1.4
Los Gatos	139	106	88	-2.8	-1.3
San Jose	131	100	86	-2.3	-1.2
San Martin	-	110	91	-2.9	-
Average	**103**	**89**	**77**	**-1.6**	**-0.9**

[1] Percentage change results shown may differ slightly from those calculated using displayed data points due to rounding for display purposes.

[2] Monitoring site moved from Richmond to San Pablo in 1997.

Table E-2. 8-hour Max Ozone Expected Peak Day Concentrations at Bay Area Sites: 1986–2014

	Expected Peak Day			Annual Percentage[1]	
Monitoring Site:	**1986–1988**	**2006–2008**	**2012–2014**	**2006–2008 to 2012–2014**	**1986–1988 to 2012–2014**
Northern					
Napa	86	70	72	0.3	-0.6
San Rafael	74	56	59	1.1	-0.8
Santa Rosa	71	53	54	0.1	-0.9
Vallejo	85	67	67	-0.1	-0.8
Central					
Berkeley	-	-	47	-	-
Hayward	104	75	65	-2.2	-1.4
Oakland	62	48	49	0.4	-0.8
Oakland West	-	-	50	-	-
Redwood City	72	59	59	0.0	-0.7
Richmond/ San Pablo[2]	65	55	59	1.0	-0.4
San Francisco	56	51	51	0.0	-0.3
Eastern					
Bethel Island	105	90	83	-1.3	-0.8
Concord	101	91	82	-1.6	-0.7
Fairfield	94	87	83	-0.6	-0.4
Livermore	115	97	88	-1.5	-0.9
San Ramon	-	-	85	-	-
Southern					
Cupertino	-	-	74	-	-
Gilroy	108	85	80	-0.9	-1.0
Los Gatos	125	87	77	-1.9	-1.5
San Jose	112	73	71	-0.5	-1.4
San Martin	-	92	85	-1.3	-
Average	**90**	**73**	**69**	**-0.5**	**-0.8**

[1] Percentage change results shown may differ slightly from those calculated using displayed data points because of rounding for display purposes.

[2] Monitoring site moved from Richmond to San Pablo in 1997.

Trends in Expected Peak Day Concentrations of Ozone

Figures E-1 and E-2 show the Bay Area maximum EPDC values, by year, starting in 1980 for the 1-hour and 8-hour ozone standards. Also shown are trend lines projected to the level of the standards. Based on past progress, the Bay Area would meet the 1-hour standard by about 2022, and there is a high probability that the standard would be met between 2016 and 2028. The 8-hour standard is somewhat more stringent. The projected year for meeting the 8-hour standard is 2025, with a high probability of meeting the standard by 2030.

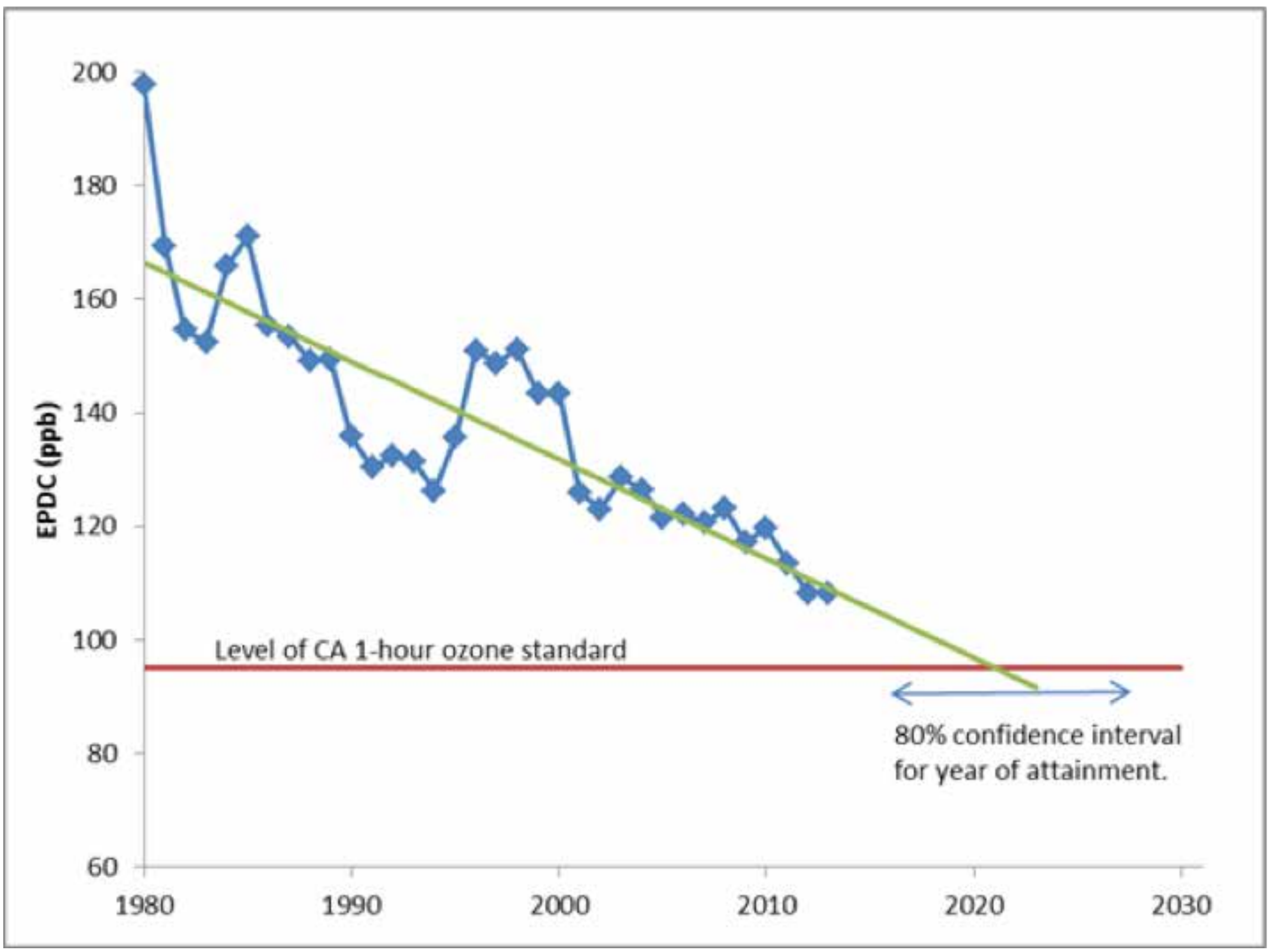


Figure E-1. **Bay Area Progress toward the California 1-hour Ozone Standard and Projected Year of Attainment**

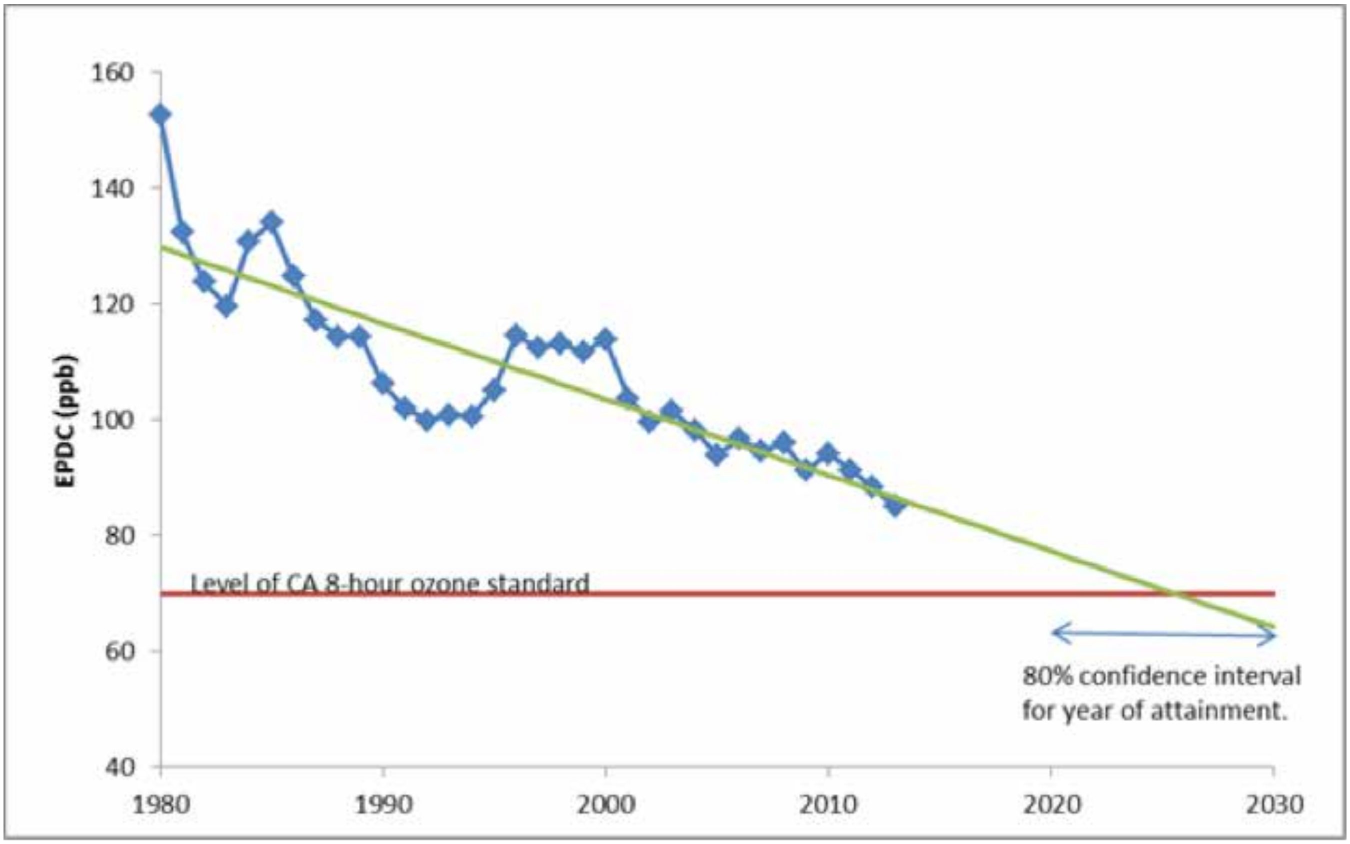


Figure E-2. **Bay Area Progress toward California 8-hour Ozone Standard and Projected Year of Attainment**

Population-Weighted Exposure to Ozone

Peak ozone concentrations reflect potential population exposure in areas with the highest ozone levels, but not the exposure of the Bay Area's population as a whole. Therefore, population-weighted (or per capita) exposure to high ozone concentrations is another indicator used to assess progress in reducing public exposure to ozone on a per-capita, region-wide basis.

Population-weighted exposure is computed by estimating hourly ozone concentrations for each census tract in the Bay Area based on the hourly values actually measured at Air District monitoring sites. Concentrations are estimated by averaging ozone from nearby monitors inversely weighted by distance to the tract. In each census tract, for each hour where its estimated ozone exceeds the standard, the estimated amount by which the ozone level exceeds the standard is multiplied by the population of the tract. These values are summed across all hours for a year for each tract, and then for all tracts in each county. The result is divided by the population of the county. The result is per capita exposure, specifically person-ppb-hours above the standard.[2]

Table E-3 shows population-weighted exposures for 1986–1988, 2006–2008 and 2012–2014 for Bay Area counties in relation to the state 1-hour ozone standard. Also shown are the total decreases in exposure between these periods. Population exposure decreased from an average of 213 to 1 person-ppb-hours above the standard per year from 1986–1988 to 2012–2014, for an overall reduction of nearly 100 percent. Thus, in 1986–1988, the average Bay Area resident was exposed to unhealthy ozone concentrations 213 hours per year. Today, that has been reduced to less than 1 hour per year.

Table E-3. **Population-Weighted Exposure to Ozone Exceeding the State 1-hour Standard**

	Per Capita Exposure (person-ppb-hours above 95 ppb/total population)			**Percent Decrease**[1]	
	1986–1988	**2006–2008**	**2012–2014**	**1986–1988 to 2012–2014**	**2006–2008 to 2012–2014**
County					
Alameda	209	29	1	100%	98%
Contra Costa	200	38	<1	100%	99%
Marin	6	1	<1	100%	100%
Napa	31	7	<1	100%	100%
San Francisco	1	<1	<1	100%	99%
San Mateo	52	2	<1	100%	98%
Santa Clara	462	50	1	100%	98%
Solano	91	19	<1	100%	100%
Sonoma	12	2	<1	100%	100%
Bay Area	**201**	**26**	**<1**	**100%**	**98%**

[1] *Values for per capita exposure are rounded to the nearest whole number. Percentage decrease is based on unrounded data.*

This dramatic reduction may be surprising, given that the Bay Area continues to violate the ozone standard. Two factors combine to make reductions in exposure much greater than reductions in peak ozone. First, ozone concentrations that violate the standard have generally been reduced most in areas with greater population density, San Jose and Concord in particular. A reduction in a densely populated area can protect many people from exposure. Second, in many instances exposure is a result of ozone levels just above the standard. Thus, a modest reduction in ozone concentration, one that reduces concentrations below the standard, can also protect many people from exposure. Both factors have resulted in dramatic reductions in exposure during the 1986 to 2014-time period.

Figure E-3 shows the Bay Area per-capita population exposure to ozone by year, and also a 3-year rolling average. Exposures vary dramatically from year to year, but the 3-year average shows progress toward reduced exposure.

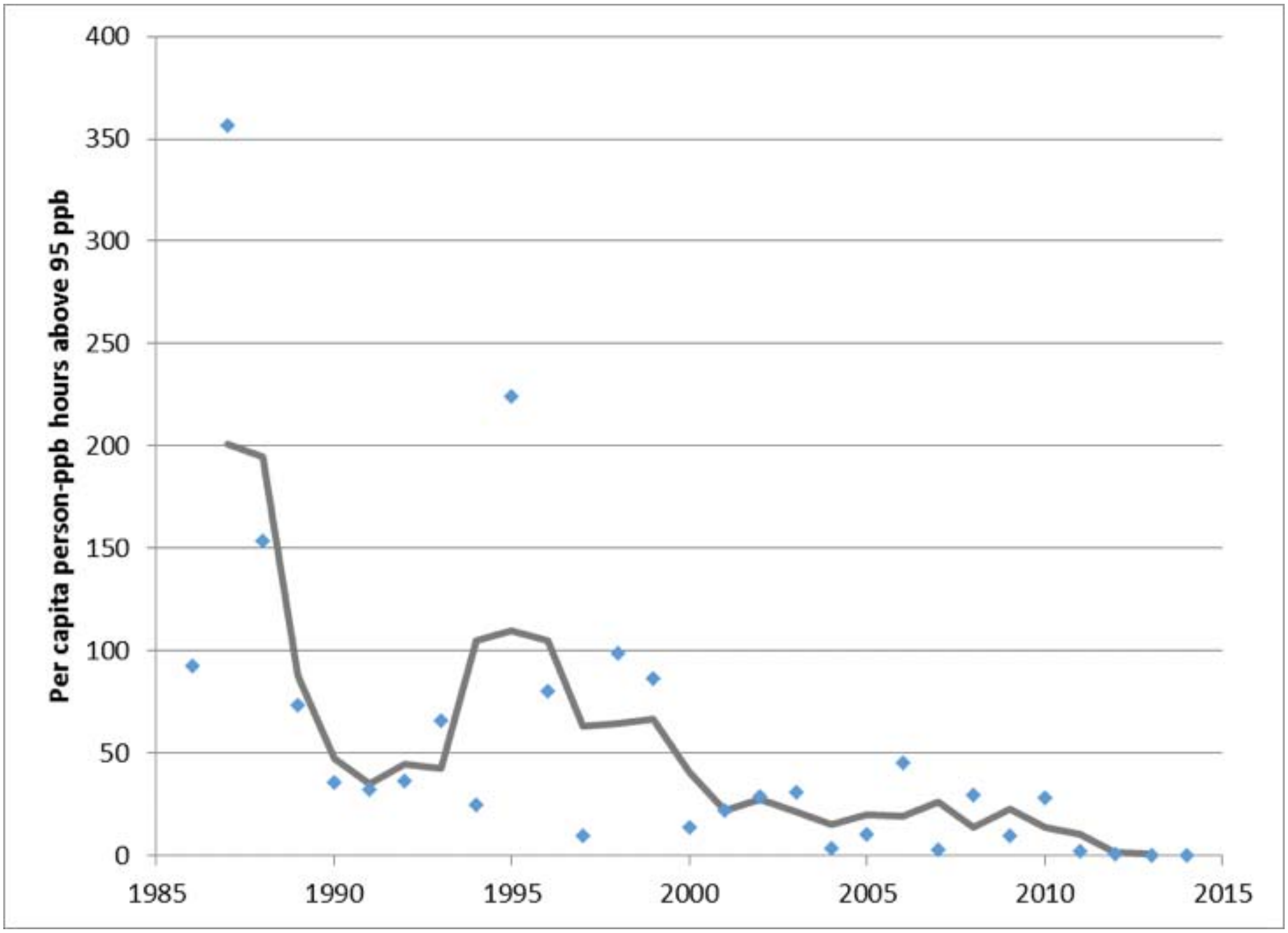


Figure E-3. **Average Per Capita Population Exposure to Ozone Levels Exceeding the State 1-hour Standard, 1986–2014.**

Area-Weighted Exposure to Ozone

The third indicator used in assessing progress in reducing exposure to ozone is area-weighted exposure. This is calculated similarly to population-weighted exposure except with census tract area replacing census tract population.

Reductions in area-weighted exposure are important because high ozone levels harm not only humans but also vegetation, other animals, and most surfaces with which it comes in contact, such as architectural finishes, tires and plastics. Table E-4 shows the average km²-ppb-hours above the state standard for each county and the Air District as a whole. The trends and exposure patterns among counties are quite similar to population-weighted exposures. The table shows reductions similar to those in Table E-3, with area-weighted exposure dropping 99.8 percent since 1986–1988 and 98 percent since 2006–2008.

Table E-4. Area-Weighted Exposure to Ozone in the Bay Area, 1986–2014.

	Area-Weighted Exposure (km^2-ppb-hours above 95 ppb/total km^2)			Percent Decrease[1]	
	1986–1988	**2006–2008**	**2012–2014**	**1986–1988 to 2012–2014**	**2006–2008 to 2012–2014**
County					
Alameda	404	77	2	100%	98%
Contra Costa	234	48	1	100%	99%
Marin	9	1	<1	100%	100%
Napa	43	9	<1	100%	100%
San Francisco	1	<1	<1	100%	99%
San Mateo	99	6	<1	100%	100%
Santa Clara	499	64	1	100%	98%
Solano	122	26	<1	100%	100%
Sonoma	17	4	<1	100%	100%
Bay Area	**191**	**30**	**<1**	**100%**	**99%**

[1] Values for area-weighted exposure are rounded to the nearest whole number. Percentage decrease is based on unrounded data.

FOOTNOTES

1 For example, NO combines with O_3 (ozone) to produce NO_2 and O_2.

2 This is sometimes termed *backyard* exposure because it assumes that everyone is at home and outside every hour that ozone exceeds the standard. While there are obvious limitations to this measure, it may be reasonable for children, who are often at or near home and frequently outside, at times when ozone exceeds the standard.

APPENDIX F

IMPLEMENTATION STATUS OF 2010 CONTROL MEASURES

Appendix F summarizes the actions that the Air District and its partner agencies have taken to implement the control measures in the 2010 Clean Air Plan. As described in Chapter Four, the 2017 Plan is an update to the Air District's most recent state ozone plan, the 2010 Clean Air Plan. The 2010 Clean Air Plan laid out a comprehensive strategy to reduce emissions of ozone precursors, particulate matter (PM), greenhouse gases (GHG) and toxic air contaminants. The Plan included 18 Stationary Source Measures (SSMs), 10 Mobile Source Measures (MSMs), 17 Transportation Control Measures (TCMs), 6 Land Use and Local Impact Measures (LUMs) and 4 Energy and Climate Measures (ECMs).

Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan

Stationary Source Measures			
Number	**Title**	**Description**	**Implementation Status**
SSM-1	Metal Melting Facilities	Limit emissions of organic compounds, fine particulates, toxic compounds and odors from foundry operations and metal melting facilities.	This measure was adopted on May 1, 2013, as part of Regulation 6-4: Metal Recycling and Shredding Operations, and Regulation 12-13: Foundry and Forging Operations.
SSM-2	Digital Printing	Reduce ROG emissions from digital printing operations by adopting VOC limits on inks and solvents used, or by adopting control technology requirements.	This measure is carried forward in the 2017 control strategy as SS27: Digital Printing Operations.

(continued)

Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Stationary Source Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
SSM-3	Livestock Waste	Reduce organic emissions from livestock waste by requiring best management practices already being implemented in other California air districts at Bay Area dairies.	This measure is carried forward in the 2017 control strategy as AG4: Livestock Waste/ Confined Animal Facilities.
SSM-4	Natural Gas Production and Processing	Reconsider exemptions for gas wells in Rule 8-37 to address methane, VOC and toxic compound leaks.	This measure is carried forward in the 2017 control strategy as SS13: Natural Gas & Crude Oil Production, Processing & Storage.
SSM-5	Vacuum Trucks	Reduce organic emissions from vacuum trucks by requiring emission controls on vacuum trucks utilized in liquid clean-up and transfer operations in refineries and at other locations.	This measure was adopted on April 18, 2012, as Regulation 8-53: Vacuum Truck Operations.
SSM-6	General Particulate Matter Emission Limitation	Reduce the District's allowable weight rate limitations for particulate matter.	This measure is carried forward in the 2017 control strategy as SS31: General Particulate Matter Emissions Limitation.
SSM-7	Open Burning	Consider further limitations on open burning in Regulation 5: Open Burning.	This measure was adopted on June 19, 2013, as amendments to Regulation 5: Open Burning.
SSM-8	Sulfur Dioxide from Petroleum Coke Calcining	Limit emissions of sulfur dioxide from coke calcining by requiring a minimum of 80 percent sulfur capture.	This measure was adopted on April 20, 2016, as Regulation 9-14: Petroleum Coke Calcining Operations.
SSM-9	Cement Kilns	Reduce NO_x and SO_x emissions from cement kilns as well as reduce toxic air contaminants. There is one cement manufacturing facility in the Bay Area, the Lehigh Southwest Cement facility.	This measure was adopted on September 19, 2012, as Regulation 9-13: Nitrogen Oxides, Particulate Matter, and Toxic Air Contaminants from Portland Cement Manufacturing. Further amendments to Rule 9-13 were adopted on October 19, 2016.

(continued)

Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Stationary Source Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
SSM-10	Refinery Boilers and Heaters	Consider options to further reduce NO_x emissions from petroleum refinery boilers and heaters.	This measure was adopted on October 19, 2013, as amendments to Regulation 9-10: Nitrogen Oxides and Carbon Monoxide from Boilers, Steam Generators and Process Heaters in Petroleum Refineries.
SSM-11	Residential Fan Type Furnaces	Reduce NO_x emissions from residential fan type central furnaces by reducing allowable NO_x emission limits on new and replacement furnace installations.	This measure is carried forward in the 2017 control strategy as SS30: Residential Fan-Type Furnaces.
SSM-12	Large Residential and Commercial Space Heating	Reduce NO_x emissions from large condominium and apartment building central furnaces, and from commercial space heating through retrofit of low NO_x burners.	This measure is carried forward in the 2017 control strategy as FSM_BL1: Large Residential and Commercial Space Heating.
SSM-13	Dryers, Ovens and Kilns	Reduce NO_x emissions from combustion devices that are currently exempt from the requirements of Regulation 9-7.	This measure is carried forward in the 2017 control strategy as FSM_SS8: Dryers, Ovens and Kilns.
SSM-14	Glass Furnaces	Reduce NO_x emission from gas-fired glass melting facilities.	Not adopted or carried forward. The only glass furnace in Bay Area has closed.
SSM-15	Greenhouse Gases in Permitting, Energy Efficiency	Mitigate increases in GHG emissions from new and modified permitted sources, reviewing implementation of energy efficiency measures, where appropriate on new sources subject to the Air District's jurisdiction.	This measure is carried forward in the 2017 control strategy as SS17: GHG BACT Threshold
SSM-16	New Source Review Addressing $PM_{2.5}$	Amend Regulation 2-2 to address the District's anticipated non-attainment status of the 24-hour $PM_{2.5}$ National Ambient Air Quality Standard.	This measure was adopted on November 1, 2012, as amendments to Regulation 2-2: New Source Review.

(continued)

Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Stationary Source Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
SSM-17	New Source Review for Toxic Air Contaminants	Amend Regulation 2-5, for communities identified in the Air District's Community Risk Evaluation (CARE) Program, cumulative impacts will be addressed by tracking the toxicity-weighted emissions from all sources in the identified communities.	This measure was adopted on December 7, 2016, as amendments to Regulation 2-5: New Source Review of Toxic Air Contaminants.
SSM-18	Revisions to Air Toxics Hotspots Program	Revise the Air District's Air Toxics Hot Spots program focusing on existing sources of toxic air contaminants.	This measure is carried forward in the 2017 control strategy as SS20: Air Toxics Risk Cap and Reduction from Existing Facilities.
Mobile Source Measures			
Number	**Title**	**Description**	**Implementation Status**
MSM-A1	Promote Clean, Fuel Efficient Light and Medium-Duty Vehicles	Expand the use of Super Ultra-Low Emission (SULEV) and Partial-Zero (PZEV) emission light-duty passenger vehicles and trucks.	With the adoption of Plan Bay Area in 2013, MTC adopted the Climate Initiatives Program. The program consists of four primary elements: 1) Climate Initiatives Grants ($36 million), 2) Public Education and Outreach ($10 million), 3) Safe Routes to Schools ($17 million), and 4) Program Evaluation ($4 million). Relative to MSM-A1, the Climate Grants Program funded the following projects: Local Government EV Fleet ($2.4 million), eFleet: Car Sharing Electrified ($570,000), and the "Experience Electric" Campaign ($925,000). Refer to MSM-A2 below for information about the Air District's programs to address zero emission vehicles. This is an ongoing program and has continued forward in the 2017 control strategy as TR14: Cars & Light Trucks.

(continued)

Table F-1. **Implementation Status of Control Measures in 2010 Clean Air Plan** *(continued)*

Mobile Source Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
MSM-A2	Zero Emission Vehicles (ZEV) and Plug-In Hybrids	Increase the adoption of zero emission and plug-in hybrid vehicles and an expanded regional charging network with new stations.	By September 2015, there were approximately 60,000 Plug-In Electric Vehicles (PEVs) on the road in the Bay Area, and an estimated 2,600 publicly available charging stations in the region. In 2013, the Air District adopted the *Bay Area Plug-In Electric Vehicle Readiness Plan.* The plan provides guidance to PEV drivers, local governments and infrastructure providers on how to successfully prepare for accelerated deployment of PEVs and identifies goals of deploying 110,000 PEVs by 2020 and 247,000 LDEVs by 2025. Since 2010, the Air District's Board of Directors has allocated over $20 million to a multi-year investment plan to spur investments in PEVs and supporting infrastructure. An initial $4 million in subsidy program resulted in the deployment of nearly 2,000 public and residential Level 2 charging stations between 2012 and 2015. The Air District also works with the U.S. EPA and Department of Energy on projects to deploy advanced zero-emission technologies. The Air District is in the process of expanding its incentive programs to provide funding for zero-emission drayage trucks and on- and off- road zero-emission equipment at multi-use facilities in addition to light-duty vehicles. This is an ongoing program and has continued forward in the 2017 control strategy as TR14: Cars & Light Trucks.
MSM-A3	Green Fleets	Develop a green fleet certification as part of ABAG's Green Business Program.	The Air District has incorporated GHG criteria in various grant programs. Funding was not provided for the inclusion of green fleet criteria in ABAG's Green Business Certification, and not pursued after the adoption of the 2010 Clean Air Plan. With the advent of ARB's Low Carbon Fuel Standard, U.S. EPA's SmartWay program and other green fleet strategies, this measure is not included in the 2017 control strategy.

(continued)

Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Mobile Source Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
MSM-A4	Replacement or Repair of High-Emission Vehicles	Accelerate the retirement of older, high emitting vehicles from the region's roadways by providing incentives to scrap them.	Since 1996, the Air District has retired more than 70,000 vehicles through the Vehicle Buy Back (VBB) program. Currently, the VBB program pays $1,000 to Bay Area vehicle owners for the retirement of eligible 1994 and older vehicles. The Air District allocates and awards approximately 7 million dollars in grant funds through the VBB program each year. This is an ongoing program and has continued forward in the 2017 control strategy as TR14: Cars & Light Trucks, with a focus on incentives for electric vehicles.
MSM-B1	Fleet Modernization for Medium- and Heavy-Duty On-Road Vehicles	Provide incentives for the purchase of new trucks that meet ARB's 2010 emission standards for heavy-duty engines.	Since 2009, the Air District has awarded more than $75 million to upgrade the Bay Area trucking fleet. This includes retrofits and/or replacement of more than 2,500 trucks in port and on-road service. The Air District has also provided more than $36 million to replace 168 buses, retrofit 502 school buses, and to replace CNG tanks on 80 buses. This is an ongoing program and has continued forward in the 2017 control strategy as TR19: Medium and Heavy-Duty Trucks.
MSM-B2	Low NO_x Retrofits in Heavy-Duty On-Road Vehicles	Provide incentives to install abatement equipment to reduce NO_x emission.	New technology exists; currently replacement with new 2010 MY compliant engines is preferable and more cost effective than installing NO_x retrofits. Therefore, this measure is not included in the 2017 control strategy.
MSM-B3	Efficient Drive Trains	Provide funding to underwrite development and demonstration of hybrid drive trains.	The Air District has submitted funding proposals to demonstrate hybrid drive technologies in trucking applications, but has not yet been awarded any funding. Components of this measure are an ongoing program, and therefore has continued forward in the 2017 control strategy as TR19: Medium and Heavy-Duty Trucks.

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Mobile Source Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
MSM-C1	Construction and Farming Equipment	Use various strategies to reduce emissions from construction and farming equipment, e.g., incentives for equipment upgrades and/or encourage the use of renewable electricity and fuels.	Since 2009, the Air District has provided more than $38 million to replace and/or upgrade hundreds of pieces of equipment used in construction, cargo-handling and agricultural operations. Projects typically involve replacing older, often uncontrolled equipment with newer units that have engines certified to the cleanest available standards. This is an ongoing program and has continued forward in the 2017 control strategy as TR22: Construction, Freight and Farming Equipment.
MSM-C2	Lawn and Garden Equipment	Provide incentives toward exchange programs targeting older lawn mowers and leaf blowers with two-stroke engines.	Currently, there are two Lawn Mower Exchange programs. The residential program serves the entire Bay Area. The commercial program serves public agencies within Alameda and Contra Costa counties. These programs offer funding for new, battery-powered, zero-emission electric lawn and garden equipment in exchange for scrapping operable gasoline-powered lawn and garden equipment. Between 2010 and 2015, the Air District allocated $834,050 to implement this measure. The Air District is exploring funding opportunities to continue and expand the Commercial Lawn & Garden Equipment Exchange Program to make it available to all areas within the Air District's jurisdiction. Likewise, the Air District intends to continue the residential Lawn Mower Exchange program. This is an ongoing program and has continued forward in the 2017 control strategy as TR23: Lawn Care Equipment.
MSM-C3	Recreational Watercraft	Establish voluntary exchange program to retire gasoline-powered four-stroke and two-stroke outboard engines used in small recreational watercrafts.	An incentive program to replace older, two-stroke marine outboard engines with low-emission, four-stroke engines currently lacks funding.

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Transportation Control Measures			
Number	**Title**	**Description**	**Implementation Status**
TCM-A1	Local and Area-wide Bus Service Improvements	Maintain and improve existing service, including new Express Bus or Bus Rapid Transit on major corridors, fund replacement of older buses, and implement Transit Priority Measures of the Transportation Climate Action Campaign.	MTC allocated a total of approximately $251.2 million in Federal Transit Administration (FTA) formula funds in FY2013 and FY2014 for replacement of buses and vans in the region, including electric trolley buses. As part of the Core Capacity Challenge Grant Program, MTC committed to allocating approximately $1.7 billion in FTA formula funds and other regional funds for replacing and rehabilitating SFMTA and AC Transit buses, trolleys and vans between FY2016 and FY2030. These funds, together with funding for replacement of other operators' buses, will be allocated in future Transit Capital Priorities program cycles. This is an ongoing program and has continued forward in the 2017 control strategy as TR3: Local and Regional Bus Service.
TCM-A2	Improve Local and Regional Rail Service	Maintain and expand existing service via funds to maintain railcars and other rail capital assets.	As part of the Transit Capital Priorities program, MTC allocated a total of approximately $466 million in Federal Transit Administration formula funds in FY2010, FY 2011 and FY2012 for replacement and rehabilitation of railcars and other rail capital assets in the region. The total includes funds allocated for BART preventive maintenance in exchange for BART local funds to be used to replace BART's railcars. As part of the Transit Capital Priorities program, MTC allocated a total of approximately $372.7 million in Federal Transit Administration formula funds in FY2013 and FY2014 for replacement of railcars and other rail capital assets in the region. As part of the Core Capacity Challenge Grant Program, MTC committed to allocating approximately $2 billion in FTA formula funds and other regional funds for replacing and rehabilitating BART and SFMTA railcars and other rail capital assets between FY2015 and FY2030. In addition, MTC adopted a Phase 1 Funding Plan for the BART Car Replacement project which makes a policy-level commitment of $871 million in Transit Capital Priorities funds for the project through FY2019 (including the amounts allocated through FY2014).

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Transportation Control Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
TCM-A2 *(continued)*			MTC also adopted a funding plan for Caltrain electrification, including replacement of railcars, and an advanced signal system that includes a commitment of $451 million in regional funds between FY2013 and FY2023. These funds, together with funding for replacement of other operators' rail assets, will be allocated in future Transit Capital Priorities program cycles. The Air District awarded $20 million in Carl Moyer funds to support electrification of the Caltrain system by 2020. This is an ongoing program and has continued forward in the 2017 control strategy as TR4: Local and Regional Rail Service Improvements.
TCM-B1	Freeway and Arterial Operations Strategies	Improve the performance and efficiency of the freeway and arterial systems via the Freeway Performance Initiative, the Bay Area Freeway Service Patrol and the Arterial Management Program.	Ramp Metering (RM) and Traffic Operations Systems (TOS) infrastructure has been installed and activated along sections of Interstate 280, 242, and on 680 between I-580 and Auto Mall park. Since 2010, 51 retiming projects have been completed on over 1,000 signals in eight Bay Area counties with a total budget of $3.75 million. These projects have an average benefit-cost ratio of 40:1 and have provided significant benefits including travel-time savings, fuel consumption savings, reduction in harmful emissions, and reduction in stops. Over 114 on-ramps are currently being modified and fitted with RM equipment and TOS equipment is being installed at 284 locations. In 2010, MTC replaced the Regional Signal Timing Program (RSTP) with the new Program for Arterial System Synchronization (PASS). In addition to the basic weekday signal coordination of the previous RSTP program, the scope of the PASS includes developing incident management flush plans, transit signal priority plans, traffic responsive timing plans, weekend timing plans, school peak timing plans, and additional timing plans as needed.

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Transportation Control Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
TCM-B1 *(continued)*			The Freeway Service Patrol program continues to patrol 540 miles of Bay Area freeway while program partners continue to monitor the program to ensure resources are being allocated efficiently and that service is being provided appropriately. In 2011, Beat 33 was added to the service map to close the gap on I-280. This is an ongoing program and has continued forward in the 2017 control strategy as TR6: Freeway and Arterial Operations.
TCM-B2	Transit Efficiency and Use	Improve transit efficiency via 511 Transit, full implementation of the Clipper program, and the Transit Hub Signage program.	MTC continues to work closely with more than two dozen Bay Area transit operators to operate, maintain and further develop the 511 Transit information system. These systems include the 511 Transit website and its features: the 511 Transit Trip Planner, 511 Departure Times, 511 Popular Destinations, as well as schedule, fare, route and agency-specific information for the region's numerous transit operators. The 511 system is also funded through the Air District, which has awarded MTC $1 million in Transportation Funds for Clean Air annually. Clipper is currently available on 20 different transit agencies, including AC Transit, BART, Caltrain, Vacaville City Coach, County Connection, Fairfield and Suisun Transit, Golden Gate Ferry, Marin Transit, Muni, Petaluma Transit, SamTrans, SF Bay Ferry, Santa Rosa City Bus, SolTrans, Sonoma County Transit, Tri Delta Transit, VINE, VTA, WestCAT and Wheels. Participating Clipper transit agencies started to discontinue paper passes in 2010 in favor of Clipper cards. This transition has led to increased usage of Clipper by all agencies, with some agencies achieving 75–90 percent market penetration rates. In 2010, Clipper began operating a pre-tax transit benefit program called Clipper Direct. Clipper Direct works with employers in the Bay Area to put cash value and transit passes directly

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Transportation Control Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
TCM-B2 *(continued)*			onto Clipper cards using employees' pre-tax dollars. Clipper also has agreements with other pre-tax transit benefit providers so that customers of those programs can also use their transit benefits to put value onto their Clipper cards. In 2013, Clipper expanded its functionality to include parking payment at five parking garages in San Francisco, operated by San Francisco Municipal Transportation Agency (SFMTA). In 2014, Clipper began operating on transit routes in Napa and Solano counties, followed by additional transit agencies in eastern Contra Costa County. As of January 2014, the Hub Signage Program was installed at 20 regional transit hubs, with another 3 hubs to be completed by fall 2014. Oakland International Airport, the final hub, was completed in 2015, in concert with BART's Oakland Airport Connector Project. This is an ongoing program and has continued forward in the 2017 control strategy as TR5: Transit Efficiency and Use.
TCM-B3	Bay Area Express Lane Network	Price travel demand on Bay Area highways by developing a seamless Express Lane Network throughout Bay Area.	Three express lanes are currently in operation: 1) I-680 (Sunol) southbound, opened in 2010; 2) 880/237 connector, opened in 2012; and 3) I-580, opened in 2015. Work continues to implement express lanes on I-580, the remainder of the existing HOV lane on SR-237, and on SR-85 and US 101 (currently in the environmental phase). In 2012 and 2013, environmental review was initiated to convert existing HOV lanes to express lanes on: • I-680 in Contra Costa County from just south of the SR-24 interchange to Alcosta, • I-680 in Contra Costa County north of the SR-24 interchange,

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Table F-1. **Implementation Status of Control Measures in 2010 Clean Air Plan** *(continued)*

Transportation Control Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
TCM-B3 *(continued)*			• I-880 in Alameda County, • I-80 between Air Base and I-680 Solano County, • Westbound approaches to the Dumbarton (SR-84), San Mateo (SR-92) and Bay bridges (I-80/I-880).
TCM-B4	Goods Movement Improvements and Emission Reduction Strategies	Invest in the region's trade corridors and continue to offer incentives to replace older engines with cleaner than required equipment.	Since 2009, the Air District has invested approximately $100 million to reduce air pollution emissions and health risk from freight movement along California's priority trade corridors. These funds have reduced truck emissions from thousands of heavy-duty diesel trucks (via retrofit or replacement), and installed shore power at 15 berths at the Port of Oakland. In combination, these efforts have achieved more than a 50 percent reduction in particulate matter in the West Oakland community. In September 2015, the Air District was awarded $48 million from the Air Resources Board for the Year-5 Goods Movement grant program. The Air District has applied for additional funding to achieve further emissions reductions from the goods movement sector. In addition, various trade corridor projects are currently under construction or are pending construction until funding is secured. For example, the Stockton Dredging project is under construction and the Truck Climbing Lanes project was completed in 2016. This is an ongoing program and has continued forward in the 2017 control strategy as TR18: Goods Movement.
TCM-C1	Voluntary Employer-Based Trip Reduction Program	Support voluntary efforts by Bay Area employers to encourage their employees to use alternative commute modes, such as transit, ridesharing, walking, bicycling and/or telecommuting.	The City of San Francisco, the City of Richmond, and the City of Berkeley each adopted a Commute Benefits Ordinance which requires employers of a certain size to offer employees the opportunity to purchase transit passes with pre-tax dollars. Following the passage of Senate Bill 1339 in 2012, the Air District and MTC adopted

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Transportation Control Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
TCM-C1 *(continued)*			the Commuter Benefits Program in 2014, which requires any employer with 50 or more employees in the Bay Area to offer commute benefits. The Commuter Benefit Program requires these employers to provide one of four alternative commute friendly strategies: 1) establish the option for employees to set aside pre-tax salary to pay for their transit or vanpool costs, 2) provide up to $75/month transit subsidy to all employees, 3) provide a shuttle service from a transit hub to the work location, or 4) provide another approved alternative. This is an ongoing program and has continued forward in the 2017 control strategy as TR2: Trip Reduction Programs.
TCM-C2	Safe Routes to Schools and Safe Routes to Transit Programs	Facilitate safe route to schools and transit by providing funds and working with transportation agencies, local governments, schools, and communities to implement safe access for pedestrians and cyclists.	MTC funded the Regional Safe Routes to School (SRTS) program via $15 million ($5 million/year) from FY 2010 through FY 2012. In May 2012, MTC committed $20 million ($5 million/year) starting in FY2013 for the SRTS program. This was distributed to the congestion management agencies in the nine counties of the Bay Area region. The CMAs conducted outreach and a request for proposals to determine which needs were to be funded. The Air District provides approximately $9 million in TFCA funding annually on a pass-through basis to the nine CMA's through its TFCA County Program Manager program. The CMA's have awarded significant funding over the years to various Safe Routes projects in their counties. The Air District also directly awarded $400,000 in TFCA Regional Funds to Solano Transportation Authority to develop and promote education and encouragement projects and programs during FY 2011 – FY 2013 as part of its Safe Routes to School Program. This is an ongoing program and has continued forward in the 2017 control strategy as TR7: Safe Routes to Schools and Safe Routes to Transit.

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Transportation Control Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
TCM-C3	Ridesharing Services and Incentives	Promote ridesharing services and incentives through the implementation of the 511 Regional Rideshare Program, as well as local rideshare programs implemented by county congestion management agencies.	The 511 Regional Rideshare Program is operated by MTC and is funded by grants from the Federal Highway Administration, U.S. Department of Transportation, MTC, BAAQMD and county congestion management agencies. The Bay Area has had an organized vanpool program since 1981. Currently managed by local, county and regional partners including MTC's 511 program, the region's vanpool service helps people with long commutes that are not well-served by transit. Plan Bay Area, adopted in 2013, enhanced the appeal of vanpooling by dedicating $6 million to reduce the cost of van rentals and encouraging more people to participate in the vanpool program. In addition, Plan Bay Area invests $13 million to expand car-sharing services to ensure vehicles are available at high demand locations, and to expand services in suburban communities. Some Plan Bay Area funds were spent on Climate Grants Program projects that included vanpool and car-sharing components, such as: Connect, Redwood City!; goBerkeley; Dynamic Rideshare Programs Demonstrated in Three Counties; and eFleet: Car Sharing Electrified. In May of 2015, the Air District's Board of Directors approved $4.36 million in TFCA funds to be allocated to the Trip Reduction Program, which provides funding for both existing shuttle and regional rideshare programs and a new pilot trip reduction program to allow for innovative and cost-effective projects that provide first- and last-mile connections. Since 2009, the Air District has allocated approximately $4 million annually in TFCA funds for commuter shuttle and rideshare projects. This is an ongoing program and has continued forward in the 2017 control strategy as TR2: Trip Reduction Programs.

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Transportation Control Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
TCM-C4	Conduct Public Outreach & Education	Encourage Bay Area residents to make choices that benefit air quality by educating the public about the health effects of air pollution and encouraging the use of alternative travel modes.	The Spare the Air (STA) Every Day Program is the backbone of the Air District's efforts to encourage the public to take direct action to reduce emissions and improve air quality. STA Every Day includes the following components: Outreach Program, Employer Program, Community Resource Teams, Winter Spare the Air and Youth Programs. This is an ongoing program and has continued forward in the 2017 control strategy as TR15: Public Outreach and Education. MTC implemented an Electrical Vehicle (EV) promotional campaign. The EV promotional campaign was aimed at building awareness, action and demand for electric vehicles in the Bay Area in order to enable the region to reduce its GHG emissions.
TCM-C5	Smart Driving	Focus on public education to encourage drivers to observe posted speed limits and adopt other fuel efficient driving practices, supplemented by speed enforcement.	MTC funded two smart driving pilots: 1) $400k to test in-use fuel saving devices that will be installed into participants' vehicles. Real-time information will be recorded during vehicle acceleration and deceleration to educate drivers about how driving behavior affects miles-per-gallon rate; and 2) $114k to test in-vehicle apps. This is an ongoing program and has continued forward in the 2017 control strategy as TR12: Smart Driving.
TCM-D1	Bicycle Access and Facilities Improvements	Expand bicycle facilities serving employment sites, educational and cultural facilities, residential areas, shopping districts and other activity centers.	Launched on August 29, 2013, the Bay Area Bike Share (BABS) program is the first bike share system to launch in California and in the United States as a unified regional system. Bike sharing allows both residents and visitors to make short trips by bike and provides an easy and cost-effective "last mile" solution, linking public transit with riders' final destinations. The BABS system operates 24-hours a day, seven-days a week in five cities along the Caltrain commuter rail corridor—San Francisco, Redwood City, Palo Alto, Mountain View and San Jose. The Bay Area's system consists of 70 stations and a fleet of 700 bikes and is

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Transportation Control Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
TCM-D1 *(continued)*			planned to increase in size in 2017 and expand to the communities of Berkeley, Oakland and Emeryville. Since its launch, BABS has achieved more than 760,000 rides and over 1,370,000 miles. Bay Area Bike Share began as a pilot project with funding from MTC's Initiatives Program and the Air District's Transportation Fund for Clean Air (TFCA) Program. The Air District began as the lead administrator of Bay Area Bike Share in partnership with MTC and local partners. Beginning in early 2016, MTC became the lead administrator of the BABS program. At MTC, the Regional Bicycle Program has been replaced with One Bay Area Grant funding. Local CMAs and/or city governments may apply grants for local bike facility improvements. Projects funded since 2012 that include a bicycle component include: Downtown Berkeley (includes improved access to BART for cyclists), Oakland's Lakeside Complete Streets and Road Diet (includes nearly a mile of Class II bike lanes), Fremont City Center Multi-Modal Improvements (includes bike connection to BART and nearby employment and housing), San Pablo Bicycle and Pedestrian Improvements in San Pablo and Richmond (one-mile buffered bike lanes), San Francisco's Masonic Avenue Complete Streets (dedicated bike space), and the Capitol Expressway Traffic and ITS Project (includes signal timing adaptive to bicycles). Between 2009 and 2014, the Air District awarded approximately $3.5 million in TFCA funds to support bicycle access and facilities improvements. Funds were used to support Bay Area Bike Share and the deployment of new racks, lockers, and bikeways in the region. The Air District has recently increased its allocation of funding for this category of projects: In FYE 2015, nearly $637,000

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Transportation Control Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
TCM-D1 *(continued)*			in TFCA funds were awarded to support the installation of 2,200 new bicycle rack parking spaces and 220 new electronic lockers; for FYE 2016, the Air District has allocated $3.84 million in TFCA funds for bicycle access and facilities improvements projects. This is an ongoing program and has continued forward in the 2017 control strategy as TR9: Bicycle and Pedestrian Access and Facilities.
TCM-D2	Pedestrian Access and Facilities Improvements	Improve pedestrian facilities and encourage walking by funding projects that improve pedestrian access to transit, employment and major activity centers.	MTC's One Bay Area Grant funds pedestrian projects. Projects funded since 2012 that include a pedestrian component include: Downtown Berkeley (includes improved access to BART for pedestrians), Oakland's Lakeside Complete Streets and Road Diet (includes 1.3 miles of new and improved pedestrian pathways), Fremont City Center Multi-Modal Improvements (includes pedestrian connection to BART and nearby employment and housing), San Pablo Bicycle and Pedestrian Improvements in San Pablo and Richmond (includes improvements to address pedestrian safety), San Francisco's Masonic Avenue Complete Streets (pedestrian enhancements), and the Capitol Expressway Traffic and ITS Project (includes signal timing adaptive to pedestrians). MTC's Climate Grants Program funded the following projects with pedestrian components: Regional Safe Routes to School, Green Ways to School, and the Safe Routes to School (SRTS) Education and Encouragement School Route Maps. This measure has continued forward in 2017 control strategy as TR9: Bicycle and Pedestrian Access and Facilities.

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Transportation Control Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
TCM-D3	Local Land Use Strategies	Promote and support land use patterns, policies and infrastructure investments that support high density mixed-use, residential and employment development in order to facilitate walking, bicycling and transit use.	In May 2011, MTC adopted Resolution 4035, which establishes program commitments and policies for investing roughly $800 million over FYs 2012-13 through 2015-16, funded by federal funds authorized by Congress in Moving Ahead for Progress in the 21st Century (MAP 21). Funds are targeted to Priority Development Area (PDA) implementation, such as transportation projects that support increased residential densities, walkability, and access to transit. The OBAG grant program was established with the adoption of Plan Bay Area in 2013. Through the OBAG program, county congestion management agencies (CMAs) are required to complete a PDA Investment and Growth Strategy. The purpose of the Strategy is to guide and identify a priority-setting process for programming OBAG funding that supports and encourages development in the region's PDAs. This is an ongoing program and has continued forward in the 2017 control strategy as TR10: Land Use Strategies.
TCM-E1	Value Pricing Strategies	Pursue implementation of value pricing strategies such as tolling on trans-bay bridges and cordon pricing.	In June 2011, the City of San Francisco approved development plans for Treasure Island (a Priority Development Area), including 8,000 residential units, along with retail and commercial uses. The Treasure Island Transportation Implementation Plan, adopted as part of the development project's approval, calls for an integrated approach to managing traffic and improving mobility management, including a congestion fee to be assessed for residents traveling by private automobile on or off the island during peak hours. The congestion fee, in combination with parking charges and a pre-paid transit voucher for each household, will help fund a comprehensive suite of transportation services including new ferry service to San Francisco and enhanced East Bay bus services. This is an ongoing program and has continued forward in the 2017 control strategy as TR11: Value Pricing Strategies, as further pricing mechanisms will be explored.

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Transportation Control Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
TCM-E2	Parking Policies to Reduce VMT	Take actions at the regional level to implement parking policies that will benefit air quality. Encourage and support local parking policies that reduce motor vehicle use.	In 2010, MTC conducted two large training sessions on utilizing the MTC publication *Reforming Parking Policies to Support Smart Growth* and focusing on how local jurisdictions can reform their approach to parking policies. In 2011, MTC conducted surveys of local jurisdictions' parking policies including existing challenges. They also provided technical assistance for five specific parking projects and conducted an economic assessment of parking structures at transit stations. Additionally, MTC conducted parking fundamentals workshops for local jurisdictions and other interested parties. In 2012-2013, MTC focused on technical analyses and communications methods culminating in a series of parking workshops aimed at planning and transportation professionals. This work received an award from the Transportation Research Board. This is an ongoing program and has continued forward in the 2017 control strategy as TR13: Parking Policies.
TCM-E3	Transportation Pricing Reform	Develop and implement a regional transportation pricing policy strategy.	This measure has continued forward in the 2017 control strategy as TR11: Value Pricing Strategies.
Land Use and Local Impacts Measures			
Number	**Title**	**Description**	**Implementation Status**
LUM-1	Goods Movement	Reduce emissions and exposure-related freight movement in the Bay Area.	For more detailed information, please see control measure TCM-B4: Goods Movement Improvements and Emission Reduction Strategies in this Appendix. This is an ongoing program and has continued forward in the 2017 control strategy as TR18: Goods Movement.
LUM-2	Indirect Source Review	Develop an indirect source review (ISR) rule to reduce construction and operating emission and population exposure associated with new or modified land uses.	The Air District initiated a broad-based stakeholder working group. Group has met once to vet ISR concepts. Staff has prepared background papers, fact sheets, work plans and a white paper. These efforts will serve as background research/material for developing an ISR rule.

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Land Use and Local Impacts Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
LUM-2 *(continued)*			This control measure has been carried forward in the 2017 control strategy as TR16: Indirect Source Review.
LUM-3	Updated CEQA Guidelines and Enhanced CEQA Review	Strengthen existing CEQA program by increasing the number of CEQA documents staff reviews and by quantifying estimated reductions in emissions of criteria pollutants, air toxics, and GHGs from the CEQA program.	Air District staff regularly assists local governments in the toxics analysis of their land use plans, especially Station Area Plans. Staff also assists local governments in accessing pollution data for sources via the Air District's permit database and roadway data. Air District staff continues to write comment letters on CEQA documents. Comments pertain to the use of CEQA thresholds, as identified and adopted by the lead agency, and adequacy of air quality analysis on local land use plans and development projects. This is an ongoing program and has continued forward in the 2017 control strategy, as TR10: Land Use Strategies.
LUM-4	Land Use Guidance	Assist local governments in the inclusion of smart growth principles and climate protection elements in their general plans.	Air District staff worked closely with MTC Station Area Planning grantees to identify any sources of toxic air contaminants in their local planning areas. In 2012 and 2013, Air District staff worked with MTC on the air quality analysis for the Plan Bay Area draft EIR. Air District staff assists local governments in the development of their local Climate Action Plans and in the review of those plans for CEQA purposes. Air District staff developed the Planning Healthy Places guidance document and maps to help local governments identify areas estimated to have elevated levels of fine particulates and/or toxic air contaminants. This is an ongoing program and has continued forward in the 2017 control strategy as TR10: Land Use Strategies .

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Land Use and Local Impacts Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
LUM-5	Monitor Health Risks in Local Communities	Track cumulative health risks related to toxic air contaminants (TACs) and directly emitted $PM_{2.5}$ from all emission sources in impacted communities, as defined by the Air District's CARE program.	In 2013, the Air District updated the maps of cumulative impact areas in the Bay Area, incorporating more recent data and using new methods. The new method accounted for areas with high cancer risk, using updated TAC modeling to estimate cancer risk. In addition to cancer risk from TACs, the updated method accounted for increased mortality and illnesses from fine particulate matter ($PM_{2.5}$) and ozone above background levels. Population vulnerability was accounted for in estimating health impacts from air pollution by using a community's existing baseline rates of mortality and illnesses to determine increases in mortality and illness from air pollution. Maps of impacted communities are used to prioritize Air District grant programs, air monitoring projects, community engagement and more. This is an ongoing program and has continued forward in the 2017 control strategy as SS39: Enhanced Air Quality Monitoring and TR10: Land Use Strategies.
LUM-6	Enhanced Air Quality Monitoring	Evaluate and enhance the regional air quality monitoring network; include black carbon and methane in air monitoring. Solicit feedback on locations of new monitors.	The Air District is involved in various studies and programs to evaluate and enhance air quality monitoring in the Bay Area. Some of the activities that the Air District has participated in since 2010 include: • A three-year monitoring study of criteria pollutants and toxic air contaminants near the Lehigh Southwest Cement Plant in Cupertino. • Establishment of a GHG monitoring network with four sites, the first two sites established on Bethel Island and at Bodega Bay. • Between 2012 and the present, the Air District has purchased and installed seven Ultra Fine Particular Matter (UFPM) counters. These counters have collected data to learn more about the effect of wind, rain, and time-of-day, temperate, and seasonal changes on UFPM levels.

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Land Use and Local Impacts Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
LUM-6 *(continued)*			• In 2013, the Air District hosted a day-long expert panel discussion assessing the latest technologies and trends in air monitoring. • Funding of the Berkeley Atmospheric CO_2 Observation Network (BEACO_2N). BEACO_2N measures air quality in the San Francisco Bay Area by blanketing a large area with a dense network of monitoring sites using low-cost instruments. These instruments are equipped with sensors that measure CO_2, CO, NO, NO_2, O_3, and aerosol. • A study to examine the contribution of diesel soot, wood smoke, charbroiled meat smoke, cellulose smoke and methane flame to the atmospheric burden of elemental carbon in the Bay Area. • Beginning in 2014, work with Lawrence Berkeley National Laboratory (LBNL) and others on a study to evaluate potential mitigation measures to reduce in-home pollutant concentrations for residences near high trafficked roadways. • In 2016, the Air District passed Regulation 12-15: Petroleum Refining Emissions Tracking. This Regulation is designed to monitor emission reductions at refineries. This is an ongoing program and has continued forward in the 2017 control strategy as SS39: Enhanced Air Quality Monitoring, TR10: Land Use Strategies, and SL3: GHG Monitoring & Measurement Network.
Energy and Climate Measures			
Number	**Title**	**Description**	**Implementation Status**
ECM-1	Energy Efficiency	Decrease the amount of energy consumed in the Bay Area through increased efficiency and conservation to reduce the amount of fossil fuel needed to produce the electricity that the region uses.	Through the Air District's implementation of Regulation 9, Rule 7 (boiler efficiency), Air District staff works with PG&E to target outreach efforts for PG&E's financing programs to public agencies needing assistance in complying with the Rule. By providing feedback on climate action plans, Air District staff facilitates information sharing among local

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Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Energy and Climate Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
ECM-1 *(continued)*			governments that are developing green building ordinances and for other programs underway across the Bay Area. School districts are a focus of this targeted outreach effort. This is an ongoing program and has continued forward in the 2017 control strategy as BL1: Green Buildings.
ECM-2	Renewable Energy	Promote the production and use of renewable energy in the Bay Area to reduce the portion of fossil fuel-based energy needed to produce the electricity that the region consumes.	In addition to its efforts described in measure ECM-1 above, the Air District also provides information about best practices including community choice aggregation. The Air District also has prepared two greenhouse gas emissions inventories. The production-based inventory analyzes the amount of GHG emissions generated by the production of goods and services that occurs within the boundaries of the Bay Area. The consumption-based inventory estimates the amount of GHGs emitted by the production of goods and services anywhere in the world that are consumed by Bay Area residents, regardless of where the GHG emissions were released to the atmosphere. Both inventories help the Bay Area to better understand the current sources of emissions, including what portion of our energy use is based on fossil fuels. This is an ongoing program and has continued forward in the 2017 control strategy in measure EN2: Decrease Electricity Demand.
ECM-3	Urban Heat Island Mitigation	Mitigate the “urban heat island” effect by promoting the implementation of cool roofing and cool paving techniques.	Air District staff worked with staff at Lawrence Berkeley National Laboratory (LBNL) to develop and promote a technical seminar on the benefits of reflective pavement for local government planners and public works staff, cement and asphalt companies, and researchers. Air District staff participated in an LBNL working group to develop a “cool schoolyards” program for cool paving. LBNL staff also made a presentation to the Air District’s Advisory Council on the urban heat island effects on energy use, climate, air pollution and GHGs. This is an ongoing program and has continued forward in the 2017 control strategy as BL4: Urban Heat Island Mitigation.

(continued)

Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Energy and Climate Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
ECM-4	Shade Tree Planting	Voluntary approaches to reduce urban heat islands by increasing shading in urban and suburban communities via planting of low VOC emitting trees.	The Air District's CEQA Guidelines include recommendations for tree planting, particularly for low VOC-emitting trees, as a mitigation measure. Ongoing CEQA commenting includes tree planting and use of Bay Friendly Landscape Guidelines as recommendations for mitigation measures. This is an ongoing program and has continued forward in the 2017 control strategy as NW2: Urban Tree Planting.

In addition to the measures above, the 2010 Clean Air Plan identified 18 Further Study Measures (FSMs). The FSMs were not a formal part of the control strategy, but the Air District did make a commitment to further evaluate these measures to determine whether or not they could be developed into control measures at a later date. The status of the FSMs is documented below.

Further Study Measures			
Number	**Title**	**Description**	**Implementation Status**
FSM-1	Adhesives and Sealants	Reduce VOC limits for architectural adhesives.	This measure is carried forward in the 2017 Plan control strategy as SS25: Coatings, Solvents, Lubricants, Sealants, and Adhesives.
FSM-2	Reactivity in Coatings and Solvents	Reduce VOC emissions from coatings operations and solvents.	This measure is carried forward in the 2017 control strategy as SS25: Coatings, Solvents, Lubricants, Sealants, and Adhesives.
FSM-3	Solvent Cleaning and Degreasing Operations	Reduce VOC emissions from solvent cleaning and degreasing operations.	This measure is carried forward in the 2017 control strategy as SS25: Coatings, Solvents, Lubricants, Sealants, and Adhesives.
FSM-4	Emissions from Cooling Towers	Research ways to reduce VOC emissions from cooling towers in refineries.	This measure was adopted by the Board of Directors in December 2015 as Regulation 11-10. Because further amendments to Reg. 11-10 are possible, this measure is also carried forward in the 2017 control strategy as SS3: Cooling Towers, and is also part of the Refinery Strategy.
FSM-5	Equipment Leaks	Research ways to reduce VOC emissions from equipment leaks through remote sensing technologies and other methods.	This measure was adopted by the Board of Directors in December 2015 as Regulation 8-18. Because further amendments to Reg. 8-18 are possible, this measure is also carried forward in the 2017 control strategy as a control measure, SS2: Equipment Leaks, and is also part of the Refinery Strategy.

(continued)

Table F-1. Implementation Status of Control Measures in 2010 Clean Air Plan *(continued)*

Further Study Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
FSM-6	Wastewater from Coke Cutting	Review coke cutting operations to determine if emissions reductions can be achieved from the resulting wastewater.	The Air District has determined that coke cutting operations are already operating to minimize emissions to the extent technically feasible. This measure has not been carried forward to the 2017 control strategy.
FSM-7	SO_2 from Refinery Processes	Review refinery processes to identify opportunities to reduce SO_2 emissions.	This measure is carried forward in the 2017 control strategy; measure is now a control measure, SS5: Sulfur Recovery Units.
FSM-8	Reduce Emissions from LPG, Propane, Butane, and other Pressurized Gases	Reduce emissions from LPG, propane, butane and other pressurized gases by requiring tanks and relief values to be gas tight, prohibiting venting during tank filling, and establishing a leakage allowance for hoses.	This measure is carried forward in the 2017 Plan control strategy; measure is now a control measure, SS28: LPG, Propane, Butane.
FSM-9	Greenhouse Gas Mitigation in BACT and BACT Deter-minations	Consider flexibility in BACT/TBACT determinations in order to reduce secondary greenhouse gas emissions from abatement devices.	This measure is carried forward in the 2017 control strategy as SS17: GHG BACT Threshold.
FSM-10	Further Reductions from Commercial Cooking Equipment	Reduce emissions from commercial cooking, and solid fueled cooking devices such as wood-fired pizza ovens.	This measure is carried forward in the 2017 control strategy as SS33: Commercial Cooking Equipment.
FSM-11	Magnet Source Rule	Reduce mobile source emissions from new and existing facilities that attract or generate a high volume of activity, including airports, regional shopping malls and distribution centers.	This measure is carried forward in the 2017 control strategy. It has been combined with TR16: Indirect Source Review.

(continued)

Table F-1. **Implementation Status of Control Measures in 2010 Clean Air Plan** *(continued)*

Further Study Measures *(continued)*			
Number	**Title**	**Description**	**Implementation Status**
FSM-12	Wood Smoke	Continue to study the impacts of existing Air District rules regarding wood burning and open burning, in order to develop more effective methods to implement, promote, expand and enforce existing rules.	In 2008, the Air District adopted Regulation 6, Rule 3 to protect Bay Area residents from the harmful health impacts of wood smoke. In the fall of 2015, the Air District adopted amendments to Regulation 6-3, greatly expanding and tightening the regulation. In anticipation of further amendments, this measure is carried forward in the 2017 control strategy as SS34: Wood Smoke.
FSM-13	Energy Efficiency and Renewable Energy	Consider additional actions the Air District may take to promote energy efficiency and renewable energy.	This measure is carried forward in the 2017 control strategy as EN1: Decarbonize Electricity Generation and EN2: Decrease Electricity Demand.
FSM-14	Winery Fermentation	Review emissions generated by fermentation at wineries to determine if reductions in VOC emissions can be achieved.	This measure is carried forward in the 2017 control strategy as an FSM_AG1: Wineries.
FSM-15	Composting Operations	Review emissions generated by composting operations and consider reductions if VOC emissions can be achieved.	This measure is carried forward in the 2017 control strategy as WA2: Composting & Anaerobic Digesters.
FSM-16	Vanishing Oils and Rust Inhibitors	Research VOC emissions reductions from vanishing oils and rust inhibitors.	This measure is carried forward in the 2017 control strategy as FSM_SS7: Vanishing Oils and Rust Inhibitors.
FSM-17	Ferry System Expansion	Work with MTC and the Water Emergency Transportation Authority to ensure that the expansion of the regional ferry network will provide the greatest air quality benefit.	This measure is not carried forward in the 2017 control strategy.
FSM-18	Greenhouse Gas Fee	Evaluate the idea of adopting a GHG fee on stationary sources to provide energy efficiency and reduce GHG emissions.	This measure is carried forward in the 2017 control strategy as FSM_SS6: Carbon Fee.

APPENDIX G

EVALUATION OF CONTROL MEASURES

This appendix summarizes the review of potential control measures for the Bay Area 2017 Plan performed by Air District staff.

Background

Pursuant to California Health & Safety Code Section 40914, the 2017 Plan is required to include all feasible control measures to reduce region-wide emissions for each nonattainment pollutant (e.g., ozone precursors). To identify feasible measures for the 2017 Plan, Air District staff reviewed and evaluated 366 potential control measures compiled from a variety of sources.[1] Air District staff sought ideas for new control measures, as well as ways to strengthen existing rules and programs. Sources of potential measures included ideas submitted by the public and Air District staff, other California air district control measures contained in recently-adopted air quality plans, and air quality plans from metropolitan areas outside of California. In addition, staff reviewed measures that had previously been considered and rejected during preparation of the 2010 Clean Air Plan to see if any elements of those measures may be appropriate for the 2017 Plan. Some of the 366 measures reviewed were repeated by multiple sources and include the following:

- 216 measures from recently-adopted air quality attainment plans or other plans
- 64 measures from the 2010 Clean Air Plan
- 118 measures suggested by the public
- 17 measures suggested by Air District staff

Staff reviewed stationary source, area source, mobile source, and transportation control measures and climate strategies from throughout California and the United States. Plans within California are shown in Table G-1. Plans from other states are shown in Table G-2.

Table G-1. California Air Quality Attainment and Other Plans

Agency	Title of Plan	Year Adopted
Air Resources Board	Proposed Short-Lived Climate Pollutant Reduction Strategy	2016
Air Resources Board	2016 State Strategy for the State Implementation Plan for Federal Ozone and $PM_{2.5}$ Standards	2016
South Coast AQMD	South Coast 2007 Air Quality Management Plan	2007
South Coast AQMD	South Coast 2012 Air Quality Management Plan	2012
South Coast AQMD	South Coast Air Toxics Control Plan for the Next Ten Years	
South Coast AQMD	Draft Vision for Clean Air: A Framework for Air Quality and Climate Planning	2012
Sacramento Metropolitan AQMD	Final Staff Report: SB656 Assessment and Control Measure Evaluation	2005
Sacramento Metropolitan AQMD	2009 Triennial Report and Plan Revision	2009
Sacramento Metropolitan AQMD	Sacramento Regional 8-Hour Ozone Attainment and Reasonable Further Progress Plan	
Sacramento Metropolitan AQMD	2010 PM_{10} Implementation/Maintenance Plan and Redesignation Request	2010
San Joaquin Valley Air Pollution Control District	San Joaquin Valley 2016 Ozone Plan for 2008 8-hour Ozone Standard, June 2016	2016
San Joaquin Valley APCD	San Joaquin Valley 2007 Ozone Plan	2007
San Joaquin Valley APCD	San Joaquin Valley 2012 $PM_{2.5}$ Plan	2012
San Joaquin Valley APCD	San Joaquin Valley 2008 $PM_{2.5}$ Plan	2008
San Joaquin Valley APCD	San Joaquin Valley 2013 Plan for the Revoked 1-Hour Ozone Standard	2013
Monterey Bay Unified APCD	2004 Update to the Triennial Report	2004
Monterey Bay Unified APCD	2005 Report on Attainment of the California Particulate Matter Standards	2005

(continued)

Table G-1. **California Air Quality Attainment and Other Plans** *(continued)*

Agency	Title of Plan	Year Adopted
Monterey Bay Unified APCD	2008 Air Quality Management Plan	2008
Ventura County APCD	Ventura County 2004 Triennial Air Quality Management Plan Revision	2004
Ventura APCD	2007 Air Quality Management Plan	2007
Imperial County	2009 8-Hour Ozone Modified Air Quality Management Plan	2009
Imperial County	2009 State Implementation Plan for Particulate Matter	2009
San Diego County APCD	2009 Regional Air Quality Strategy Revision	2009
San Diego County APCD	Redesignation Request and Maintenance Plan for the 1997 Annual and 2006 24-Hour $PM_{2.5}$ NAAQS	2013
Santa Barbara County APCD	Santa Barbara 2007 Clean Air Plan to Maintain the Federal 8-Hour Ozone Standard and Attain the State 1-Hour Ozone Standard	2007
Santa Barbara County APCD	Santa Barbara Clean Air Plan: 2004 Triennial State Ozone	2004
Butte County Air Quality Management District	Northern Sacramento Valley Planning Area: 2009 Triennial Air Quality Attainment Plan	2009
Placer County Air Pollution Control District	2012 Triennial Progress Report	2012
	Final 2016 Owens Valley Planning Area PM_{10} State Implementation Plan	2016
City of Berkeley	Climate Action Plan, 2009	2009
City of Oakland	Energy and Climate Action Plan, 2012	2012
City of Pleasanton	Climate Action Plan, 2012	2012
City of Santa Rosa	Climate Action Plan, 2012	2012

Table G-2: Out-of-State Air Quality Attainment and Other Plans

Agency	Title of Plan	Year Adopted
Maryland Department of the Environment	Baltimore Serious Attainment Area 0.08 ppm 8-Hour Ozone State Implementation Plan	2013
Cecil County, Maryland	8-Hour Ozone State Implementation Plan	2013
City of Chicago	Chicago Climate Action Plan, 2010	2010
City of Albuquerque	Climate Action Plan, 2009	2009
City of New Orleans	Carbon Footprint Report, 2009	2009
Pinal County Township	2012 Five Percent Plan for PM_{10}, State of Arizona, Pinal County Township	2012
Texas Commission on the Environment	Austin Climate Protection Plan and Action Items, 2008	2008
Connecticut Department of Energy and the Environment	Revision to Connecticut's State Implementation Plan, 2008	2008
Allegheny County Health Department	Crittenden County State Implementation Plan, 2006	2006
Texas Commission on the Environment	Dallas-Fort Worth Attainment Demonstration SIP Revision, 2011	2011
Wilmington Area Planning Council	Delaware State Implementation Plan for Attainment of the 8-Hour Ozone NAAQS, 2007	2007
Colorado Air Quality Council	Denver Metro Area & North Front Range Ozone Plan, 2008	2008
State of New Mexico	Dona Ana County, New Mexico Natural Events Action Plan Reevaluation, 2005	2005
City of Houston	Emissions Reduction Plan, 2008	2008
Massachusetts Department of Environmental Protection, Energy, and Natural Resources	Final Massachusetts State Implementation Plan Revision: 8-Hour Ozone Attainment, 2008	2008
Georgia Department of Natural Resources	State Implementation Plan for the Chattanooga $PM_{2.5}$ Nonattainment Area, 2009	2009
Georgia Department of Natural Resources	State Implementation Plan for the Chattanooga Ozone Nonattainment Area, 2012	2012
Georgia Department of Natural Resources	Proposed Georgia's State Implementation Plan for the Atlanta 8-Hour Ozone Nonattainment Area, 2012	2012
Oregon Global Warming Commission	Interim Roadmap to 2020: Keep Oregon Cool, 2010	2010
Texas Commission on Environmental Quality	Collin County Attainment Demonstration SIP Revision, 2012	2012

(continued)

Table G-2: Out-of-State Air Quality Attainment and Other Plans *(continued)*

Agency	Title of Plan	Year Adopted
Louisiana Department of Environmental Quality	Louisiana State Implementation Plan, 2004	2004
Maryland Department of the Environment	Maryland's Greenhouse Gas Reduction Plan, 2013, Maryland Department of the Environment	2013
Maryland Department of the Environment	Maryland's Re-Designation Request & Maintenance Plan for Fine Particulate Matter ($PM_{2.5}$), 2012, Maryland Department of the Environment	2012
Metropolitan Washington Air Quality Committee	National Capital Region Climate Change Report, 2008, Metropolitan Washington Air Quality Committee	2008
New Jersey Department of Environmental Protection	New Jersey State Implementation Plan Revision, 2007	2007
New York State Department of Environmental Conservation	New York State Implementation Plan for Ozone, 2008	2008
Fredericksburg Area Metropolitan Planning Organization	Ozone Advance Action Plan, 2013, Fredericksburg Area Metropolitan Planning Organization	2013
City of New York	Plan NYC: Climate Change Chapter, 2013	2013
Metropolitan Washington Air Quality Committee	Plan to Improve Air Quality in the Washington, DC-MD-VA Region, 2008	2008
Michigan Department of Environmental Quality	2009 Proposed Revision to Michigan's State Implementation Plan for Achieving the Ozone National Ambient Air Quality Standard	2009
New York Department of Environmental Conservation	Redesignation Request and Maintenance Plan for the 1997 Annual and 2006 24-Hour $PM_{2.5}$ NAAQS: New York–Northern New Jersey–Long Island, NY–NJ–CT Nonattainment Area, 2013	2013
Louisiana Department of Environmental Quality	Shreveport-Bossier City Metropolitan Statistical Area Early Action Compact Air Quality Improvement Plan, 2004	2004
State of Washington Department of Ecology	State Implementation Plan Revision for the Thurston County, Washington Second 10-Year Limited Maintenance Plan for PM_{10}, 2013	2013
Texas Commission on Environmental Quality	Texas 2010 HGB Attainment Demonstration SIP Revision for the 1997 8-Hour Ozone Standard, 2010	2010
Wyoming Department of Environmental Quality	Upper Green River Basin Air Quality Citizens Advisory Task Force Recommendations to the Wyoming Department of Environmental Quality, 2012	2012

Control Measure Framework and Evaluation Criteria

Potential control measures were reviewed and evaluated, as described below and summarized in Table G-3. Potential measures were initially screened to identify and eliminate measures that have been either implemented and completed by the Air District, or implemented within the Air District's jurisdiction by the Air Resources Board, U.S. EPA or another agency.

Remaining measures were evaluated according to the following criteria specified in California Health & Safety Code Section 40922:

- Cost-effectiveness
- Technological feasibility
- Total emission reduction potential
- Rate of reduction
- Public acceptability
- Enforceability

In applying the California Health & Safety Code criteria, staff evaluated potential control measures based upon their potential to reduce emissions of multiple air pollutants, including particulate matter, toxic air contaminants and greenhouse gases, in addition to ozone precursors. Staff also looked for opportunities to reduce population exposure to air pollutants, especially in the "impacted communities" identified in the Air District's CARE program. For example, control measures SS20, which proposes to increase the stringency of the Air District's Air Toxics Hotspot program, and SS21, which proposes to revise Health Risk Assessment Guidelines for the Air District's New Source Review program, will both help to reduce population exposure emissions to toxic air contaminants in impacted communities. SS39 proposes to enhance the Air District's air quality monitoring so as to better inform its efforts to improve air quality and reduce population exposure in impacted communities.

In reviewing measures based on the evaluation criteria described above, some measures were eliminated for the reasons shown in Table G-3.

Measures that are recommended for inclusion in the 2017 Plan fall into two categories:

- Measures incorporated in one of nine control measure categories:
    - Stationary Source
    - Transportation
    - Energy
    - Agriculture
    - Water
    - Waste
    - Buildings
    - Natural and Working Lands
    - Super-GHG Pollutants
- Further Study Measures: This category includes measures which appear to have merit but require more research and information to determine if they are viable for implementation. These measures will be further evaluated but are not proposed as formal control measures at this time.

Table G-3 indicates the outcome of the review of the 366 potential measures reviewed by Air District staff. Of the 366 control measures reviewed, 168 have been incorporated into the 85 control measures in the 2017 Plan. Totals in table do not match due to (1) duplication or overlap among the potential measures reviewed, (2) many of the proposed 2017 control measures incorporate multiple actions that have been combined within a single measure, or (3) multiple reasons were given for the rejection of a control measure.

Table G-3. Outcome of All Feasible Measures Review

Category	Category Definition	# of Measures
Already Implemented by the Air District		138
Already Implemented by Another Agency	Measures that have already been implemented through state, federal, or regional programs.	14
Measures Deemed Infeasible	De minimus or no sources exist in the Bay Area	3
	Not cost-effective	11
	Not publicly acceptable	1
	Not technologically feasible	3
	Not enforceable	22
	Other	9
	Subtotal: Measures deemed infeasible:	49
Total Potential Measures Incorporated into Draft Control Strategy		**168**
Included as Further Study Measures	Measures which meet some evaluation criteria but require further analysis to determine if they are potentially viable.	27

FOOTNOTES

[1] Air District staff and staff of the Metropolitan Transportation Commission collaborated in evaluating transportation control measures for the 2017 Plan.

APPENDIX H

EMISSION IMPACTS OF CONTROL STRATEGY

The proposed control strategy for the 2017 Plan consists of 85 distinct measures targeting a variety of local, regional and global pollutants. Some measures are expected to reduce the full set of air pollutants and greenhouse gases (GHGs), while others target a limited subset of pollutants. Table H-1 below lists these control measures by economic sector, and shows estimates of emission reductions where estimates could be made. For some measures, as explained in more detail below, emissions could not be estimated at this time. However, all proposed control measures are expected to reduce emissions of air pollutants and/or GHGs, either directly or indirectly, even if no specific emission reduction estimate can be provided at this time.

Estimated reductions in GHG emissions are listed in two columns, for both 100- and 20-year time horizons. The significance of these time horizons is described in the text below. Emission reduction estimates are shown as annual reductions achieved by a specific year (2030), as opposed to cumulative reductions over multiple years.

Table H-1. Emission Impacts from Control Measures

Control Measure No.	Control Measure Title	Estimated Emission Reductions[1]							Annual Dollar Benefits[3] (USD/yr)
		2030 Criteria Air Pollutants (lbs/day)					2030 Greenhouse Gases (MT CO_2e/yr)[2]		
		ROG	NO_X	$PM_{2.5}$[4]	SO_2	NH_3	100-yr time frame	20-yr time frame	
Agriculture Sector									
AG1	Agriculture Guidance and Leadership								
AG2	Diary Digesters								
AG3	Enteric Fermentation								
AG4	Livestock Waste	400							Low

(continued)

Table H-1. **Emission Impacts from Control Measures** *(continued)*

Control Measure No.	Control Measure Title	Estimated Emission Reductions[1]							Annual Dollar Benefits[3] (USD/yr)
		2030 Criteria Air Pollutants (lbs/day)					2030 Greenhouse Gases (MT CO_2e/yr)[2]		
		ROG	NO_X	$PM_{2.5}$[4]	SO_2	NH_3	100-yr time frame	20-yr time frame	
Buildings Sector									
BL1	Green Buildings	30	367	53	9		141,767	141,767	High
BL2	Decarbonize Buildings	54	635	98	34		313,586	313,586	High
BL3	Market-Based Solutions								
BL4	Urban Heat Island Mitigation	3	31	6	3		14,512	14,512	Medium
Energy Sector									
EN1	Decarbonize Electricity Production								
EN2	Decrease Electricity Demand								
Natural and Working Lands									
NW1	Carbon Sequestration in Rangelands						57,500	57,500	Medium
NW2	Urban Tree Planting								
NW3	Carbon Sequestration in Wetlands						90,000	90,000	Medium
Super-GHGs									
SL1	Super-GHGs						28,600	57,200	Medium
SL2	Guidance for Local Planners								
SL3	GHG Monitoring and Emissions Measurement Network								

(continued)

Table H-1. Emission Impacts from Control Measures *(continued)*

Control Measure No.	Control Measure Title	Estimated Emission Reductions[1]							Annual Dollar Benefits[3] (USD/yr)
		2030 Criteria Air Pollutants (lbs/day)					2030 Greenhouse Gases (MT CO_2e/yr)[2]		
		ROG	NO_X	$PM_{2.5}$[4]	SO_2	NH_3	100-yr time frame	20-yr time frame	
Stationary Source Sector									
SS1	Fluid Catalytic Cracking in Refineries			1,222		241			High
SS2	Equipment Leaks	4,546					340	860	Medium
SS3	Cooling Towers	4,720							Medium
SS4	Refinery Flares	60			90				Low
SS5	Sulfur Recovery Units				900				Medium
SS6	Refinery Fuel Gas				6,000				Medium
SS7	Sulfuric Acid Plants				2,800				Medium
SS8	Sulfur Dioxide from Coke Calcining				2,356				Medium
SS9	Enhanced NSR Enforcement for Changes in Crude Slate								
SS10	Petroleum Refining Emissions Tracking								
SS11	Petroleum Refining Facility-Wide Emission Limits								
SS12	Petroleum Refining Climate Impact Limits								
SS13	Oil and Gas Production, Processing and Storage						35,530	89,870	Medium
SS14	Methane from Capped Wells						19	47	Low

(continued)

Table H-1. Emission Impacts from Control Measures *(continued)*

Control Measure No.	Control Measure Title	Estimated Emission Reductions[1]							Annual Dollar Benefits[3] (USD/yr)
		2030 Criteria Air Pollutants (lbs/day)					2030 Greenhouse Gases (MT CO_2e/yr)[2]		
		ROG	NO_X	$PM_{2.5}$[4]	SO_2	NH_3	100-yr time frame	20-yr time frame	
***Stationary Source Sector** (continued)*									
SS15	Natural Gas Processing and Distribution						283,062	715,980	High
SS16	Basin-Wide Methane Strategy[5]								
SS17	GHG BACT Threshold								
SS18	Basin-Wide Combustion Strategy			604			1,600,000	1,600,000	High
SS19	Portland Cement				4,493		85,055	85,055	High
SS20	Air Toxics Risk Cap and Reduction from Existing Facilities								
SS21	New Source Review for Toxics								
SS22	Stationary Gas Turbines		1,500						Medium
SS23	Biogas Flares		572						Low
SS24	Sulfur Content Limits of Liquid Fuels								
SS25	Coatings, Solvents, Lubricants, Sealants and Adhesives								
SS26	Surface Prep and Cleaning Solvent								
SS27	Digital Printing								
SS28	LPG, Propane, Butane	5,000							Medium

(continued)

Table H-1. Emission Impacts from Control Measures *(continued)*

Control Measure No.	Control Measure Title	Estimated Emission Reductions[1]							Annual Dollar Benefits[3] (USD/yr)
		2030 Criteria Air Pollutants (lbs/day)					2030 Greenhouse Gases (MT CO_2e/yr)[2]		
		ROG	NO_X	$PM_{2.5}$[4]	SO_2	NH_3	100-yr time frame	20-yr time frame	
***Stationary Source Sector** (continued)*									
SS29	Asphaltic Concrete	400							Low
SS30	Residential Fan Type Furnaces		13,200						High
SS31	General PM Emission Limitation			300					High
SS32	Emergency Backup Generators						2	2	Low
SS33	Commercial Cooking Equipment			340					
SS34	Wood Smoke			60					Medium
SS35	PM from Bulk Material Storage, Handling and Transport, Including Coke and Coal			4					Low
SS36	PM from Track Out			360					High
SS37	PM from Asphalt Operations			175					High
SS38	Fugitive Dust			500					High
SS39	Enhanced Air Quality Monitoring								
SS40	Odors								
Transportation Sector									
TR1	Clean Air Teleworking	620	389	509			319,517	319,517	High
TR2	Trip Reduction Programs	41	24	10			20,066	20,066	Medium
TR3	Local and Regional Bus Service	3	2	2			1,536	1,536	Low

(continued)

Table H-1. Emission Impacts from Control Measures *(continued)*

Control Measure No.	Control Measure Title	Estimated Emission Reductions[1]							Annual Dollar Benefits[3] (USD/yr)
		2030 Criteria Air Pollutants (lbs/day)					2030 Greenhouse Gases (MT CO_2e/yr)[2]		
		ROG	NO_X	$PM_{2.5}$[4]	SO_2	NH_3	100-yr time frame	20-yr time frame	
Transportation Sector *(continued)*									
TR4	Local and Regional Rail Service	134	68	110			69,070	69,070	High
TR5	Transit Efficiency and Use	6	6	4			2,906	2,906	Low
TR6	Freeway and Arterial Operations	19	18	42			27,364	27,364	Medium
TR7	Safe Routes to Schools and Transit	0.39	0.25	0.33			203	203	Low
TR8	Ridesharing, Last Mile Connection	0.34	0.22	0.29			176	176	Low
TR9	Bicycle Access and Pedestrian Facilities	17	14	14			9,128	9,128	Medium
TR10	Land Use Strategies	43	27	35			22,275	22,275	Medium
TR11	Value Pricing	534	335	438			274,947	274,947	High
TR12	Smart Driving	825	518	677			425,247	425,247	High
TR13	Parking Policies	0.59	0.37	0.48			306	306	Low
TR14	Cars and Light Trucks	64	64	14			3,963	3,963	Medium
TR15	Public Outreach								
TR16	Indirect Source Review								
TR17	Planes								
TR18	Goods Movement								
TR19	Medium and Heavy Duty Trucks	44	362	10			138,306	138,306	Medium
TR20	Ocean Going Vessels		38						Low
TR21	Commercial Harbor Craft	0	29	2			1,313	1,313	Low

(continued)

Table H-1. Emission Impacts from Control Measures *(continued)*

Control Measure No.	Control Measure Title	Estimated Emission Reductions[1]							Annual Dollar Benefits[3] (USD/yr)
		2030 Criteria Air Pollutants (lbs/day)					2030 Greenhouse Gases (MT CO_2e/yr)[2]		
		ROG	NO_X	$PM_{2.5}$[4]	SO_2	NH_3	100-yr time frame	20-yr time frame	
***Transportation Sector** (continued)*									
TR22	Construction, Freight and Farming Equipment	1	59	2			1,931	1,931	Low
TR23	Lawn Care Equipment	2,835	315	630			21,854	21,854	Low
Waste Sector									
WA1	Landfills	400					233,308	590,132	High
WA2	Composting and Anaerobic Digesters	1,400				1,400	1,241	3,139	High
WA3	Green Waste Diversion	542					162,997	408,591	High
WA4	Recycling and Waste Reduction						45,185	72,838	Medium
Water Sector									
WR1	Limit GHGs from POTWs								
WR2	Support Water Conservation								
Total Estimated Emissions Reductions		**22,774**	**18,573**	**6,222**	**16,685**	**1,641**	**4,432,811**	**5,581,187**	

[1] Blank values in this table do not necessarily imply that there are no emission reductions associated with a given control measure. For a variety of reasons, it may not be possible to estimate reductions at this time. See the discussion in the text below for more details.

[2] This table presents GHG emission reductions estimated using both a 100-year and a 20-year timeframe. See the discussion in the text below for more details.

[3] The Annual Dollar Benefits column shows the estimated annual dollar value in a three tiered scale of avoided costs related to key health impacts (non-fatal heart attacks, asthma-related hospital visits, etc.), premature mortality, and the social cost of reducing greenhouse gases. Low is less than $1,000,000; Medium is between $1,000,000 and $10,000,000; High is greater than $10,000,000.

[4] In the Transportation Sector, PM2.5 includes diesel and non-diesel fine particulate matter.

[5] No GHG emission reductions are included for the measure SS16: Basin-Wide Methane Strategy to avoid double-counting. This measure proposes amending a general rule to serve as a stopgap for large methane leaks, while sector-specific regulations are developed. These sector-specific rules, which target the same GHG emissions, are assumed to be adopted and implemented by 2020. Please see short-term GHG reductions expected from this measure in the control measure text.

Approach to Quantification

Air District staff estimated emission reductions for control measures wherever possible, with the exception of many transportation measures, which were estimated by MTC staff. Estimating the emissions impacts of the control strategy is a challenging task, complicated by the fact that various control measures affect numerous emission sources, and a wide variety of implementation actions are employed. In addition, the outcome of certain implementation actions—such as pursuing partnerships and collaborations, promoting adoption of model ordinance and best practices by local agencies, legislative advocacy, and public outreach and education—are difficult to quantify. Because of these challenges, Air District staff opted to use conservative assumptions in estimating potential emission reductions.

In some cases, emission reductions could not be estimated, for different reasons, including:

- Emissions reductions could not be estimated for certain control measures or implementation actions because emissions factors and/or methodologies have not yet been developed.

- In the case of some regulatory measures, additional technical information and analysis is required and will occur during the rule development process.

- The level of uncertainty is too high to make realistic assumptions. For example, in the case of energy measure EN1 (Decarbonize Electricity Production) the potential emission reductions depend on many factors, such as how PG&E and other electricity providers will respond if the state adopts more ambitious renewable energy requirements, changes in rainfall patterns, etc.

- Many of the control measures in the 2017 Plan will help to support implementation of the state's AB 32 Scoping Plan, and have already been accounted for in the assumptions behind the GHG projections in Figure 3-9 in chapter 3. In order to avoid potential double-counting, no emission reductions have been claimed for measures that support the implementation of state policies or regulations unless additional (surplus) emission reductions can be clearly identified and attributed to Air District actions.

100-year vs. 20-year Time Horizons for GHGs

The concept of global warming potential (GWP) was developed by the Intergovernmental Panel on Climate Change (IPCC) as an index to evaluate the ability of individual greenhouse gases to trap heat in the atmosphere relative to CO_2 over a given time period. As stated in Chapter 3, this metric facilitates the comparison of global warming impacts from different GHGs by providing a means to express emissions from all GHGs in the same unit, CO_2-equivalent (CO_2e). To be consistent with current scientific practice, the Air District used a 100-year time horizon to develop GHG emissions inventory and projections, emission reduction estimates and corresponding graphs in the 2017 Plan. This time period works well for most of the proposed control measures in the 2017 Plan, where CO_2 is the primary climate pollutant of concern and is given a GWP value of 1. However, for some measures, it is more relevant and appropriate to use a shorter time horizon, such as when evaluating the impacts of measures that will reduce emissions of methane or other super-GHGs in the near-term. In these instances (e.g., SS15: Natural Gas Processing and Distribution), emission reductions have also been expressed using a 20-year time frame to highlight the much greater near-term benefit of actions to address super-GHGs that have a high GWP.

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FINAL 2017 CLEAN AIR PLAN

VOLUME 2

April 19, 2017

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SS1: Fluid Catalytic Cracking Units in Refineries

Brief Summary:
This control measure will reduce emissions of condensable particulate matter (PM) from fluid catalytic cracking units (FCCUs) at the four Bay Area refineries where these devices are operated, as well as precursors to the formation of secondary PM. These reductions will be achieved through Air District Regulation 6, Rule 5 (Rule 6-5), adopted in December 2015, ("Particulate Emissions from Refinery Fluidized Catalytic Cracking Units") and possible further amendments to this rule.

Purpose:
Reduce health impacts of fine PM from refinery FCCUs. FCCUs are large sources of fine PM (classified as $PM_{2.5}$ in Air District inventories) which is emitted both as filterable matter, and also as condensable gases which are not captured or detected with filters, but which condense into solid or liquid $PM_{2.5}$ after they are emitted from the FCCU and cool to ambient temperature. Secondary PM is formed in the atmosphere, not as a result of condensation, but as a result of a reaction between ammonia and both nitrogen oxides (NO_x) and sulfur oxides (SO_x). Rule 6-5 was adopted, and may be further amended, to address condensable PM and secondary PM from refinery FCCUs.

Source Category:
Stationary Source - petroleum refineries

Regulatory Context and Background:
An FCCU is a complex processing unit that cracks heavy oils from crude distillation units into lighter oils using a chemical reaction that is promoted by a powdered catalyst. The emissions from an FCCU come from the "regenerator" portion of the FCCU where used catalyst, that has become coated with coke during the cracking reaction, is heated to burn off the coke so that the catalyst may be reused. The FCCU emissions consist of the combustion emissions from this coke burn-off process. In the Bay Area, four of the five petroleum refineries operate an FCCU (Chevron, Shell, Tesoro, Valero). All four FCCUs are equipped with add-on particulate controls: three refineries use electrostatic precipitators (ESPs), while Valero operates a tertiary cyclone. ESPs and tertiary cyclones are expected to remove about 99 percent of filterable PM from the FCCU regenerator exhaust, although they are ineffective in removing the vapors that constitute condensable PM. Valero also operates a wet scrubber on its FCCU exhaust which probably provides significant condensable PM control. Ammonia occurs in the FCCU exhaust because it is added to promote the operation of ESPs, although it appears that excessive ammonia is being used.

District Regulation 6, Rule 1 (Rule 6-1) addresses filterable PM emissions from many sources, including FCCUs. However, the test methods used to monitor compliance with this rule only quantify filterable PM emissions, and are incapable of measuring condensable PM. Similarly, federal rules, NSPS Subpart J and NESHAP Subpart UUU, have PM emission limits for FCCUs that do not address condensable PM emissions because of monitoring limitations. In addition, because of the high exhaust temperature of an FCCU, it is unlikely that the opacity limits in Rule

6-1 and Subpart J constitute a limit on condensable PM emissions from FCCUs. Therefore, no federal or Air District regulation, or Air District permit condition, currently addresses condensable PM or secondary PM from refinery FCCUs.

In 2003, the South Coast AQMD adopted Rule 1105.1 to limit emissions of both filterable PM and ammonia from FCCUs. The ammonia limits were proposed because of ammonia's role in the formation of both condensable PM and secondary PM. Prior to the adoption of the Air District's Rule 6-5, Rule 1105.1 appeared to be the only air pollution rule in California to address either condensable PM or secondary PM from refinery FCCUs.

In December 2015, the Air District adopted Rule 6-5 to impose the same 10 ppmv ammonia emission limit as South Coast Rule 1105.1. Rule 6-5 allows a refinery, in lieu of compliance with the 10 ppmv limit, to perform an ammonia optimization study and to propose a higher ammonia limit that results in lower overall condensable PM emissions; this may be possible because ammonia, in addition to contributing to condensable and secondary PM formation, also promotes the capture of PM at ESPs.

Implementation Actions:
The Air District will:

- During development of Rule 6-5, the Air District began a program of testing Bay Area FCCUs for condensable PM emissions using a relatively new EPA test method (Method 202). This testing is expected to continue through 2016.
- During 2016 and 2017, the Air District will evaluate refinery progress in performing ammonia optimizations, as well as the results of Method 202 testing, to determine appropriate further actions. These may include limits on condensable PM emissions as well as limit on SO_2 emissions, or other measures.

Emission Reductions:

Pollutants*	2020	2030
$PM_{2.5}$	1,222	1,222
TACs	241	241

**criteria pollutants and TACs are reported in lbs/day*

Emission Reductions Methodology:
Implementation of this control measure is estimated to reduce condensable PM from FCCUs by approximately 50 percent. However, due to uncertainty in both the baseline emissions and the results of the ammonia optimization, the actual emissions reductions may differ from this estimate. Further reductions of $PM_{2.5}$ and other pollutants will be determined by specific implementation actions in a future amendment of Regulation 6-5.

Exposure Reductions:
Emissions from the Bay Area's five major oil refineries have been steadily decreasing over the past several decades, however, refineries are major sources of criteria air pollutants, TACs, and GHGs. Refineries are also located in impacted communities, including in Richmond. In October

2014, the Air District Board of Directors adopted a Refinery Emissions Reduction Resolution, which established a goal of reducing refinery criteria air pollutant emissions by 20 percent or as much as feasible by 2020. In response to that directive, the Air District has developed a Bay Area Refinery Emissions Reduction Strategy. The Refinery Strategy ensures that refineries are taking the strongest feasible steps to reduce emissions and minimize their health impacts on neighboring residents and the region as a whole. This measure is one of twelve control measures in the 2017 Plan that make up the Refinery Strategy. Specifically, Rule 6-5, as adopted in 2015, will achieve emission reductions of ammonia and a corresponding reduction of condensable PM2.5. Ammonia is a toxic air contaminant (TAC). Also, exposure to PM2.5 is by far the leading public health risk from air pollution in the Bay Area, accounting for more than 90 percent of premature mortality related to air pollution. Further emission reductions through a future amendment of Rule 6-5 will be estimated based on Method 202 emission testing that will be completed in 2016.

Emission Reduction Trade-Offs:
The ammonia emission limit in Rule 6-5 allowed an ammonia optimization option to prevent increases in overall PM emissions as a result of ammonia use reductions. Future amendments of Rule 6-5 must consider all of the pollutants emitted from FCCUs and ensure that emission limits that target $PM_{2.5}$ do not result in unintended emission increases of other pollutants.

Costs:
The cost of further reductions of $PM_{2.5}$ will depend on the specific future implementation actions proposed for Rule 6-5. However, there are expected to be cost-effective control options given that the costliest option in terms of capital cost – installation of a wet scrubber on the FCCU exhaust – has been demonstrated at several US refineries.

Co-Benefits:
Further reductions in condensable PM emissions are expected to result in reductions in secondary $PM_{2.5}$ formation.

Issue/Impediments:
None.

Sources:

1. South Coast AQMD: Final Staff Report, Rule 1105.1 ("Reduction of PM10 and Ammonia Emissions from Fluid Catalytic Cracking Units"), September 16, 2003.
2. Bay Area Air Quality Management District: Bay Area 2010 Clean Air Plan, Executive Summary, September 2010.
3. Bay Area Air Quality Management District: Final Staff Report, Petroleum Refinery Emissions Reduction Strategy, Appendix A (FCCUs), December 2015.

SS2: Equipment Leaks

Brief Summary:
This control measure would further reduce emissions of total organic gases (TOG) – including reactive organic compounds (ROG) and methane – from equipment leaks at petroleum refineries.

Purpose:
The purpose of this control measure is to achieve further reductions in fugitive emissions of total organic gases (including ROG, toxic organics, and methane) at refineries.

Source Category:
Stationary sources – petroleum refineries, chemical plants, bulk plants and bulk terminals.

Regulatory Context and Background:
Component leaks commonly occur at the joints or connections between sections of piping, at valves, at pumps or from barrier fluid contained between seals, and at leaking pressure relief devices (PRDs).

The Air District originally adopted Regulation 8, Rule 18 in 1980 and has amended it twice, first in 1992 and again in 2004. In addition, some minor changes were made to the rule in 1998 and 2002. The original intent of the rule was to control fugitive organic gas leaks from valves and connectors at refineries, chemical plants, bulk plants, and bulk terminals. Rule amendments adopted in 1992 significantly lowered the allowable leak concentration limits to the lowest levels in the country and required more effective inspection and repair programs in order to reduce emissions and promote self-compliance. The 1992 amendments reduced ROG emissions by an estimated 1,200 pounds/day.

The allowable leak standard is 500 parts per million volume (ppmv) for pumps, compressors, and PRDs.[1] For valves and other equipment, the allowable leak standard is 100 ppmv. Leaks are detected using a portable combustible gas indicator.

The U.S. Environmental Protection Agency (EPA) has promulgated leak detection and repair (LDAR) standards for facilities in the synthetic organic chemical manufacturing industry but not for petroleum refineries. The EPA's standards in 40 CFR parts 60 and 63 include LDAR provisions for monitoring and repairing equipment in heavy liquid service and do not rely on instrumental monitoring, but instead rely on "visual, audible, olfactory, or any other detection method."

Implementation Actions:
In December 2015, the Air District amended Rule 8-18. The Air District will develop an implementation plan for the Rule. The amendments strengthened the Rule through the

[1] PRDs are also subject to the requirements of Air District Regulation 8, Rule 28, *Episodic Releases from Pressure Relief Devices at Petroleum Refineries and Chemical Plants*.

following changes:

- Requiring future monitoring of equipment in heavy liquid service;
- Reducing the amount of equipment that can be added to the "non-repairable" equipment list;
- Addition of a maximum mass emission rate for fugitive equipment subject to the rule;
- Requiring facilities to identify the causes of background readings greater than 50 ppmv;
- Adding a maximum leak concentration and maximum mass emission rate for fugitive equipment placed on the "non-repairable" equipment list;
- Clarification of definitions; and
- Provisions for heavy liquid components will take effect on Jan 1, 2018.

Emission Reductions:

Pollutants*	2020	2030
ROG	4,546	4,546
CO_{2e}	340	340

**criteria pollutants are reported in lbs/day; CO_{2e} is reported in metric tons/year (100 yr GWP)*

Once in full effect, Regulation 8, Rule 18 is anticipated to reduce ROG emissions from the five Bay Area refineries by approximately 4,546 pounds per day. GHG emission reductions (340 MT CO_2e per year) are equivalent to 860 MT CO_2e per year, on a 20-year timeframe.

Emission Reductions Methodology:
The emissions reductions for this measure were conservatively estimated by only calculating reductions due to proposed inspection requirements for components in heavy liquid service at the five Bay Area refineries. The Air District has estimated the effect of these controls by relying upon a correlation equation method included in the EPA Protocol and the ARB Guidelines. The correlation equation method generally relies on measured leak concentration data. Instead of using actual measurements, the Air District further conservatively assumed that with the new inspection requirements for heavy liquid components, all would leak at the highest concentration allowed by the leak limits. Using this methodology, the estimated reductions of Total Organic Gas (TOG) emissions at the five Bay Area refineries would be 6,723 lbs per day. In order to be conservative, ROG emission reductions were then calculated as a portion of TOG emission reductions, based on engineering judgement and historical difference between TOG and ROG emission estimates at refineries.

Methane emission reductions, expressed as CO_2e, were estimated using the stricter leak detection limit in the rule, and conservatively assuming that methane represents a small percentage of emissions leaked from the components addressed by the regulation, since any methane-rich gas would be combusted at the refinery.

Emission Reduction Trade-Offs:
None

Costs:
Expansion of leak detection and repair program is anticipated to cost approximately $6.8 million per year (capital costs: $250,000).

Co-Benefits:
None identified.

Issue/Impediments:
There are thousands of additional equipment components in heavy liquid service that would be required to be identified and monitored under an expanded LDAR program. This would be a major undertaking for refineries. In addition, equipment in heavy liquid service is handled at an elevated temperature and may require special equipment to handle safely.

Sources:
1. Bay Area Air Quality Management District, Proposed Regulation 8, Rule 18: Equipment Leaks, December 16, 2015
2. EPA Method 21 – Determination of Volatile Organic Compound Leaks
3. Bay Area Air Quality Management District, staff report for Refinery Emissions Reduction Strategy, October 2015.

SS3: Cooling Towers

Brief Summary:
Petroleum refineries use cooling towers to return waste heat to the environment through the evaporation of water. Leaks in heat exchange systems can result in emissions of total hydrocarbons (THC) and, sometimes, toxic air contaminants (TACs). This control measure is intended to reduce THC and TAC emissions from cooling towers in petroleum refineries. The amendments to Air District Regulation 11, Rule 10, *Hexavalent Chromium Emissions from Cooling Towers* which has been renamed *Hexavalent Chromium from All Cooling Towers and Total Hydrocarbon Emissions from Petroleum Refinery Cooling Towers* were adopted by the Air District's Board of Directors on December 16, 2015.

Purpose:
To reduce THC and TAC emissions from cooling towers at Bay Area refineries by requiring more rapid detection and repair of leaking heat exchangers.

Source Category:
Stationary sources – petroleum refineries

Regulatory Context and Background:
The Bay Area has five large-scale petroleum refineries which operate a total of 34 cooling towers. These cooling towers are large, industrial heat exchangers that dissipate significant heat loads to the atmosphere through the evaporation of water. Process liquids, which often contain THC and sometimes TACs, may leak into cooling tower water and then be evaporated into the environment. The longer leaks go undetected and unrepaired, the greater the quantity of emissions.

The Air District developed Regulation 11, Rule 10 (Rule 11-10) in 1989 to eliminate the use of hexavalent chromium additives in cooling towers.

In 2009, US EPA promulgated, and, in 2013, amended, 40 CFR, part 63, subpart CC, National Emission Standards for Hazardous Air Pollutants from Petroleum Refineries (MACT CC). MACT CC requires periodic monitoring (monthly or quarterly) of heat exchangers in organic TAC service and requires repair of leaks as soon as is practicable (but no later than 45 days after detection).

Implementation Actions:
On December 16, 2015, the Air District Board of Directors adopted the following amendments to Rule 11-10, which went into effect July 1, 2016:

- Owners and operators of cooling towers at petroleum refineries will be required to install continuous THC monitors or test for THC in cooling water daily unless the APCO approves an alternative monitoring regime.
- The amended regulation establishes a THC concentration standard of 6 ppmv (by volume) for existing cooling towers and a 3 ppmv standard for new cooling towers when measured

in stripped air by a continuous analyzer. The THC concentration standard is 84 ppbw (by weight) when measured in cooling water.

- Refineries are required to minimize the leak within 5 calendar days and shall repair the leak within 21 days.

Because the scope of the regulation has increased, the title has been amended from "Hexavalent Chromium Emissions from Cooling Towers" to "Hexavalent Chromium Emissions from All Cooling Towers and Total Hydrocarbon Emissions from Petroleum Refinery Cooling Towers." Staff is preparing an implementation plan for the amended regulation.

Emission Reductions:

Pollutants*	2020	2030
ROG	4,720	4,720

**criteria pollutants are reported in lbs/day*

Exposure Reductions:
The Bay Area has five petroleum refineries which operate a total of 32 cooling towers, which are large, industrial heat exchangers used to dissipate significant heat loads to the atmosphere through the evaporation of water. This control measures would require more rapid detection of heat exchanger leaks. Based on the Air District's emissions inventory, the cooling towers collectively emit approximately 2.7 tons per day (TPD) of organic gases (978 tons per year), estimated using AP-42 emission factors for four of the refineries and emissions from water analysis data from the fifth refinery. The amended rule will require that the refineries ensure that total hydrocarbons in the cooling tower water do not exceed 84 ppbw (parts per billion weight). This 84 ppbw limit translates into an emission rate of 0.7 lbs of hydrocarbons emitted for every million gallons of recirculated water. Through this calculation, staff estimated that the overall THC emissions would be reduced by approximately 88 percent by these rule amendments.

Emission Reduction Trade-Offs:
None

Costs:
Air District staff expect the cost to implement the amended regulation to be in the range of $1-3 million per year divided among the five major Bay Area refineries, depending on the monitoring methods selected and the number of leaks that need to be repaired.

Co-Benefits:
A co-benefit of Rule 11-10 will be reduction of TAC emissions that are present in some process liquids.

Issue/Impediments:
None identified

Sources:

1. Bay Area Air Quality Management District, 2011 Base Year Emissions Inventory,
2. Bay Area Air Quality Management District, Petroleum Refinery Emissions Reduction Strategy: Staff Report, October 2015

SS4: Refinery Flares

Brief Summary:
The Air District's refinery flare monitoring Regulation 12, Rule 11 (Rule 12-11) has been in place since 2003, and the flare reduction Rule 12-11 has been in place since 2005. Air District staff will review the results of these rules at each of the five refineries in the Bay Area to identify amendments that may make the rules more effective at reducing emissions.

Purpose:
Reduce frequency and magnitude of flaring events, thereby reducing particulate matter (PM), black carbon, and unburned hydrocarbons that may occur during a significant flare event.

Source Category:
Permitted Point Sources – refinery flares

Regulatory Context and Background:
July 20, 2005, the Air District adopted Regulation 12, Rule 12 (Rule 12-12) to reduce flaring at the Bay Area's five oil refineries. The rule, the first of its kind in the nation, affected flares that were in operation at the time of the rules adoption. The rule was intended to reduce air pollution by minimizing flaring during normal operations. Flaring – the burning off of excess gases at refineries to prevent them from being vented directly into the atmosphere – would still be allowed when necessary to safely operate a refinery.

In June 2003, the Board adopted a flare monitoring rule which required refineries to monitor and report flare emission data to the Air District. By installing compressors to recover refinery gases and by instituting better operating practices, flare emissions have been reduced by 75 percent - from 1,600 pounds per day of total organic compounds, on average, to 400 pounds per day at the present time. The 2005 rule built on the 2003 rule by making the reductions permanent.

The 2005 rule requires that each refinery prepare a Flare Minimization Plan (FMP) that determines how best to further minimize flaring. Air District staff carefully reviews the plans for effectiveness and takes public comment on them. The FMPs must include:

- Detailed information about equipment and operating practices related to flares,
- Steps the refinery has taken and will take to minimize the frequency and duration of flaring, a schedule for implementation of all feasible flare prevention measures.

Plans must be approved by the Air District. The FMPs are updated annually to incorporate the latest technologies and practices.

Rule 12-12 also requires a causal analysis of flaring events involving the emission of more than 500,000 cubic feet of gases. Less significant events will also be included in a required annual report and feasible prevention measures will be incorporated into the FMPs. These evaluation processes will result in continuous improvement and management of major flaring events.

The entire structure of this rule relies on critical review of the causes of flaring so that effective corrective actions can be determined, and implemented. Without commitment to this process, flaring events and resulting emissions are not prevented to the degree they could be with such commitment.

Implementation Actions:
The Air District will:

- Propose amending Rule 12-12 to mirror the "breakdown" requirements in Regulation 1. This will allow both the Air District and the refineries to evaluate areas of opportunity to further reduce emissions from flares and to redefine flaring that should be allowed in the FMP.

Emission Reductions:

Pollutants*	2020	2030
ROG	60	60
SO_2	90	90

**criteria pollutants are reported in lbs/day*

Emissions Reductions Methodology:
Based on analysis of current emissions and operations at the five Bay Area refineries, staff estimates that more effective failure investigations and corrective actions at the refinery with the highest current emissions could reduce those emissions by approximately one-third, so that ROG would be reduced by about 60 lb/day and SO2 would be reduced by about 90 lb/day.

Exposure Reductions:
Emissions from the Bay Area's five major oil refineries have been steadily decreasing over the past several decades, however, refineries are major sources of criteria air pollutants, TACs, and GHGs. Refineries are also located in impacted communities, including in Richmond. In October 2014, the Air District Board of Directors adopted a Refinery Emissions Reduction Resolution, which established a goal of reducing refinery criteria air pollutant emissions by 20 percent or as much as feasible by 2020. In response to that directive, the Air District has developed a Bay Area Refinery Emissions Reduction Strategy. The Refinery Strategy ensures that refineries are taking the strongest feasible steps to reduce emissions and minimize their health impacts on neighboring residents and the region as a whole. This measure is one of twelve control measures in the 2017 Plan that make up the Refinery Strategy. Specifically, this measure will reduce exposure to toxic air contaminants, which hare included in smoke from flares.

Emission Reduction Trade-Offs:
None

Costs:
The work associated with conducting root cause failure analysis is typically done by existing refinery staff. Implementing preventive/corrective actions can be significant, and costly if refinery process units, infrastructure, or flare systems must be redesigned. However, these

costs are offset by the benefits of reducing costs associated with a refinery incident, fire damage, equipment repair and associated lost production.

Co-Benefits:
Improved production, less equipment damage, and potential for reduced methane emissions. Methane is typically a component of flared gas, but usually burns effectively at the flare tip. Very little quantitative information is available regarding unburned methane during flare events.

Issue/Impediments:
None, however, adequate follow up will be required to prevent recurrence.

Source:

1. http://www.baaqmd.gov/Divisions/Compliance-and-Enforcement/Refinery-Flare-Monitoring/Emissions.aspx

SS5: Sulfur Recovery Units

Brief Summary:
Each of the five Bay Area refineries operates one or more sulfur recovery units (SRUs) that produce marketable, elemental sulfur from gaseous sulfur compounds removed from petroleum feedstocks. SRUs in the Bay Area are subject to a 30-year old limit (both federal and Air District imposed via Rule 9-1) on sulfur dioxide (SO_2). This control measure is projected to reduce actual SO_2 emissions from sulfur recover units by about 68 percent based on current, achievable practices.

Purpose:
Reduce SO_2 emissions from SRUs at petroleum refineries.

Source Category:
Permitted Sources – petroleum refineries

Regulatory Context and Background:
Crude petroleum naturally contains some sulfur compounds. California crude oils typically contain between one and two percent sulfur by weight. Because gasoline, diesel fuel, and other refined petroleum products are required to contain sulfur in concentrations on the order of parts per million, this sulfur must be removed, most of it recovered in the SRU. Unrecovered sulfur is emitted, mostly as SO_2.

In 1983, the Air District established a 250 ppm limit on emissions of SO_2 from SRUs through Rule 9-1. The United States Environmental Protection Agency (U.S. EPA) subsequently established identical limits in its *Standards of Performance for Petroleum Refineries* and *Standards of Performance for Petroleum Refineries for which Construction, Reconstruction, or Modification Commenced after May 14, 2007*. The Air District's limit, however, applies to all SRUs regardless of the date of construction, reconstruction or modification.

In November, 2010, the South Coast Air Quality Management District (SCAQMD) published a staff report on the SO_2 limits of equipment subject to its Regional Clean Air Incentives Market (RECLAIM) program. SCAQMD found SO_2 limits of 10 ppm to be feasible through SRU and tail gas treating system process improvement, and SO_2 limits of 5 ppm to be achievable by installing wet caustic scrubbers[1]. However, cost effectiveness of wet caustic scrubbers sometimes exceeded $50,000 per ton of SO_2 removed. SCAQMD elected to establish a limit of 5 ppm for SRUs as part the RECLAIM cap-and-trade program.

A review of the Bay Area refineries' SRUs' emissions show that all of them easily attain the 250 ppm limit. Two of them already achieve the 10 ppm SO_2 limit. A third SRU has achieved a 10 ppm limit during a source test using existing equipment, though it normally emits SO_2 at about twice this rate. The two remaining refineries have SRUs that would require 75-85 percent emission reductions to attain the 10 ppm SO_2 limit.

[1] A wet caustic scrubber is a control method that removes a pollutant by bringing the polluted gas stream into contact with a caustic (or alkaline) scrubbing liquid.

Implementation Actions:
The Air District will:

- Consider amendments to Rule 9-1, *Sulfur Dioxide* to achieve the lowest SO_2 emission feasible through increased efficiency of sulfur recovery units and improved tail gas treatment (i.e., an SO_2 limit of 10 ppm).
- Consider amendments to Rule 9-1 to achieve the lowest SO_2 emission feasible through installation of wet caustic scrubbers (i.e., an SO_2 limit of 5 ppm).
- Review cost effectiveness and incremental cost effectiveness of controls required to achieve the SO_2 limits of 5 ppm and 10 ppm.

Emission Reductions:

Pollutants*	2020	2030
SO_2	900	900

**criteria pollutants are reported in lbs/day*

Emission Reductions Methodology:
Total SRU SO_2 emissions are estimated to be 1,400 lb/day. The total reduction of 900 lb/day was calculated by adding the estimated emissions reductions for each individual SRU. These individual SRU emissions reductions were estimated by first determining the current tail gas SO_2 concentration and current emissions, calculating the percentage concentration decrease that would be needed to meet the 5 ppm SO_2 limit, and applying that percentage reduction to the current emissions.

Exposure Reductions:
Emissions from the Bay Area's five major oil refineries have been steadily decreasing over the past several decades, however, refineries are major sources of criteria air pollutants, TACs, and GHGs. Refineries are also located in impacted communities, including in Richmond. In October 2014, the Air District Board of Directors adopted a Refinery Emissions Reduction Resolution, which established a goal of reducing refinery criteria air pollutant emissions by 20 percent or as much as feasible by 2020. In response to that directive, the Air District has developed a Bay Area Refinery Emissions Reduction Strategy. The Refinery Strategy ensures that refineries are taking the strongest feasible steps to reduce emissions and minimize their health impacts on neighboring residents and the region as a whole. This measure is one of twelve control measures in the 2017 Plan that make up the Refinery Strategy.

Costs:
There is considerable uncertainty in the cost of control as emission reductions can result from efficiency improvements within the unit itself, from a variety of proprietary tail gas treatment technologies, or the addition of add-on control equipment (e.g., wet caustic scrubbers).

Co-Benefits:
There will be less secondary $PM_{2.5}$ formation from reduced sulfates.

Issue/Impediments:
None

Sources:

1. Code of Regulations, Title 40, part 60, subpart J, *Standards of Performance for Petroleum Refineries* [54 FR 34031, August 17, 1989, as amended at 55 FR 40178, Oct. 2, 1990]
2. Code of Regulations, Title 40, part 60, subpart Ja, *Standards of Performance for Petroleum Refineries for which Construction, Reconstruction, or Modification Commenced after May 14, 2007* [77 FR 56480, September 12, 2012]
3. *California Crude Oil Production and Imports*, Margaret Sheridan, Fossil Fuels Office, Fuels and Transportation Division, California Energy Commission, April, 2006
4. SCAQMD Rule 2002: RECLAIM
5. SCAQMD, Final Staff Report: SOx RECLAIM, Part 1, BARCT Assessment & RTC Analysis, November 2, 2010

SS6: Refinery Fuel Gas

Brief Summary:
The lightest components of crude oil separated by a refinery's atmospheric fractionator are methane and ethane, which are also the primary components of natural gas. These products, along with gases produced at other refinery process units, commonly called refinery fuel gas (RFG), are used as fuel in steam generators, process heaters, and other combustion units. Because RFG contains naturally occurring sulfur compounds, it produces sulfur dioxide (SO_2) as a combustion byproduct.

Purpose:
Reduce SO_2 emissions from RFG combustion at petroleum refineries.

Source Category:
Permitted Sources - petroleum refineries

Regulatory Context and Background:
RFG can contain between a few hundred and a few thousand parts per million-volume (ppmv) sulfur in the form of hydrogen sulfide (H_2S) and organic sulfur compounds, such as mercaptans. During combustion, the sulfur in all of these compounds will oxidize to form SO_2, which is a criteria air pollutant and a precursor to particulate matter. Scrubbing with an amine solution can be effective at removing H_2S and some acidic sulfur containing compounds, but is generally ineffective at removing nonacidic sulfur compounds. Hydrotreating, a catalytic chemical process, converts these sulfur compounds to hydrogen sulfide which can then be removed by scrubbing.

In 1990, the Air District modified Regulation 9, Rule 1: *Sulfur Dioxide*, requiring all refineries that process more than 20,000 barrels per day of crude oil to operate a sulfur removal and recovery system that removes and recovers, on a refinery wide basis, 95 percent of the H_2S from RFG.

In 2008, the United States Environmental Protection Agency (EPA) promulgated 40 CFR part 60, subpart Ja, *Standards of Performance for Petroleum Refineries for which Construction, Reconstruction, or Modification Commenced after May 14, 2007*. The regulation limits H_2S concentration in combustion units to 162 ppmv, determined hourly on a three-hour rolling average, and to 60 ppmv, determined daily on a 365-day rolling average. Alternatively, refiners can choose to comply with post-control SO_2 emission limits of 20 parts per million- volume, dry (ppmvd), determined hourly on a three-hour rolling average, and 8 ppmvd, determined daily on a 365-day rolling average, with all SO_2 concentrations corrected to 0 percent oxygen.

The South Coast Air Quality Management District's (SCAQMD) Rule 431.1 limits the sulfur content of RFG, calculated as H_2S, to 40 ppmv, four-hour average. The initial compliance date was May 4, 1994 for large refineries and May 4, 1996 for small refineries. SCAQMD allows facilities to demonstrate equivalent SO_2 emission reductions within the facility, provided alternative plans have been approved by the Executive Officer in writing.

All of the major refineries in the Bay Area are complying with federal limits for H_2S, but two of them combust RFG with elevated levels of organic sulfur compounds in some or all of their combustion units.

Implementation Actions:
The Air District will:

- Consider amendments to Rule 9-1, *Sulfur Dioxide*, that would reduce fuel sulfur limits for RFG and determine the appropriate averaging periods.

Emission Reductions:

Pollutants*	2020	2030
SO_2	6,000	6,000

**criteria pollutants and TACS are reported in lbs/day*

Emission Reductions Methodology:
Total RFG SO_2 emissions are estimated to be 8,600 lb/day. RFG sulfur processing and removal is linked with nearly all refinery processes, and improved sulfur removal is typically implemented with other refinery modifications. To estimate potential emission reductions, sets of improvements that reduce sulfur in RFG were developed for the two refineries which currently combust RFG with elevated levels of organic sulfur compounds. The estimated reduction of 6,000 lb/day is based on those improvements.

Exposure Reductions:
Emissions from the Bay Area's five major oil refineries have been steadily decreasing over the past several decades, however, refineries are major sources of criteria air pollutants, TACs, and GHGs. Refineries are also located in impacted communities, including in Richmond. In October 2014, the Air District Board of Directors adopted a Refinery Emissions Reduction Resolution, which established a goal of reducing refinery criteria air pollutant emissions by 20 percent or as much as feasible by 2020. In response to that directive, the Air District has developed a Bay Area Refinery Emissions Reduction Strategy. The Refinery Strategy ensures that refineries are taking the strongest feasible steps to reduce emissions and minimize their health impacts on neighboring residents and the region as a whole. This measure is one of twelve control measures in the 2017 Plan that make up the Refinery Strategy.

Emission Reduction Trade-Offs:
None

Costs:
Because sulfur processing and removal is linked with nearly all refinery processes, costs are difficult to estimate. If improved sulfur removal is combined with other refinery upgrades (e.g. propane and butane recovery or processing sweeter crudes), there could be revenue enhancements and a net cost reduction. Without increased revenue, the two refineries with elevated levels of organic sulfur compounds in their RFG could see net costs in the range of $1-3 million per year. The other refineries could see more modest costs to improve refinery processes depending on the form of the final rule.

Co-Benefits:
There will be less secondary $PM_{2.5}$ formation from reduced sulfates.

Issue/Impediments:
None

Sources:

1. Regulation 9, Rule 1, Sulfur Dioxide, last modified March 15, 1995
2. 40 CFR part 60, subpart J, *Standards of Performance for Petroleum Refineries* [54 FR 34031, August 17, 1989, as amended at 55 FR 40178, Oct. 2, 1990]
3. 40 CFR part 60, subpart Ja, *Standards of Performance for Petroleum Refineries for which Construction, Reconstruction, or Modification Commenced after May 14, 2007* [77 FR 56480, September 12, 2012]
4. SCAQMD Rule 431.1: Sulfur Content of Gaseous Fuels, amended June 12, 1998

SS7: Sulfuric Acid Plants

Brief Summary:
Sulfuric acid is used as a catalyst in alkylation units at petroleum refineries. Over time, sulfuric acid is contaminated with petroleum products and needs to be regenerated.

The first step in the process is thermal decomposition of spent sulfuric acid in a furnace, producing sulfur dioxide (SO_2). The catalytic reaction oxidizing SO_2 to SO_3 (which then reacts with water to form fresh sulfuric acid) is an equilibrium reaction which is never 100 percent efficient. As a result, there is always some unreacted SO_2 that is vented to the atmosphere.

There are three acid plants associated with Bay Area refineries. The Tesoro Refinery near Martinez operates an acid plant; Eco Services in Martinez operates an acid plant as a support facility for the Shell and Valero refineries on a regular basis and serves as a backup facility for the Tesoro Refinery when Tesoro's acid plant is shut down; and Chemtrade West in Richmond operates an acid plant as a support facility for Chevron Products.

Purpose:
Reduce SO_2 emissions from sulfuric acid regeneration associated with petroleum refining.

Source Category:
Permitted Sources – sulfuric acid plants

Regulatory Context and Background:
In 1977, the United States Environmental Protection Agency (EPA) promulgated 40 CFR part 60, subpart H, *Standards of Performance for Sulfuric Acid Plants*. The regulation limits SO_2 emissions to 4 pounds per ton of acid produced and limits sulfuric acid mist emissions to 0.15 pounds per ton of acid produced. Air District Regulation 9, Rule 1 (Rule 9-1) establishes emission limits for sulfur dioxide from all sources including ships, and limits ground level concentrations of sulfur dioxide. In 1992, the Air District amended Rule 9-1, establishing an SO_2 emission limit of 300 parts per million-volume (ppmv) for sulfuric acid plants, calculated at 12 percent oxygen.

In 2007, Rhodia, Inc. entered into a consent decree with EPA and the United States Department of Justice limiting SO_2 emissions from the acid plant (now operated by Eco Services) to 2.2 pounds per ton of 100 percent sulfuric acid produced, 365-day average, and 3.0 pounds per ton of 100 percent sulfuric acid produced, three-hour average.[1]

In their November 2010, RECLAIM Report, South Coast Air Quality Management District (SCAQMD) staff recommended a limit of 0.14 lbs per ton of acid produced (10 ppmv), which was adopted by SCAQMD.

[1] This was part of a nation-wide consent decree and was not limited to the Martinez acid plant.

A review of EPA's RACT/BACT/LAER Clearinghouse[2] (RBLC) revealed a 2006 synthetic minor permit from New Jersey with an SO_2 limit of 0.2 lbs per ton of acid produced and a 2012 PSD permit from Indiana with an SO_2 BACT limit of 0.25 lbs per ton of acid produced, 24-hour average.

The New Jersey Department of Environmental Protection provided the Air District with two recent source test reports for the facility in Union County, New Jersey with the 0.2 pound per ton limit. The State of New Jersey confirmed that the facility was in compliance with its emission limits.

Implementation Actions:
Consider amendments to Rule 9-1, *Sulfur Dioxide*, that would limit SO_2 emissions from acid plants associated with petroleum refining. Consider establishing BARCT limits of 0.2 lbs. of acid mist per ton of acid produced.

Emission Reductions:

Pollutants*	2020	2030
SO_2	2,800	2,800

**criteria pollutants are reported in lbs/day*

Emission Reductions Methodology:
Total Acid Plant SO_2 emissions are estimated to be 3,300 lb/day. The total reduction of 2,800 lb/day was calculated by adding the estimated emissions reductions for each acid plant. These emissions reductions were estimated by first determining the current SO_2 outlet concentration and current emissions, calculating the percentage concentration decrease that would be needed to meet the 10 ppm SO_2 limit, and applying that percentage reduction to the current emissions.

Exposure Reductions:
Emissions from the Bay Area's five major oil refineries have been steadily decreasing over the past several decades, however, refineries are major sources of criteria air pollutants, TACs, and GHGs. Refineries are also located in impacted communities, including in Richmond. In October 2014, the Air District Board of Directors adopted a Refinery Emissions Reduction Resolution, which established a goal of reducing refinery criteria air pollutant emissions by 20 percent or as much as feasible by 2020. In response to that directive, the Air District has developed a Bay Area Refinery Emissions Reduction Strategy. The Refinery Strategy ensures that refineries are taking the strongest feasible steps to reduce emissions and minimize their health impacts on neighboring residents and the region as a whole. This measure is one of twelve control measures in the 2017 Plan that make up the Refinery Strategy.

[2] The RBLC is a national database of case-by-case emission limitations made by permitting authorities when authorizing new sources of air pollution.

Emission Reduction Trade-Offs:
None

Costs:
BARCT limits of 0.2 lbs per ton of acid produced will require wet scrubbers at each of the three acid plants. One acid plant already has a wet scrubber, but it may need to be upgraded or replaced to meet the new standards. Capital costs are estimated at $7,000,000 for each facility, amortized to $700,000 annually. Operating costs are estimated at $200,000 per year at two facilities, and $300,000 per year for the third (higher caustic costs for higher SO_2 reductions). Total costs are $2,800,000 per year.

Co-Benefits:
There will be less secondary $PM_{2.5}$ formation from reduced sulfates.

Issue/Impediments:
None

Sources:

1. 40 CFR part 60, subpart H, *Standards of Performance for Sulfuric Acid Plants* [42 FR 37936, July 25, 1977]
2. South Coast Air Quality Management District, Final Staff Report: Sox RECLAIM, Part 1, BARCT Assessment & RTC Analysis, November 2, 2010
3. US Environmental Protection Agency, RACT/BACT/LAER Clearinghouse (RBLC) Clean Air Technology Center
4. Bay Area Air Quality Management District, Regulation 9: Rule 1, *Inorganic Gaseous Pollutants: Sulfur Dioxide*, last amended March 1995

SS8: Sulfur Dioxide from Petroleum Coke Calcining

Brief Summary:
This control measure will limit emissions of sulfur dioxide (SO_2) from petroleum coke calcining by requiring that emission controls at coke calcining kilns remove an equivalent of 59 percent of the SO_2 created by the calcining process. These reductions will be achieved through Air District Regulation 9, Rule 14 (Rule 9-14), adopted in April 2016.

Purpose:
Reduce SO_2 and particulate matter emissions.

Source Category:
Stationary source – petroleum coke calcining operations

Regulatory Context and Background:
The Air District is a nonattainment area for the California PM_{10} and $PM_{2.5}$ clean air standards and for the national $PM_{2.5}$ standards. Particulate matter (PM) comes from natural sources (dust, sea salt), motor vehicles (mostly diesel soot), and industrial sources (catalyst emissions from refineries, black carbon from power plants). Particulates can also form in the air from reaction of ammonia with NO_X and sulfur oxides (SO_X). Exposure to PM pollution has the greatest health impact because the smallest particles can penetrate deep into the lungs, causing damage to lung tissue. The finest of these particles can penetrate through lung tissue into the bloodstream causing a large variety of health issues such as aggravating existing heart disease.

SO_2 is a pungent-smelling gas commonly formed from the burning of fossil fuel materials that contain sulfur, such as coal or oil, and from certain industrial processes, such as petroleum refining, chemical production, and metal smelting. It is also released from natural sources such as volcanoes, geothermal hot springs and wildfires.

Once emitted into the atmosphere, SO_2 reacts with chemicals in the air, such as ozone, or in the presence of water to form sulfuric acid and eventually reacts with ammonia in the air to form ammonium sulfate, a component of $PM_{2.5}$.

Two coke calcining kilns at the Bay Area's only petroleum coke calcining facility emit a total of 4.0 tons per day of sulfur dioxide when the Carbon Plant is fully operational. Air District staff has investigated more stringent SO_2 limits at coke calcining facilities. The Carbon Plant currently operates a dry sorbent injection abatement device to control SO_2 emissions to maintain compliance with the current SO_2 limit in Regulation 9, Rule 1 (Rule 9-1) of 400 ppm by volume or 113 kg (250 pounds) per hour, whichever is more restrictive. The Carbon Plant as well as Air District staff have source tested the calcining operation and have determined that the Carbon Plant currently reduces SO_2 emissions, on average, by approximately 42 percent overall, which is higher than previously known. The South Coast AQMD and San Luis Obispo County APCD both require a minimum of 80 percent SO_2 control, which is more restrictive than the Air District's current requirements.

An analysis of the impact of an 80 percent SO_2 control showed a significant impact on the Bay Area's Carbon Plant. Therefore, the Air District adopted Rule 9-14: Coke Calcining Operations which would allow for a mass emission limit of 1,050 tons per year (tpy) which is equivalent to 59 percent control in a typical year. This emission limit is a combined limit for both kilns. Staff anticipates this mass emission standard will realize an SO_2 emission reduction of 430 tpy. The rule also proposes an hourly limit of 320 pounds per hour for the combined SO_2 emissions from both kilns.

Implementation Actions:

The Air District will:

- Ensure that both of the Carbon Plant's kilns comply with the SO_2 pounds per hour emission limit by January 1, 2019.
- Ensure that both kilns comply with the tons per year emission limit by January 1, 2020.

Emission Reductions:

Pollutants*	2020	2030
SO_2	2,356	2,356

**criteria pollutants are reported in lbs/day*

Emission Reductions Methodology:

The estimated emissions reduction is equal to the difference between the carbon plant's average emission rate and the new emission limit created by this rule.

Exposure Reduction:

Emissions from the Bay Area's five major oil refineries have been steadily decreasing over the past several decades, however, refineries are major sources of criteria air pollutants, TACs, and GHGs. Refineries are also located in impacted communities, including in Richmond. In October 2014, the Air District Board of Directors adopted a Refinery Emissions Reduction Resolution, which established a goal of reducing refinery criteria air pollutant emissions by 20 percent or as much as feasible by 2020. In response to that directive, the Air District has developed a Bay Area Refinery Emissions Reduction Strategy. The Refinery Strategy ensures that refineries are taking the strongest feasible steps to reduce emissions and minimize their health impacts on neighboring residents and the region as a whole. This measure is one of twelve control measures in the 2017 Plan that make up the Refinery Strategy.

Emission Reductions Trade-offs:

None identified.

Costs:

Air District staff has estimated that it will cost between \$4 and \$5 million to upgrade the existing SO_2 controls system to meet the requirements of Rule 9-14. Under the Air District's standard method for distributing one-time capital costs over the life of the equipment, that translates to an annual cost of \$680,000/year. Another significant cost is the purchase of dry sorbent material to react with the SO_2 in the process stream and to convert it to an inert solid that is captured in the existing particulate matter control system. Based on cost quotes from a sorbent supplier, Air District staff estimates these costs to be $500 per ton of additional sorbent.

In summary, the estimated annual cost for the Carbon Plant to improve their current Dry Sorbent Injection (DSI) system to comply with the 1,050 tpy emission requirement in Rule 9-1 is approximately $1.87 million.

Issues/Impediments:
None identified.

Sources:

1. South Coast AQMD Rule 1119: Petroleum Coke Calcining Operations – Oxides of Sulfur.
2. San Luis Obispo County Air Pollution Control District Rule 440: Petroleum Coke Calcining and Storage Operations.
3. South Coast AQMD November 2010 SO_X Reclaim BARCT Assessment Staff Report.
4. Applied Development Economics October 2015 Socioeconomic Analysis of Carbon Plant and draft Regulation 9 Rule 14.
5. Bay Area Air Quality Management District, Draft Staff Report: Proposed Regulation 9, Rule 14: Petroleum Coke Calcining Operations, January 2016.

SS9: Enhanced NSR Enforcement for Changes in Crude Slate

Brief Summary:
This measure would enhance the Air District's New Source Review (NSR) permit program to ensure that refineries are complying with all applicable NSR permit requirements when they change the type of crude oil they process, i.e. changes to the crude slate. This requirement would compel refineries to submit a permit application providing details of any significant change in crude slate, which would allow the Air District to review the change and determine whether it is subject to NSR requirements. Requiring a review of all such significant crude slate changes will allow the Air District to evaluate such changes in detail and ensure that they will comply with applicable NSR permitting requirements.

Purpose:
To ensure compliance with NSR program requirements.

Source Category:
Stationary Source – petroleum refineries

Regulatory Context and Background:
The Air District's NSR program is a comprehensive air permitting program that applies to a wide range of stationary source facilities within the Air District's regulatory jurisdiction. The program requires a facility to obtain a permit and implement state-of-the-art air pollution control technology whenever a facility installs a new source of air emissions or makes a modification to an existing source.

The Air District's NSR program is set out in Regulation 2, Rule 2 (Rule 2-2) and is the Air District's fundamental permitting requirement for regulating criteria pollutant emissions. It requires facilities to obtain an NSR permit for any new or "modified" source of air emissions, and to satisfy a number of air pollution control requirements in order to be eligible for the permit. [1] These requirements vary somewhat depending on the pollutant involved, being somewhat more stringent for pollutants for which the region is not in attainment of the applicable ambient air quality standards (non-attainment pollutants) and somewhat less stringent for pollutants for which the region is in attainment of the applicable ambient air quality standards (attainment pollutants).

This control measure is designed to ensure that refineries comply with applicable NSR permitting requirements when they change the types of crude oil – known as the refinery's

[1] "Modified source" is defined in Regulation 2-1-234 as (i) any physical change, change in the method of operation, increase in throughput or production, or other similar change to a source that will result in an increase in the source's permitted emissions (or for "grandfathered" sources that are not subject to any permit limits, in increase in the source's physical capacity to emit air pollutants); or (ii) for sources at "major" facilities, which includes all Bay Area refineries, any change that will result in a "significant" increase in the source's actual emissions as defined in EPA's federal NSR regulations.

"crude slate" - that they process.[2] Concerns have been raised that refineries may be making changes associated with moving to new crude oil slates that are subject to NSR permitting requirements, but without obtaining NSR permits or complying with the substantive requirements of the NSR program. A situation could arise where a refinery makes a physical change or change in its method of operations associated with a change in crude slate that meets the definition of a "modification" and would thus require the refinery to obtain an NSR permit under Rule 2-2 and implement the NSR program requirements before making the change. If a refinery makes such a "modification" associated with crude slate changes without applying for or obtaining an NSR permit, it may be difficult or impossible for the Air District (and the public) to discover that the modification was made. Refineries are large, complex operations, and any modifications associated with crude slate changes may be relatively subtle and not immediately obvious.

In 2000, the Air District added the term "alteration" in Regulation 2, Rule 1 (Rule 2-1) Section 233, defined as a change at a source that does *not* increase emissions and is therefore not a "modification" (i.e., a change that does increase emissions). Rule 2-1 Section 301 requires facilities to obtain a permit before making either an "alteration" or a "modification," and so a permit is required for all such changes, whether they increase emissions (a modification) or do not increase emissions (an alteration). In this manner, *all* changes at a facility that may impact emissions require a permit review, which allows the Air District to determine whether or not they are subject to NSR requirements.

Air District staff is investigating potential amendments to Rule 2-1 to expand the definition of "alteration" to include any significant crude slate change at a petroleum refinery. A crude slate change that increases emissions would be a "modification," and a crude slate change that does not increase emissions would be an "alteration." In both cases the refinery would need to obtain a permit before making the change. If the refinery believes that the crude slate change will involve an emissions increase (i.e., will be a "modification"), it can apply for an NSR permit and implement the NSR requirements as it would for any other modification. If the refinery believes that the crude slate change will not involve an emissions increase (i.e., will be an "alteration"), it can apply to have the change permitted as an alteration, which is not subject to NSR. The Air District will then review the application to determine whether there will in fact be any emissions increase or not. If the Air District confirms that there will not be any increase, it will issue a permit and authorize the change as an alteration. If the Air District finds that there will be an increase, however, it will require the change to be treated as a modification and will require the refinery to implement the NSR requirements as a condition to making the crude slate change.

[2] The term "crude slate" refers to the mix of crude oil types that a refinery processes, and it reflects various characteristics of the crude oil such as sulfur content and density. The crude slates being refined by Bay Area refineries have been changing recently, and they are expected to continue to change in the future as California's crude oil resources in the Central Valley start to become depleted and refineries look to other sources of crude oil.

Implementation Actions:
The Air District would revise the definition of "alteration" in Rule Section 2-1-233 to clarify that any significant crude slate change is an alteration, such that refineries will need to obtain Air District approval before making such a change. The approval process will allow the Air District to review the change and determine whether it is subject to NSR permitting requirements, and if so, to ensure compliance with any applicable NSR requirements.

Emission Reductions:
This proposed revision is primarily aimed at improving compliance with and enforcement of the Air District's NSR program; it is difficult to quantify the extent of any additional emission reductions associated with such revisions. In situations where a refinery making a crude slate change would have complied with all NSR permitting requirements anyway, the proposed amendment would have essentially no impact. If refineries are making crude slate changes subject to NSR without complying with the regulations, then better enforcement to require the refineries to implement these requirements - as called for in this measure - will have substantial emission reduction benefits.

Exposure Reductions:
Emissions from the Bay Area's five major oil refineries have been steadily decreasing over the past several decades, however, refineries are major sources of criteria air pollutants, TACs, and GHGs. Refineries are also located in impacted communities, including in Richmond. In October 2014, the Air District Board of Directors adopted a Refinery Emissions Reduction Resolution, which established a goal of reducing refinery criteria air pollutant emissions by 20 percent or as much as feasible by 2020. In response to that directive, the Air District has developed a Bay Area Refinery Emissions Reduction Strategy. The Refinery Strategy ensures that refineries are taking the strongest feasible steps to reduce emissions and minimize their health impacts on neighboring residents and the region as a whole. This measure is one of twelve control measures in the 2017 Plan that make up the Refinery Strategy.

Emission Reduction Trade-Offs:
None identified at this time.

Costs:
This measure would entail compliance costs, however, they would not be new costs imposed by additional regulations; they are simply existing compliance costs. These costs may be viewed as "additional" by refineries if they have not been complying with existing regulations, and therefore incurring compliance costs of the existing regulation. The extent of any such compliance costs is unknown, given that the scope of any such non-compliance is unknown.

Co-Benefits:
None.

Issue/Impediments:
None.

SS10: Petroleum Refining Emissions Tracking

Brief Summary:
On April 20, 2016, the Air District Board adopted Regulation 12, Rule 15 (Rule 12-15). The regulation includes provisions to: 1) improve petroleum refinery emissions inventories of criteria pollutants, toxic air contaminants (TACs) and greenhouses gases (GHGs), 2) collect volume and composition data on crude oil and other feedstocks processed by refineries, and 3) expand refinery fenceline air monitoring. The improved emission inventory requirement also applies to five refinery support facilities.

Purpose:
The purpose of this control measure is to implement Rule 12-15; to improve the quality of refinery air emissions data, so that the public may be better informed, and to better inform future rulemaking efforts. Rule 12-15 itself does not include emission limits or trigger levels for emission mitigation actions, although the information provided through implementation of Rule 12-15 could lead to emission limits or emission mitigation triggers in separate, future rulemaking.

Source Category:
Stationary sources – petroleum refineries

Regulatory Context and Background:
A petroleum refinery is an industrial facility that converts crude oil into gasoline, diesel fuel, heating oil, lubricating oil, and other products. The Bay Area has five large-scale petroleum refineries that rank among the ten largest sources of air pollution in the air basin and are classified as major sources of criteria pollutants, toxic air contaminants, and greenhouse gases. As a result, the refineries are subject to Air District major source permitting requirements to operate, as well as when constructing or modifying operations.

Numerous federal, state, and local regulations apply emission limits and associated monitoring, record keeping, and reporting requirements to owners and operators of equipment commonly found at petroleum refineries including:

- Federal standards under 40 CFR parts 60 and 63 that apply to storage tanks, combustion equipment, equipment leaks, wastewater treatment plants, sulfuric acid plants, sulfur recovery units, flares, and common refinery process units;
- State Air Toxics Control Measures that apply to combustion units; and
- Air District Rules that apply to storage tanks, combustion equipment, equipment leaks, wastewater treatment plants, sulfur dioxide emissions, hydrogen sulfide emissions, flares, and other common refinery process units.

In addition, petroleum refineries are required under 40 CFR part 98 to report greenhouse gas emissions annually to the federal government and by California’s Mandatory Reporting Rule to report greenhouse gas emissions annually to the State of California.

Implementation Actions:
Air District staff will prepare an implementation plan to identify required actions and deadlines for both refineries and responsible District staff. New Rule 12-15 requires refineries to:

- Prepare reports of emissions of criteria pollutants, toxic air contaminants, and greenhouse gases from the refinery (refineries and certain refinery support facilities),
- Generate a crude slate report describing the characteristics of crude oil and imported feedstocks processed by the refinery, and
- Develop air monitoring plans and install and operate fenceline air monitoring systems.

Emission Reductions:
None. Rule 12-15 is intended to provide information rather than reduce emissions.

Exposure Reductions:
Rule 12-15 is intended to provide information rather than reduce emissions.

Emission Reduction Trade-Offs:
None.

Costs:
According to the socioeconomic study prepared for Rule 12-15, the costs associated with this rule include:

- $315,000 per refinery, per year for 10 years as the annualized cost of preparing Air Monitoring Plans and installing fence-line air monitors, and
- $140,000 per refinery, each year, for new emissions inventories and crude/feedstock reports, and operation and maintenance of air monitoring systems.

Co-Benefits:
Increased transparency and tracking of refining emissions.

Issue/Impediments:
None.

Sources:

1. Regulation 12, Rule 15: Petroleum Refining Emissions Tracking, April 20, 2016.
2. Socioeconomic Analysis of Proposed Regulation 12, Rule 15, prepared for Bay Area Air Quality Management District, Applied Development Economics, Inc., March, 2016.

SS11: Petroleum Refining Facility-Wide Emissions Limits

Brief Summary:
This control measure would limit facility-wide emissions of greenhouse gases (GHG) and three criteria air pollutants - particulate matter (PM), oxides of nitrogen (NO_X), and sulfur dioxide (SO_2) - from Bay Area petroleum refineries through Air District Regulation 12, Rule 16.

Purpose:
The purpose of this control measure is to prevent increases of GHG and certain criteria air pollutant emissions that could result from operational changes at Bay Area refineries in order to protect the climate, and the region's air quality.

Source Category:
Stationary sources – petroleum refineries

Regulatory Context and Background:
A petroleum refinery is an industrial facility that converts crude oil into gasoline, diesel fuel, jet fuel, lubricating oil, and other products. The Bay Area has five large-scale petroleum refineries that rank among the ten largest sources of air pollution in the air basin. Refineries and their associated facilities contribute significantly to carbon dioxide (CO_2) emissions (the primary driver of climate change), criteria pollutant emissions (including NO_X, SO_2, and PM), and toxic air contaminant emissions which can exacerbate community health risks. While refinery criteria pollutant emissions have declined over time, refinery GHG emissions have been relatively stable in the last few years[1], so there is a possibility that changes in facility operations, crude or product slates, or increases in production could increase GHGs and other emissions from refineries.

Given community concern about the potential for emission increases from oil refineries, the Board of Directors directed Air District staff to evaluate draft Regulation 12, Rule 16 (Rule 12-16) as an option to address potential emission increases from operational changes at the Bay Area refineries. Draft Rule 12-16 reflects a policy recommendation from Communities for a Better Environment (CBE) and their associated organizations. The rule, as proposed by CBE, would limit the emissions of climate pollutants and three criteria pollutants: PM, NOx, and SO_2 from Bay Area petroleum refineries and three associated facilities. The draft rule would establish facility-wide emissions limits for the covered pollutants at each of the affected facilities to ensure that each facility does not increase emissions. Each facility emissions limit would be set at the historical maximum-annual emissions reported for that facility, with an additional allowance over the maximum annual emission rate for each pollutant to allow for normal variation. Rule 12-16 will be evaluated alongside Regulation 11, Rule 18, which focuses on existing sources of toxic air contaminants (TACs) such as refineries (see SS20: Air Toxics Risk Cap and Reduction from Existing Facilities).

[1] According to ARB's GHG mandatory reporting data from 2008 through 2015.

Implementation Actions:
The Air District will develop draft language for new regulation, Rule 12-16, based on CBE's proposal, in order to evaluate its cost-effectiveness and socioeconomic impacts as part of the rule development process. Staff will also evaluate Rule 12-16, alongside Rule 11-18, in a combined Environmental Impact Report to ensure that all of the potential environmental impacts for both rules are considered and addressed.

Emission Reductions:
Emission reductions are not expected from Rule 12-16 because the rule is designed to prevent future facility-wide emissions increases over a baseline based on the latest years of operations.

Exposure Reductions:
Refineries are major sources of criteria air pollutants, TACs, and GHGs and are also located in impacted communities, including in Richmond. In October 2014, the Air District Board of Directors adopted a Refinery Emissions Reduction Resolution, which established a goal of reducing refinery criteria air pollutant emissions by 20 percent or as much as feasible by 2020. In response to that directive, the Air District has developed a Bay Area Refinery Emissions Reduction Strategy. The Refinery Strategy ensures that refineries are taking the strongest feasible steps to reduce emissions and minimize their health impacts on neighboring residents and the region as a whole. This measure is one of twelve control measures in the 2017 Plan that make up the Refinery Strategy.

Costs:
The costs and economic impacts of Rule 12-16 to refineries and other affected parties will be analyzed as part of the rule development process.

Source:

1. California Air Resources Board (2016) 2030 Target Scoping Update Plan Concept Paper. June 17. Available at: http://www.arb.ca.gov/cc/scopingplan/document/2030_sp_concept_paper2016.pdf

SS12: Petroleum Refining Climate Impacts Limit

Brief Summary:
This control measure would limit facility-wide carbon intensity at each Bay Area petroleum refinery through new Air District Draft Regulation 13, Rule 1. Carbon intensity limit for each refinery would be calculated on a simple-barrel basis, and require execution of cost-effective energy efficiency projects.

Purpose:
The purpose of this control measure is to prevent increases in carbon dioxide (CO_2) from Bay Area refineries, at current levels of production.

Source Category:
Stationary sources – petroleum refineries

Regulatory Context and Background:
The Bay Area has five large-scale petroleum refineries that, along with their associated facilities, contribute significantly to greenhouse gas (GHG) emissions, among other pollutants. Though refinery GHG emissions have stabilized over time, there is concern that changes in crude or product slate could increase these emissions, even at current levels of production. As conventional oil resources dwindle and technology advances, unconventional hydrocarbon deposits such as shale oil, tar sands, and heavy oils in once-unreachable areas have become viable resources. The emission profiles, and resulting climate and health impacts, of these new sources of crude oil are not well understood.

There are numerous existing federal, state, and local regulations that apply emission limits and associated monitoring, record keeping, and reporting requirements to refineries, though not all refinery sources are covered. In April 2016, the Air District adopted a new rule (Regulation 12, Rule 15) to improve the quality of refinery air emissions data so that the public may be better informed, and to better inform future rulemaking to further reduce emissions. Rule 12-15 requires that all refineries: 1) submit consistent, enhanced periodic emissions inventory information; 2) submit periodic crude slate information; and 3) install and operate new air monitoring facilities at refinery fence lines (see SS10: Petroleum Refining Emission Tracking).

Meanwhile, the Air District continues to seek to minimize the health and environmental impacts of emissions from refinery sources. One way to address any GHG emission increases resulting from refineries changing crude slates is to establish a limit on their carbon intensity, generally characterized as the average GHG emissions released per barrel of crude oil processed.[1] Refineries are already held accountable for the upstream and downstream portion of their emissions at the state level through the Low Carbon Fuel Standard (LCFS) regulation.

[1] There is no standard way to calculate carbon intensity; it is generally defined as the average rate of carbon emissions relative to the intensity of a specific activity (in this case, refining). Air District staff has currently chosen to calculate carbon intensity based on crude oil processed but this definition may change in the future.

However, the LCFS assumes an average refining carbon intensity for all California refineries hence it does not track changes in the carbon intensity of crude processing at the individual refineries.

In order to complement the State's efforts and address local community concerns, the Air District staff proposes to cap each Bay Area refinery's carbon intensity. Carbon intensity limits for each refinery would be expressed on a simple-barrel basis, or carbon dioxide equivalent per barrel of crude oil processed (CO_2e/barrel). These carbon intensity calculations must account for all emissions generated by the refining process, including those associated with imported power or purchased hydrogen. The carbon intensity limit would be set at a level that is consistent with the expected benefits of implementing cost-effective energy efficiency measures that the refineries identified in the 2011 energy audits required by the Air Resources Board (ARB). This effort would constitute a first step in the Basin-wide Combustion Strategy (See SS18), which ultimately seeks to reduce emissions of greenhouse gas, criteria air pollutant and toxic emissions from stationary combustion sources throughout the Air District.

Implementation Actions:
The Air District will evaluate the cost-effectiveness and socioeconomic impacts of establishing a carbon intensity limit for each of the Bay Area refineries as part of the rule development process.

Emission Reductions:
Emission reductions are not expected from this measure since a facility-wide carbon intensity limit for refineries would be based on the current carbon intensity of each refinery. This approach is designed to prevent increases in facility GHG emissions, within each facility's current level of production. However, facility GHG emissions may still increase with production increases since capping carbon intensity only limits GHG emissions per unit produced.

Exposure Reductions:
Criteria air pollutant emissions from the Bay Area's five major oil refineries have generally been decreasing over the past several decades, while GHG emissions have been relatively stable in the last few years.[2] However, refineries are major sources of criteria air pollutants, TACs, and GHGs. Refineries are also located in impacted communities, including in Richmond. In October 2014, the Air District Board of Directors adopted a Refinery Emissions Reduction Resolution, which established a goal of reducing refinery criteria air pollutant emissions by 20 percent or as much as feasible by 2020. In response to that directive, the Air District has developed a Bay Area Refinery Emissions Reduction Strategy. The Refinery Strategy ensures that refineries are taking the strongest feasible steps to reduce emissions and minimize their health impacts on neighboring residents and the region as a whole. This measure is one of twelve control measures in the 2017 Plan that make up the Refinery Strategy.

Costs:

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[2] According to ARB's GHG mandatory reporting data from 2008 through 2015.

The costs and economic impacts of a refinery carbon intensity limit will be analyzed as part of the rule development process.

Source:

1. ARB (2013-2015) Energy Efficiency and Co-Benefits Assessment of Large Industrial Sources Public Reports. Available at: http://www.arb.ca.gov/cc/energyaudits/publicreports.htm.

SS13: Natural Gas and Crude Oil Production, Processing and Storage

Brief Summary:
Upstream natural gas and crude oil production, processing and storage operations are responsible for significant emissions of organic compounds including methane, a potent greenhouse gas (GHG), toxic air contaminants (TACs), and volatile organic compounds (VOCs). This control measure seeks to control fugitive and vented emissions from these operations by working with the California Air Resources Board (ARB) on their upcoming oil and gas rule, and by potentially amending an existing Air District rule (Rule 8-37) to address any local concerns specific to the Bay Area.

Purpose:
To reduce emissions of methane, a potent GHG, and other organic compounds from natural gas and crude oil production, processing and storage facilities throughout the Bay Area.

Source Category:
Stationary sources – oil and gas production facilities

Regulatory Context and Background:
In 2011, the California Air Resources Board (ARB) completed a comprehensive survey of the oil and gas industry for the calendar year 2007 with the intention of developing a rule to address emissions of GHGs from these industrial sectors. This survey found 68 active crude oil and natural gas facilities[1,2] in the Air District, which ARB estimated to emit a total of 198,987 MT CO_2e, using a 20-year time horizon, during that year (ARB, 2013)[3]. However, this source-level estimate may be considered as conservatively low given that recent studies have shown a large gap between atmospheric (or “top down”) estimates and source-level (or “bottom up”) estimates of methane emissions from this sector nationally and state-wide (Brandt *et al.*, 2014; Jeong *et al.*, 2013).

<u>Laws Affecting Organic Emissions from the Oil & Gas Sector:</u>

Federal
In 2015, the U.S. Environmental Protection Agency (EPA) proposed a suite of actions to reduce methane and further reduce VOC emissions from the oil and natural gas industry. Some of these actions are focused on regulation, such as updating the 2012 New Source Performance Standards (NSPS) to address methane and clarifying the agency’s air permitting rules for oil and gas production. In 2016, EPA adopted final updates to the NSPS that reduce methane and VOC

[1] In ARB’s survey, any facility that extracts crude oil, natural gas or both was considered as an individual facility, regardless of the size of the operation. In this context, crude oil or natural gas wells may be counted as facilities.
[2] While more recent data from California’s Division of Oil, Gas & Geothermal Resources (DOGGR) and the Air District indicate a higher number of wells, ARB’s 2007 data are presented as a conservative estimate.
[3] Calculated using ARB’s estimates of carbon dioxide and methane emissions for the Air District, and a global warming potential (GWP) for methane of 86 over 20 years, per Chapter 8 of the IPCC Fifth Assessment Report.

emissions from new and modified sources in the oil and gas industry. However, these recent regulatory actions for methane emission reductions apply to new and modified sources only, and not to existing facilities which are responsible for the majority of this sector's emissions (EPA, 2015). In March 10, 2016, EPA announced its intention to explore regulating methane emissions from existing oil and gas operations. EPA started outreach efforts with stakeholders in March 2016 and launched a formal information collection request (ICR) process in April of 2016 (EPA, 2016). However, the ICR was rescinded by EPA in March 2, 2017 (EPA, 2017), and no new methane regulations are expected at the federal level in the foreseeable future.

State

In April 2015, ARB released the first draft of its proposed regulation to address GHGs from this industry, titled "Greenhouse Gas Emissions Standards for Crude Oil and Natural Gas Facilities." If adopted, this rule would apply to existing and new, onshore and offshore oil and gas production, processing and storage facilities, including natural gas underground storage and transmission compressor stations. It would regulate fugitive and vented methane emissions from equipment at these facilities, such as at uncontrolled oil and produced water tanks (also known as degassing units), compressor seals, and pneumatic control systems. ARB staff has also proposed controlling vapors from well stimulation (fracking and acid stimulation) and incorporating methane-leaking components into air districts' leak detection and repair (LDAR) programs. ARB staff formed a local air district workgroup in which Bay Area Air District staff members are actively participating. The final draft of this rule was released for public comment on May 31, 2016. This draft of the rule was presented by ARB staff to its Board on July 21, 2016 for initial recommendations. ARB's Board directed staff to continue to work with local districts and other state agencies on implementation and coordination, address significant comments, and then bring the final environmental analysis and proposed regulation for approval at a subsequently scheduled public hearing. ARB staff currently intends that most aspects of the regulation, such as reporting, record-keeping and flash testing requirements, as well as LDAR and compressor strategies, will come into effect on January 1, 2017. Provisions requiring retrofits of existing sources will be effective January 1, 2018, to provide time for covered entities to come into compliance with new requirements.

Regional

Air District Regulation 8, Rule 37, (Rule 8-37) adopted in March 20, 1985 and amended in October 17, 1990, limits emissions of organic compounds from natural gas and crude oil production facilities. However, methane is exempted from this rule because it was aimed at reducing ozone formation at the time of the rule's adoption and subsequent amendment.[4] Rule 8-37 also lacks regulatory requirements for important sources of organic emissions from this sector such as liquid storage tanks, dehydration units and separators. Staff also expects to find other opportunities for emission reductions as this rule is updated.

[4] EPA has officially excluded methane from the definition of VOCs –organic compounds that participate in atmospheric photochemical reactions, such as the formation of ozone– since methane has negligible photochemical reactivity. In other words, methane is not considered an ozone precursor.

South Coast Rule 1148.1, adopted in March 5, 2004 and amended in September 2015, limits emissions of VOCs, TACs and total organic compounds (TOCs), which includes methane, from crude oil and natural gas wells and associated equipment that produce more than a barrel of oil or 200 standard cubic feet of gas per day. It requires closed ventilation for any tank systems with 95 percent abatement of all tank and process vapors. Rule 1148.1 has an equipment leak standard of 500 ppm for TOCs (SCAQMD, 2015).

Implementation Actions:
Air District staff will continue working with ARB staff on the development of its Oil and Natural Gas Production, Processing and Storage rule. Once adopted, the Air District plans to collaborate with ARB on the implementation and enforcement of the Oil & Gas rule, including its provisions for natural gas underground storage facilities. The Air District will also consider amending Rule 8-37 to ensure it properly addresses local needs and concerns that may not be the focus of ARB's rule, including:

- Applicability of Thresholds
    - The Air District wants to ensure that any emissions applicability threshold applies to facilities and associated equipment in the Bay Area. ARB's rule provides flexibility for a local air district to implement lower leak thresholds or require more frequent inspections, which the Air District may do if deemed necessary and cost-effective.
- Testing Methodology
    - The Air District wants to ensure that all testing and sampling methodology required by ARB and Air District rules is scientifically sound, cost effective, and appropriate. To this purpose, Air District staff will continue to provide comments on testing and sampling procedure, particularly in their areas of expertise such as leak detection and flash emissions[5] testing methodology as collection of a representative sample is very complex.
- Storage Tanks and Loading
    - There may be significant flash, working and weathering losses to the atmosphere associated with storage tanks at some well sites within the Air District. Air District staff will evaluate whether closed (vapor collection system) tankage would be a cost effective control strategy. Tank vapors can be controlled onsite by routing these vapors back to process equipment, to onsite combustion equipment or to other abatement equipment. Additionally, significant emissions may result from the transfer of liquid materials into mobile tankage and vacuum trucks. Air District staff will evaluate potential control strategies for these loading operations, including the utilization of a balance system where displaced vapors are routed back to onsite tankage.

The Air District will monitor the progress of EPA's rulemaking for existing oil and gas facilities to make sure any proposed rule amendments are in harmony with federal efforts. In addition, the

[5] Flash emissions occur when volatile compounds in a liquid are exposed to temperature increases or pressure decreases, as is the case when produced liquid separated from extracted natural gas or crude oil is transferred from the production separators to atmospheric storage tanks.

Air District will leverage its current efforts to develop a fixed site GHG monitoring network over the region and deploy a mobile GHG measurement platform to collect source-specific data on active oil and gas wells and associated facilities with the long-term goal to better characterize GHG and toxic emissions from this sector (see SL3: GHG Monitoring and Emissions Measurement Network).

Emissions Reductions:

Pollutants*	2020	2030
CO_{2e}	35,530	35,530

** CO_{2e} is reported in metric tons/year (100 yr GWP)*

Emissions Reductions Methodology:
Applying the control strategies required in ARB's rule to Bay Area oil and gas facilities, including installing vapor collection on open separators and tank systems, upgrading to low-bleed pneumatic devices and pumps (or installing gas capture), maintaining and repairing compressors, and implementing an LDAR program, would be expected to reduce methane emissions on the order of 89,870 MT CO_2e per year (20-year GWP), or 35,530 Mt CO_2e per year (100 yr GWP). Though some of these strategies have control efficiencies over 95 percent for emissions, this estimate assumes a 50 percent reduction of methane emissions in order to be conservative. More precise emission reduction estimates will be calculated as more detailed equipment inventory for these facilities is developed.

Costs:
The cost to oil and gas facilities to implement an LDAR program will be approximately $100,000 – 200,000 per year, based on the overall LDAR cost estimated by ARB and the number of LDAR components in the Bay Area (ARB, 2016). ARB estimated that fitting separators and tank systems with vapor recovery units (VRUs) would cost $35,000 – 100,000 per two tank system. Some additional costs may also be incurred from the replacement of polyethylene tanks with tanks of steel or a similar material compatible with pressure applications such as VRUs.

Co-Benefits:
Reduction of methane emissions from oil and gas facilities will likely reduce toxic air emissions frequently co-emitted with methane. Toxic air emissions detected in testing of the headspace vapors of storage tanks in the Oil and Gas industry include benzene, toluene, ethylbenzene, xylenes (collectively known as BTEX) and n-Hexane.

Issue/Impediments:
None at this time.

Sources:
1. EPA (2015) EPA's Air Rules for the Oil & Gas Industry. Available at: http://www3.epa.gov/airquality/oilandgas/pdfs/og_fs_081815.pdf
2. EPA (2016) EPA Taking Steps to Cut Methane Emissions from Existing Oil and Gas Sources. *EPA Connect: The Official Blog of the EPA Leadership*. Available at:

https://blog.epa.gov/blog/2016/03/epa-taking-steps-to-cut-methane-emissions-from-existing-oil-and-gas-sources/

3. EPA (2017) Information Request for the Oil and Natural Gas Industry. Available at: https://www.epa.gov/controlling-air-pollution-oil-and-natural-gas-industry/oil-and-gas-industry-information-requests
4. Brandt, A.R. *et al.* (2014) Methane Leaks from North American Natural Gas Systems. *Science* 343: 733-735,doi: 10.1126/science.1247045.
5. Jeong, S. *et al.* (2013) A Multitower Measurement Network Estimate of California's Methane Emissions. *J. Geophys. Res. Atmos.*, 118, 11,339-11,351, doi:10.1002/jgrd.50854.
6. ARB (2013) 2007 Oil and Gas Industry Survey Results Final Report (Revised). Available at: http://www.arb.ca.gov/cc/oil-gas/FinalReportRevised.pdf
7. Air District (2016) Regulation 8, Rule 37: Natural Gas and Crude Oil Production Facilities. Available at: http://www.baaqmd.gov/~/media/files/planning-and-research/rules-and-regs/reg-08/rg0837.pdf?la=en
8. South Coast Air Quality Management District (SCAQMD) (2015) Rule 1148.1 – Oil and Gas Production Wells. Available at: http://www.aqmd.gov/docs/default-source/rule-book/reg-xi/rule-1148-1.pdf?sfvrsn=
9. ARB (2016) Staff Presentation on February 4, 2016 Workshop. Available at: http://www.arb.ca.gov/cc/oil-gas/meetings/Reg_Workshop_Feb2016.pdf

SS14: Methane and Other Fugitive Emissions from Capped Oil and Gas Wells

Brief Summary:
Recent studies have shown that capped oil and gas wells have the potential of emitting methane, volatile organic compounds (VOCs) and toxic air contaminants (TACs). There are over 1,200 capped oil and gas wells in the Bay Area but no emissions data are available for these facilities. This control measure seeks to better characterize emissions from these capped oil and gas wells, and to explore rulemaking to address these emissions.

Purpose:
To reduce fugitive emissions of methane, VOCs and toxic pollutants from capped oil and gas wells in the Bay Area in order to provide climate protection, prevent ozone formation and reduce health impacts in the region.

Source Category:
Stationary source – oil and gas production facilities

Regulatory Context and Background:
Currently, there are a total of 1,442 oil and gas wells in the nine districts within the jurisdiction of the Bay Area Air Quality Management District (Air District) (DOGGR, 2016). Of these wells, only 113 are actively producing oil and/or gas while 1,250 are plugged/capped and 72 are idle. A recent study by Kang *et al.*, published in the Proceedings of the National Academy of Sciences, has been the first to measure methane leak rates from abandoned oil and gas wells. The study focused on 19 abandoned wells in Pennsylvania, five of which were plugged. The median methane leak rate at these wells (1.3×10^{-3} kg/day per location) was significantly higher than at forested, wetland, grassland and river locations near the wells, chosen with identical aerial footprint to the nearest well to serve as controls in the study (1.6×10^{-7} kg/day per location). Methane measurements obtained from the wells ranged from 1.5×10^{-5} to 2.1 kg/day per well, with three out of the 19 wells found to be high emitters, having methane flow rates three orders of magnitude larger than the median leak rate. In addition, the study found higher ratios of ethane, propane and n-butane to methane emissions at well locations than at their surroundings, indicating that abandoned wells may also emit certain VOCs. These results are not surprising since natural gas is known to contain up to five percent ethane, propane, n-butane and other VOCs.

At the present time, there are no emissions data available for capped or abandoned oil and gas wells in the Bay Area. As an initial estimate, methane emissions from Bay Area capped wells were calculated to be approximately 51 MT CO_2e/yr[1], using the median leak rate from the Kang *et al.* (2014) study. However, methane emissions could be up to three orders of magnitude higher if the Bay Area wells have leak rates comparable to the high emitter wells in the study. Moreover, these capped wells may also be emitting toxic pollutants that have been associated with active wells in the past. McKenzie *et al.* (2012) estimated elevated cancer and non-cancer

[1] Using the 20-yr time horizon global warming potential of methane, 86, per the IPCC Fifth Assessment Report.

risks for residents within ½ mile of an active natural gas well due to benzene, trimethylbenzene, xylene and aliphatic hydrocarbon emissions.

Laws Affecting Fugitive Emissions from Capped Wells:
In the Air District, fugitive emissions of organic compounds from oil and gas production facilities, such as oil and gas wells, are regulated under Regulation 8, Rule 37 – Natural Gas and Crude Oil Production Facilities (Rule 8-37). However, methane is explicitly exempt from this regulation (8-7-112) because it was aimed at reducing ozone formation at the time of the rule's adoption and subsequent amendment.[2] Rule 8-37 may be updated to remove the methane exemption and improve the VOC control requirements (See SS13: Oil and Gas Production, Processing and Storage). Furthermore, the definitions of natural gas production facility (8-37-213) and crude oil production facility (8-37-214) appear to exclude any facility not engaged in the active production of natural gas or crude oil, an d thus would exclude capped wells. Methane emissions from capped oil and gas wells are not addressed by ARB's Cap and Trade Program.

Implementation Actions:
To support the development of an Air District program to regulate fugitive emissions from capped oil and gas wells, the Air District will:

- Gather background data: Engage the Division of Oil, Gas & Geothermal Resources (DOGGR) to obtain more information on inactive oil and gas wells in the Bay Area, including any applicable requirements and regulations, and to identify any other relevant stakeholders. Review existing regulation and programs from other local air districts, and conduct extensive literature search on fugitive emissions of inactive or capped oil and gas wells.
- Characterize emissions from these facilities: Coordinate with and leverage the Air District's current efforts to develop a fixed site GHG monitoring network over the region and deploy a mobile GHG measurement platform to collect source-specific data (see SL3: Greenhouse Gas Monitoring and Emissions Measurement Network).
- Consider rulemaking for these facilities: Draft a new rule or amend Rule 8-37 to establish limits for methane emissions, in support of the objectives in the Air District's 10-Point Climate Action Work Program and of ARB's AB 32 Scoping Plan, and for VOC and toxic pollutant emissions, consistent with existing regulations.

Emission Reductions:

Pollutants*	2020	2030
CO_{2e}	19	19

CO_{2e} is reported in metric tons/year (100 yr GWP)

Emissions Reductions Methodology:
Due to accessibility issues (e.g., plugged wells under built structures), it likely will not be possible to repair all leaking wells. Assuming Bay Area capped wells were emitting methane at

[2] EPA has officially excluded methane from the definition of VOCs –organic compounds that participate in atmospheric photochemical reactions, such as the formation of ozone– since methane has negligible photochemical reactivity. In other words, methane is not considered an ozone precursor.

the median leak rate from the Pennsylvania well study (Kang *et al.,* 2014), repairing 90 percent of leaking wells would result in emissions reductions on the order of 47 MT CO_2e per year (20 year GWP) or 19 MT CO_2e per year (100 year GWP). However, if a fourth of the Bay Area wells were in the “high emitter” category (a fraction similar to that found in the same study), emissions reductions could be on the order of 18,000 metric tons of CO_2e per year. In addition, leaking plugged wells are likely emitting toxic pollutants such as BTEX[3] in addition to methane (Warneke *et al*., 2014). Based on typical mixing ratios of methane to toxic VOCs emitted from active oil and gas wells, these repairs could also result in emissions reductions on the order of 200 pounds per year of benzene, 340 pounds per year of toluene, and 225 pounds per year of C8 aromatics such as ethylbenzene and xylenes.

Emission Reduction Trade-Offs:
None.

Costs:
TBD. The operator cost of re-plugging abandoned wells that are leaking natural gas depends on the number and depth of these wells, as well as the price of cement in the Bay Area Region. In California, DOGGR plugged 1,307 orphan wells from 1977 to 2010 at a total cost of $23.7 million, an average cost of about $18,000 per well (DOGGR, 2016).

Co-Benefits:
Reduction in fugitive emissions from capped oil and gas wells would reduce methane emissions, a potent greenhouse gas, resulting in climate protection. It would also have potential health benefits on populations near capped wells by reducing toxic emissions such as benzene and toluene, which can increase the risk of cancer and other serious health effects.

Issues/Impediments:
The Air District will coordinate with state agencies, including ARB and the DOGGR, to ensure non-duplicative regulations. The Air District will also coordinate with the Yolo-Solano Air Quality Management District to strive for consistent treatment of sources within Solano County. In addition, some wells may be buried, or otherwise not accessible for testing and compliance verification.

Sources:

1. Division of Oil, Gas & Geothermal Resources (DOGGR), California Department of Conservation (2016) Online Well Record Search. Available at: http://owr.conservation.ca.gov/WellSearch/WellSearch.aspx
2. Kang, M., Kanno, C.M., Reid, M.C., Zhang, X., Mauzerall, D.L., Celia, M.A., Chen, Y., and Onstott, T.C. (2014) Direct measurements of methane emissions from abandoned oil and gas wells in Pennsylvania. PNAS, 111 (51), 18,173-18,177, doi: 10.1073/pnas.1408315111.

[3] BTEX stands for benzene, toluene, ethylbenzene, and xylenes.

3. McKenzie, L.M., Witter, R.Z., Newman, L.S. and Adgate, J.L. (2012) Human health risk assessment of air emissions from development of unconventional natural gas resources. Sci. Total Environ., 424, 79-87, doi: 10.1016/j.scitotenv.2012.02.018.
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5. DOGGR, California Department of Conservation (2016) Idle Well Program. Available at: http://www.conservation.ca.gov/dog/idle_well

SS15: Natural Gas Processing, Storage and Distribution

Brief Summary:
This control measure would seek to ensure reductions of methane emissions from natural gas pipelines, storage and processing operations by working with the California Public Utilities Commission (CPUC) to develop rules and procedures to reduce methane emissions as required by Senate Bill 1371.

Purpose:
Significantly reduce the emissions of methane, a potent greenhouse gas, from the natural gas processing, storage and distribution network throughout the Bay Area and improve climate protection.

Source Category:
Stationary sources – natural gas processing, storage and distribution

Regulatory Context and Background:
Overview: In 2014, approximately 93 million metric tons (MMT) of natural gas were consumed in the nine Bay Area counties (CEC, 2015). Based on a 0.2 percent line loss rate, 0.02 MMT of natural gas were lost due to fugitive emissions (leaks) from natural gas pipelines (Markey, 2013; EIA, 2012). This loss translates to 1.4 MMT of CO_2e, when using a 20-year time horizon.[1,2] It is worth noting that this estimate does not account for large, undetected natural gas leaks such as the Aliso Canyon storage facility leak. Preliminary calculations by the Air Resources Board (ARB) estimate that 2.4 MMT of CO_2e were released from the time this leak was discovered, in October 2015, until it was controlled in February 2016 (ARB, April 2016). It is difficult to incorporate large and unanticipated natural gas leaks, such as the Aliso Canyon leak, into emissions estimates since their frequency is unknown and their magnitude is difficult to quantify accurately even if detected. However, top-down methane emissions estimates for the U.S., California and for its San Francisco and South Coast air basins suggest that there are large, unaccounted emissions from the oil and gas system in bottom-up inventories, and that a large fraction of these originate from a small number of "super-emitters" (Brandt et al., 2014; Jeong et al., 2013; Fairley and Fischer, 2015; Cui et al., 2015).

There are approximately 1,450 miles of natural gas transmission lines within boundaries of the nine Bay Area counties, about 1,300 miles of which are owned by one entity (PHMSA, 2013). A natural gas Leak Detection Repair, Rehabilitation and Replacement (LDAR) program could have a major beneficial impact on greenhouse gas emissions. Pipes constructed out of cast iron or bare steel are the pipes most likely to leak, releasing 27.25 and 12.58 cubic feet of methane per hour, per mile, respectively, according to the U.S. Environmental Protection Agency (EPA) (40 CFR Part 98). PHMSA also lists these materials as high-risk pipeline infrastructure that is prone

[1] Calculated using a 20-yr global warming potential (GWP) of 86 for methane, per the IPCC Fifth Assessment Report.
[2] Calculated assuming that natural gas consists of 90 percent methane, and varying amounts of ethane, propane, butane and inert compounds.

to failure (PHMSA, 2011). Cast iron and bare steel leak 18 times more gas than plastic pipes and 57 times more gas than protected steel (40 CFR Part 98).

Laws Affecting GHG Emissions from Natural Gas Pipelines: Senate Bill 1371: Natural Gas Leakage Abatement, Leno, was signed into law by Governor Brown on September 21, 2014 (California Public Utilities Code, Sections 975-978). SB 1371 seeks to reduce natural gas leaks and associated greenhouse gas emissions (methane) from California utility gas systems. Methane emissions from natural gas lines are not addressed by ARB's Cap and Trade Program (ARB, 2015). SB 1371 requires the CPUC, in consultation with the ARB, to reduce emissions of natural gas from intrastate transmission and distribution natural gas lines to the maximum extent feasible in order to advance the state's goals in reducing emissions of greenhouse gases pursuant to the California Global Warming Solutions Act of 2006 (CA PUC 975(B)(2)).

The CPUC adopted rule(s) must:

- Provide for the technologically-feasible and cost-effective repair of leaks and leaking components within a reasonable time after discovery, consistent with the California Global Warming Solutions Act of 2006 and established safety requirements and the goals of reducing air pollution and the climate change impacts of methane emissions.
- Evaluate the operations, maintenance, and repair practices to determine whether existing practices are effective at reducing methane leaks and promoting public safety and whether alternative practices may be more effective at reducing natural gas emissions.
- Establish and require the use of best practices for leak surveys, patrols, leak survey technology, leak prevention, and leak reduction.
- Establish protocols and procedures for the development and use of metrics to quantify the volume of emissions from leaking gas pipelines, and for evaluating and tracking leaks geographically and over time, that may be used for required plans or other state emissions tracking systems, including the regulations for the reporting of greenhouse gases to ARB.
- Require the calculation and reporting to the CPUC and the ARB of a baseline system-wide leak rate and periodically update that system-wide leak rate calculation, and annually report on measures that will be taken in the following year to reduce the system-wide leak rate.

Under this statute, the CPUC started the rulemaking process in January 2015 under proceeding number R.15-01-008. Air District staff has actively participated in the rulemaking process, including presenting at the policy and technology panels on the initial workshop of the proceeding as well as attending all subsequent meetings to date. In May 2015, in accordance with the requirements of SB 1371, affected utilities reported the following to the CPUC:

- A summary of their leak management practices.
- A list of new methane leaks in 2013 by grade.
- A list of open leaks that are being monitored or are scheduled to be repaired.
- A best estimate of gas loss due to leaks.

In addition, current CPUC rulemaking process includes stakeholders from underground natural gas storage facilities and calls for the emissions from this sector to be estimated. However, it is uncertain whether methane emissions from underground storage will be addressed by CPUC's

Gas Leak Abatement rule.[3] Phase 1 of the CPUC rulemaking process, on the subject of "Policies and Guidelines", is currently underway and scheduled to conclude by December 2016. Phase 2, on the subject of "Ratemaking and Performance Based Financial Incentives", is scheduled for January 2017 through the summer of 2017.

Implementation Actions:
Before embarking on the development of an Air District program to regulate methane emissions from natural gas pipelines, the Air District will:

- Continue to engage with CPUC and ARB staff responsible for developing and implementing the required elements of SB 1371;
- Continue to participate in the CPUC regulatory process;
- Assess the CPUC-developed regulations for areas where Air District efforts may result in additional methane emission reductions and to ensure harmony with the Air District's Climate Protection Strategy; and
- Review the utility-reported data, when available, to glean additional information on GHG emissions and practices used to prevent and minimize methane emissions.

Listed below are the elements a potential Air District program may contain to address this major source of GHG emissions. The program may require entities responsible for natural gas pipelines to audit and reduce methane emissions in four phases.

<u>Phase 1</u>: Develop:

- Consistent methods for estimating and reporting natural gas/methane losses from natural gas lines, and
- Inventory of the estimated natural gas/methane losses from Bay Area natural gas pipelines sources.

<u>Phase 2</u>: Audit the pipeline system: Identify and map all the natural gas lines in the Air District by:

- Type of piping: transmission lines, distribution mains, or service lines and capacities;
- Material from which it is constructed: cast iron, bare steel, plastic, or protected steel;
- Components: valves, connectors, pumps, compressors, PRDs.
- Prioritize pipe according to leaks, capacity, age, and construction materials.

<u>Phase 3</u>**:** Develop an LDAR Program plan that would include an audit of the natural gas lines. Also, identify and prioritize piping that should be rehabilitated or replaced and establish a plan for doing so. Plan would be subject to approval by Air District with periodic updates.

[3] The current draft of ARB's Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities rule (Oil & Gas rule), dated May 31st, 2016, includes provisions for natural gas underground storage facilities [95668(i)] which require continuous monitoring and timely leak repairs. [4] This can be easily accomplished by segregating a line segment and flooding it with water and capturing the natural gas at an exit point.

Phase 4: Implement the Air District approved LDAR Program plan according to the approved schedule. Ensure that natural gas is captured when evacuating lines for inspection and repair.[4]

Emission Reductions:

Pollutants*	2020	2030
CO_{2e}	283,062	283,062

**CO_{2e} is reported in metric tons/year (100 yr GWP)*

If a natural gas LDAR program could reduce line losses by 50 percent, this program would result in an estimated emissions reduction of 715,980 MT of CO_2e per year (20 year GWP) or 283,062 MT of CO_2e per year (100 year GWP).

Exposure Reductions:
N/A

Emission Reduction Trade-Offs:
None

Costs:
Cost estimates will be developed during rule making. However, the approximate cost of LDAR programs at Bay Area refineries is $4,100 per 1,000 components. Cost for such a program for natural pipelines could be much higher due to the higher inaccessibility (pipes are buried and may need to be excavated) and much greater geographical expanse of the natural gas distribution network.

Co-Benefits:
A reduction in the amount of natural gas line losses not only reduces GHG emissions, it also reduces VOC emissions. Natural gas contains up to five percent ethane, propane and other VOCs. Thus, this control measure may also result in reductions of VOC emissions associated with natural gas. In addition, methane contributes to background tropospheric ozone levels, and studies consistently show that reducing global methane emissions can lower tropospheric ozone (ARB, 2014). Furthermore, a reduction of methane leaks would result in improved safety of the natural gas line network in the Bay Area and reduce the risk of gas explosions and fires.

Issues/Impediments:
The Air District would have to coordinate with several state and local agencies, including the ARB, the California Energy Commission (CEC), the CPUC, the local Certified Unified Program Agencies (CUPA), the Pipeline and Hazardous Materials Safety Administration (PHMSA) to ensure non-duplicative regulations.

[4] This can be easily accomplished by segregating a line segment and flooding it with water and capturing the natural gas at an exit point.

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SS16: Basin-Wide Methane Strategy

Brief Summary:
This control measure seeks to better quantify and reduce emissions of methane, and its co-pollutants, from all sources throughout the Air District by implementing a coordinated strategy that combines research, rulemaking, collaborations with state agencies, and other programs.

Purpose:
This control measure seeks to reduce emissions of methane and its co-pollutants, such as nitrous oxide (N_2O) and volatile organic compounds (VOCs), throughout the Air District.

Source Category:
Stationary and area sources.

Regulatory Context and Background:
The latest science has underscored the need to immediately reduce emissions of super-GHGs in order to stabilize global warming below 2°C, a critical threshold to avoid the worse impacts of climate change (IPCC, 2014). Methane (CH_4) is a powerful super-GHG. It is 86 times more potent than carbon dioxide (CO_2) when compared on a 20-year time horizon (or 34 times on a 100-year basis) and it has a much shorter atmospheric lifespan of 12 years (vs. 20 – 200 years) (IPCC, 2014). Due to these factors, actions to reduce methane emissions can provide significant and immediate climate benefits while CO_2 emissions are steadily reduced to achieve long-term climate stability. Curbing methane emissions would also reduce emissions of its co-pollutants, which can include key climate, criteria and toxic pollutants, resulting in public health and (further) climate benefits. For example, finding and reducing methane leaks from oil and gas production facilities would decrease emissions of frequently co-emitted toxic volatile organic compounds (VOCs), such as benzene, toluene, ethylbenzene, and xylenes. Focusing on methane sources in the waste sector would also address emissions of co-pollutants such as nitrous oxide, a potent greenhouse gas (GHG) that warms the atmosphere 298 times faster than CO_2 on a per-molecule basis.

The importance of super-GHGs, and particularly of methane, has been recognized at the international, national, and state levels. There have been many global efforts focused on reducing methane emissions such as the Global Methane Initiative (a partnership of 43 countries comprising over 70 percent of global methane emissions that focuses on methane abatement and recovery), and several methane-specific climate pledges made ahead of the Paris COP21[1]. In March 2014, the White House published a Strategy to Reduce Methane Emissions as part of the President's Climate Action Plan. As part of that strategy, the U.S. Environmental Protection Agency (EPA) and other federal agencies have undertaken several actions to reduce methane from the waste, agriculture, coal mining, and oil and natural gas

[1] COP21 stands for the 21st Conference of the Parties of the United Nations Framework Convention on Climate Change, which convened in December 2015. The climate pledges, or Intended Nationally Determined Contributions (INDCs), are non-legally binding emission reduction that countries committed to ahead of the COP21.

sectors. For instance, EPA recently adopted a regulation for new oil and gas production facilities (June 2016) and is currently exploring a regulation for existing oil and gas operations. However, initial efforts on the regulation for existing operations were rescinded by EPA in March 2, 2017 (EPA, 2017), and no new methane regulations are expected at the federal level in the foreseeable future. In the State of California, the Air Resources Board (ARB) released a proposed super-GHG, or short-lived climate pollutant (SLCP) reduction strategy in April 2016 and is expected to present the final SLCP strategy to their Board for approval in late 2016. The proposed strategy addresses emissions of methane (and other super-GHGs) not covered in ARB's Cap-and-Trade program. In the document, ARB emphasizes the critical role that air districts can play in the success of the State's strategy by implementing super-GHG emission reduction strategies in their own jurisdictions.

Methane is the second leading greenhouse gas (GHG) in the Bay Area Air District. In 2015, sources in the district emitted an estimated 10 million metric tons of CO_2 equivalent (MMT CO_2e), about 10 percent of the GHG inventory when calculated on a 20-year basis[2]. According to a recent study commissioned by the Air District to evaluate its methane inventory (Fischer and Jeong, 2016), three source categories represent approximately 84 percent of these emissions. These categories are mainly related to human activities; landfills are the largest source by far, accounting for 53 percent of these emissions, followed by livestock (16 percent) and natural gas production and distribution (15 percent). These emissions estimates carry a large uncertainty (50 percent or more), consistent with a recent study that suggests that methane emissions in the Air District's "bottom-up" inventory[3] are 1.5 – 2 times lower than expected from top-down measurements (Fairley and Fischer, 2015). This "methane gap" has been repeatedly observed for the U.S. and California regions, where top-down observations that account for ambient methane concentrations suggest that there are large, unaccounted methane emissions in bottom-up inventories (Brandt et al., 2014; Hsu et al., 2010; Jeong et al., 2013; Cui et al., 2015).

Given the importance and potential co-benefits of controlling methane, the Air District will implement a comprehensive basin-wide methane strategy to reduce the region's methane emissions, in support of ARB's methane reduction goals (40 – 45 percent below current levels by 2030). Elements of this strategy will include: 1) intensifying efforts to improve the Air District's methane emissions inventory, 2) considering amendments to existing Air District Regulation 8, Rule 2 (Rule 8-2) to prohibit significant methane leaks throughout the district, 3) collaborating with state agencies on their methane rules under development, 4) identifying cost effective and technically feasible methane emissions reduction opportunities throughout the Bay Area, and 5) considering the removal of methane exemptions from existing Air District rules when appropriate. These elements are described in more detail below.

[2] Based on the 20-yr global warming potential (GWP) reported for methane in the IPCC Fifth Assessment Report.

[3] The Air District traditionally develops its emissions inventory through a bottom-up methodology. In this approach, established emission factors (e.g., methane emitted per unit of natural gas burned) are combined with activity data (e.g., throughput of natural gas) to generate source-specific emissions estimates.

- ***Improve Methane Emissions Inventory***: The Air District will improve its methane emissions estimates by tracking regional methane emission patterns using a fixed-site GHG monitoring network, and by conducting source-specific measurements of methane throughout the Bay Area. See **SL3: Greenhouse Gas Monitoring and Measurement Network** for more details.

- ***Prohibit Significant Methane Leaks***: Currently, there is no Air District rule designed to address large leaks of methane. Air District Rule 8-2 prohibits leaks of organic compounds that exceed 15 pounds per day (and a concentration of 300 ppm) but methane and natural gas are exempted from that prohibition. Thus, the Air District would be limited in its ability to take action should a large natural gas leak similar to the Aliso Canyon storage facility leak occur in the Bay Area. To prevent this potential scenario, the Air District will consider rule amendments to Rule 8-2 that establish a limit above which methane leaks would be prohibited in the region. This leak limit would apply to all stationary sources, including methane leaks from natural gas pipelines, storage tanks, underground storage facilities, refineries, and oil and gas production operations. This rule would serve as a near-term action while additional efforts to address particular sectors are finalized. Such efforts include collaborating with state agencies on their methane rules under development, and seeking cost effective methane reduction opportunities (see items below).

- ***Collaboration with State and Other Agencies***: The Air District will continue to collaborate with ARB on their development of an oil and gas production regulation, and with ARB and the California Public Utility Commission (CPUC) on their joint development of a natural gas processing and distribution network regulation, both of which are aimed at reducing methane emissions from these sources. In addition, Air District staff will seek cooperation with other agencies or groups that have similar methane reduction goals, such as the ongoing collaboration with the City of San Francisco's Department of the Environment on potential emission reduction opportunities for local governments.

- ***Methane Reduction Opportunities***: The Air District plans to continually identify cost effective and technically feasible methane emissions reduction opportunities throughout the Bay Area. These opportunities will include, but are not limited to, the following initiatives, identified based on the existing methane emissions inventory:
  - Stationary Sources
    - *Natural Gas & Oil Production:* In addition to collaborating with ARB staff on their oil and gas rule, the Air District will consider amending its existing rule for oil and gas facilities (Rule 8-37) to address methane and VOC emissions from facilities which would otherwise be exempted from ARB's rule. These include smaller facilities, which are more prevalent in the Bay Area, and capped oil and gas wells, if these facilities prove to be a significant source of emissions. See **SS13: Natural Gas and Crude Oil Production, Processing and Storage** and **SS14: Methane and Other Fugitive Emissions from Capped Oil and Gas Wells** for more details.
    - *Natural Gas Distribution Network:* The Air District will continue participating in CPUC and ARB's joint development of the Natural Gas Leak Abatement rule, described in detail in **SS15: Natural Gas Processing, Storage and Distribution**.

- Waste
  - *Landfills:* The Air District will propose amendments to the existing Air District landfill rule (Regulation 8, Rule 34) with stricter control and fugitive leak standards, and will evaluate if methane emissions from facilities currently exempt from this rule warrant regulation. See **WA1: Landfills** for more details.
  - *Composting and Anaerobic Facilities:* The Air District will consider a rule requiring best practices to reduce methane (and co-pollutant) emissions from composting operations and anaerobic digesters, similar to those adopted in other districts, and will explore further measures to address anaerobic digestion emissions. See **WA2: Composting Operations** for further details.
- Water
  - *Publically Owned Treatment Works (POTWs):* The Air District will seek to better understand and quantify methane and nitrous oxide emissions at POTWs in order to inform potential rulemaking to address these potent greenhouse gases. See **WR1: Limit GHGs from POTWs** for more details.
- Agriculture
  - *Livestock:* The Air District will seek to reduce methane emissions associated with raising livestock by promoting methane capture for on-site energy production, and by engaging with the agriculture community to develop best practices to address enteric fermentation emissions. See **AG2: Dairy Digesters** and **AG3: Enteric Fermentation** for further details.
  - *Confined Animal Facilities:* See **AG4: Livestock Waste/Confined Animal Facilities** for additional information.

- ***Remove Methane Exemption from Relevant Rules***: Air District Regulation 8 rules limit the emissions of organic pollutants. In many cases, the specific Reg. 8 rule addresses an industry or source that does not emit methane, such as dry cleaning or architectural coatings. In others, the focus of control may be emissions of smog forming (precursor) compounds, though the industry may also emit methane. Due to that original intent, organic compounds were generally defined in these rules as "any compound of carbon, excluding methane, carbon monoxide, carbonic acid, metallic carbides or carbonates and ammonium carbonate." Out of the 53 rules that are currently part of Regulation 8, only four rules do not exclude methane as a regulated pollutant. The majority of the rules that exclude methane regulate products like solvents, coatings, and adhesives; in those cases, removal of the methane exemption would not result in reductions of methane emissions. However, there are a few Regulation 8 rules that may benefit from the removal of the methane exclusion. Air District staff will examine emissions and other relevant data to determine if removing the exemption from these rules would result in methane emissions reduction.

Implementation Actions:

The Air District will:

- improve quantification of methane and nitrous oxide in the Air District emissions inventory
- consider amending Regulation 8-2 to prohibit significant leaks of methane throughout the Air District

- address emissions of methane and its co-pollutants from the following sources, prioritizing rule development efforts based on the magnitude of emissions:
  - Natural gas & oil production, natural gas distribution network, natural gas underground storage, and refineries
  - Landfills, composting sites and anaerobic digestion facilities
  - POTWs
  - Livestock and confined animal facilities
- consider removing the methane exemption from existing Air District Regulation 8 rules, when appropriate

Emissions Reductions:
This section presents near-term GHG emission reductions for one element of the strategy, amending Rule 8-2, designed to serve as a stopgap for large methane leaks, while sector-specific regulations are developed. These emissions reductions, estimated to be 0.64 MMT CO_2e per year on a 20-year horizon (or 0.25 MMT CO_2e/yr on a 100-yr basis), are expected to increase once sector specific rules targeting the same GHG emissions in a more comprehensive way are adopted and implemented. Please see GHG reductions from these sector specific rules in their respective control measures (outlined above).

Emissions Methodology:
Oil & Gas Sector: Recent scientific evidence suggests that large leaks ("super emitters") can account for a large portion of the fugitive emissions from the natural gas distribution network, oil and gas wells, and natural gas storage facilities (Lyon et al., 2016). Given these findings, gross estimations of the potential methane reductions from amending Rule 8-2 for this sector were calculated assuming that 80 percent of emissions are due to 20 percent of the leaks – leaks most likely to be defined as a prohibited leak – and a 50 percent discovery and fixing rate for these leaks.

- Natural Gas Distribution Network: Air District staff estimated that the Bay Area natural gas distribution network emits approximate 1.4 MMT of CO_2e per year (based on a 0.2 percent leak rate and using the 20-year time horizon for methane). Using the methodology outlined above, the potential GHG emission reduction would be 0.57 MMT CO_2e per year.
- Natural Gas & Oil Production: ARB estimated that 68 active crude oil and natural gas facilities in the Air District emit a total of approximate 0.2 MMT CO_2e, using a 20-year time horizon, during 2007. Applying the assumptions given above, GHG emissions would be reduced approximately 72,000 MT CO_2e per year.
- Natural Gas Storage Facilities: Considering the environmental incident at the Aliso Canyon natural gas storage facilities, the Air District would monitor facilities such as this quite closely. Potential emission reductions from these sources will be estimated during rule development.
- Petroleum Refineries: Currently, methane emissions from refineries are estimated to constitute less than 2 percent of the anthropogenic methane emitted in the Bay Area. However, preliminary study findings indicate that fugitive methane emissions from refineries may be significantly higher than bottom-up inventory estimates. Due to the

uncertainty in the fugitive emissions from this sector, emission reductions cannot be estimated at this time.

Waste, Water and Agriculture Sectors: Due to the uncertainty and poor understanding of the emissions from sources in these sectors, such as composting, wastewater treatment, and livestock, emissions reductions from amending Rule 8-2 cannot be estimated at this time.

Emission Reduction Trade-Offs:

None

Costs:

Costs are expected to vary widely depending on the source type and proposed regulation and thus will be developed during rulemaking.

Co-Benefits:

The methane strategy has the potential to reduce other pollutants, such as VOCs and toxic compounds associated with oil and gas production, ammonia (a precursor to secondary PM), and N_2O, a potent GHG frequently co-emitted with methane from sources in the waste sector.

Issues / Impediments:

None

Sources:

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SS17: GHG BACT Threshold

Brief Summary:
This measure would lower the threshold at which facilities subject to the Air District’s New Source Review permit program must implement the “Best Available Control Technology” to control their greenhouse gas (GHG) emissions below the current 75,000 tons per year (tpy) CO_2e. In addition, this threshold would apply to all regulated facilities, not just “major” facilities.

Purpose:
The purpose of this control measure is to lower GHG emissions in the Bay Area.

Source Category:
Stationary Source – all regulated facilities

Regulatory Context and Background:
The Air District’s New Source Review (NSR) program is a comprehensive air permitting program that applies to a wide-range of stationary source facilities within the Air District’s regulatory jurisdiction. The program requires a facility to obtain a permit and implement state-of-the-art air pollution control technology whenever a facility installs a new source of air emissions or makes a modification to an existing source.

The federal NSR program requirements were established in the 1977 federal Clean Air Act (CAA) Amendments. The CAA requires local programs to implement requirements through the CAA’s system of “cooperative federalism,” under which each state or local agency develops and adopts an NSR program that meets (or exceeds) the minimum requirements of the federal NSR program. These programs are submitted to the United States Environmental Protection Agency (EPA) for review and approval. In 1988, the California legislature enacted the California Clean Air Act, which imposes additional state-law NSR permitting requirements that go beyond the federal NSR program in certain aspects. Each air district in California is required to adopt an NSR program that meets both the additional state-law requirements and the federal NSR program requirements; these programs are subject to review and approval by the California Air Resources Board. The Air District’s NSR program operates within the overlay of these state and federal requirements.

The Air District’s NSR program is set out in Regulation 2, Rule 2 (Rule 2-2) and is the Air District’s fundamental permitting requirement for regulating criteria pollutant emissions. It requires facilities to obtain an NSR permit for any new or “modified” source of air emissions, and to satisfy a number of air pollution control requirements in order to be eligible for the permit. [1]

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[1] “Modified source” is defined in Regulation 2-1-234 as (i) any physical change, change in the method of operation, increase in throughput or production, or other similar change to a source that will result in an increase in the source’s permitted emissions (or for “grandfathered” sources that are not subject to any permit limits, in increase in the source’s physical capacity to emit air pollutants); or (ii) for sources at “major” facilities (maximum emissions of any pollutant over 100 tpy or 250 tpy, depending on the facility type), any change that will result in a significant increase in the source’s actual emissions as defined in EPA’s federal NSR regulations.

These requirements vary somewhat depending on the pollutant involved. For pollutants for which the region is not in attainment of the applicable air quality standards ("non-attainment" pollutants), the NSR requirements are generally more stringent. For pollutants for which the region is in attainment of the applicable air quality standards ("attainment" pollutants), the requirements are generally less stringent. The requirements for attainment pollutants are referred to as "Prevention of Significant Deterioration" (PSD) requirements and include: (i) using the "Best Available Control Technology" (BACT) to limit emissions; and (ii) conducting an air quality impact analysis to ensure that the source being permitted will not jeopardize continued attainment of the applicable air quality standards or cause other adverse air quality impacts.

PSD is the element of the NSR program under which GHGs are regulated. The PSD provisions require new and modified sources at "major" facilities that will increase GHG emissions by 75,000 tpy or more of CO_2e to go through the PSD permitting process and implement BACT to reduce their GHG emissions.[2] More specifically, if a facility is a "major" facility under the federal CAA, it must comply with the PSD BACT requirement (i) for any new source that will emit 75,000 tpy or more CO_2e, and (ii) for any modification to an existing source that will result in a net increase in emissions of 75,000 tpy or more CO_2e. The District's NSR program incorporates this 75,000 tpy CO_2e threshold from EPA's federal NSR regulations, which regulate GHGs at that level.

Since this 75,000 tpy CO_2e threshold was adopted 2012, it has become apparent that a lower threshold may be appropriate for GHG permitting for the Bay Area. Specifically, an evaluation of all permit applications that the Air District has received over the past ten years indicates that reducing the threshold below the current 75,000 tpy CO_2e will subject a substantial additional amount of GHG emissions to the BACT requirement. Staff continues to investigate an appropriate revised threshold.

In addition, Air District staff is proposing to make the revised threshold apply at all facilities, not just facilities that have emissions of regulated air pollutants over the 100/250 tpy federal "major" facility threshold. Staff believes facilities under this latter threshold should be subject to regulation if their GHG emissions are of sufficient magnitude. While the EPA is limited to regulating GHG emissions only from major facilities, the Air District is not precluded from adopting the more stringent approach under its rulemaking authority under the California Health and Safety Code.[3]

It should be noted that the while a new lower threshold would require more sources to implement BACT to limit their GHG emission, as with the existing BACT requirement, the regulations will not prescribe exactly what technology must be applied in any particular case. Specifically, as with the current regulations, that determination will be made on a case-by-case basis by evaluating the most stringent level of GHG emissions control that can feasibly be

[2] A "major" facility is one that emits 100 tpy or more of a regulated air pollutant other than GHGs (or 250 tpy or more for certain source categories).

[3] The 2014 Supreme Court's decision in *Utility Air Regulatory Group v. EPA* (134 S.Ct. 2427) held that the EPA cannot regulate GHGs under the CAA from facilities that do not exceed this major facility threshold.

implemented for each individual source being permitted, taking into account considerations such as energy impacts, any ancillary environmental impacts, and economic impacts. Therefore, the BACT requirement for GHGs under a revised CO_2e threshold will work just as it does under the current threshold.

Implementation Actions:
The Air District would create a new subsection in Section 2-2-304, the provision in Rule 2-2 that sets forth the PSD BACT requirement. Section 2-2-304, as enacted in the December 2012 amendments, incorporates the federal PSD BACT requirement by reference, including the 75,000 tpy CO_2e thresholds discussed above. The proposed revisions would create two subsections in Section 2-2-304: (i) Subsection 2-2-304.1, which would continue to incorporate the federal PSD BACT requirement by reference; and (ii) Subsection 2-2-304.2, which would be the new requirement to apply BACT at a lower threshold.

Emission Reductions:
Emission reductions will result from additional sources being required to implement GHG BACT under the lower threshold. However, it is difficult to predict with certainty what the impacts will be for these sources, as the BACT requirement does not prescribe any specific emissions performance level. Generally speaking, however, Air District staff expect that overall GHG emission reductions from a new lower threshold will be modest at first, but will become significant over time as new and more effective GHG emissions control technologies become available.

Exposure Reductions:
None.

Emission Reduction Trade-Offs:
None.

Costs:
This proposed change would be expected to result in cost impacts as additional sources would be required to implement BACT under the lower threshold. However, it is difficult to predict with certainty what the impacts will be for these sources, as the BACT requirement does not prescribe any specific course of action these sources must take to comply and what cost impacts would result.

Overall, additional costs for regulated facilities will most likely be fairly limited in the near term for the same reasons that GHG emission reduction impacts will most likely be limited in this time frame. In the longer term, however, lowering the BACT threshold for GHGs may well involve increased compliance costs as new technologies become more widely used. It is worth noting, however, that the BACT requirement has a built-in cost-effectiveness test, as specified in CAA Section 169's mandate to take into consideration "economic impacts and other costs."

Co-Benefits:
For many facilities, reduction of GHG emissions will likely reduce criteria air pollutants frequently co-emitted in processes that typically generate GHGs (e.g., combustion), particularly if energy efficiency is selected as BACT. Alternatives to combustion-based abatement that reduce GHG emissions will be considered as part of energy efficiency BACT, if cost-effective and feasible (see control measure SS18).

Issue/Impediments:
None

SS18: Basin-Wide Combustion Strategy

Brief Summary:
This control measure seeks to stabilize and then reduce emissions of greenhouse gas (GHG), criteria air pollutant and toxic emissions from stationary[1] combustion sources throughout the Air District by first establishing carbon intensity caps on major GHG sources, and then adopting new rules to reduce fuel use on a source-type by source-type basis.

Purpose:
Reduce emissions of greenhouse gas, criteria air pollutant and toxic emissions from stationary combustion sources throughout the Air District.

Source Category:
Stationary combustion sources.

Regulatory Context and Background:
Fuel combustion contributes significantly to carbon dioxide (CO_2) emissions, the primary driver of anthropogenic climate change. It is also a significant source of criteria pollutants (including nitrogen dioxide (NOx), sulfur dioxide (SO_2), and particulate matter (PM) emissions) and toxic air contaminants, which can exacerbate health risks. One way to address these emissions is to find opportunities to increase the efficiency of combustion processes in order to reduce fuel consumption. Fuel use reduction would directly result in emission reductions of these pollutants, and since this approach also leads to fuel cost savings, most if not all of the investment can be recovered over time. Reducing combustion emissions would help the Air District attain and maintain compliance with state and federal air quality standards, reduce local contributions to anthropogenic climate change, and reduce emissions of some toxic pollutants.

Though many stationary sources of combustion emissions are already well-controlled as a result of existing Air District regulation targeting criteria and toxic pollutants, combustion from stationary sources still accounts for over half of all GHG emissions in the Bay Area. Combustion emissions from all stationary sources in the Air District are about 40 million metric tons of carbon dioxide equivalent (MMT CO_2e), including combustion for electricity generation, residential and commercial uses, and combustion at industrial facilities such as oil refineries and cement plants. Residential and commercial fuel usage account for approximately 10 MMT CO_2e of that total, while industrial combustion (including electricity production) generates approximately 30 MMT CO_2e. Typical combustion sources in the industrial and electricity-generation sectors include natural-gas fired turbines, furnaces, boilers, and process heaters, though the top GHG emitting sources will vary by specific facility. For instance, in the refinery sector, the equipment units that comprise the fluid catalytic cracking (FCC) plant, the co-

[1] For the purpose of this control measure, stationary combustion sources include all non-mobile sources, including residential/commercial buildings and electricity generation. In the 2017 Plan, building- and energy-related emission sources are also discussed in the Building and Energy sectors.

generation plant, and the hydrogen plant – which include boilers, steam generators, and heaters – are usually the largest sources of these emissions. Building and water heating, which typically involve natural gas combustion, is responsible for the majority of the GHG emitted from the residential and commercial sector.

The Air District will implement a Basin-wide Combustion Strategy to address emissions from stationary industrial combustion, the largest contributor of GHG emissions within the Air District's direct regulatory jurisdiction.[2] The first phase of the strategy would evaluate carbon intensity caps as an immediate action to prevent GHG emissions increases at current levels of production from the largest sectors. The second phase would involve developing source-specific regulations to reduce combustion emissions through increased efficiency, and through lower GHG alternatives to combustion-based abatements devices. Both phases of the combustion strategy are described below:

- ***Phase 1: Carbon Intensity Caps – Stabilize Combustion Efficiency***

The Air District will explore establishing a regulatory cap on the carbon intensity of the major industrial combustion sources in the region, at a level consistent with their current performance, which include petroleum refineries, power plants, and cement plants. Carbon intensity is the amount of CO_2 emitted for each unit of product or output generated (e.g., pounds of CO_2 emitted per kW-hrs of electricity generated for a power plant). In general, the carbon intensity of a facility can be an indication of its efficiency when compared to similar facilities in the same sector.

One advantage of this approach is that since carbon intensity is a rate-based-standard (e.g., CO_2/unit produced) and not an absolute standard (e.g., CO_2 emissions), it does not limit production at particular facilities. Therefore, it would reduce the economic incentive for industry to move outside of the Bay Area due to increased production. Moving outside the Bay Area may result in greater overall emissions due to pollution associated with transporting the product and/or less stringent air pollution regulation.

Nearly 75 percent of CO_2 emissions from industrial combustion in the Bay Area come from the refining of transportation fuels, the generation of electricity and the production of cement. Each of these key industries would be subject to a carbon intensity standard that makes the most sense for that industry. For instance, petroleum refineries use large quantities of energy to convert crude oil into transportation fuels, mainly supplied from the combustion of crude oil and natural gas, and from grid electricity. The methodology to calculate the carbon intensity for the refining sector would need to account for the CO_2 emissions from all of these sources. The simplest way to define carbon intensity, the average CO2 emissions released per barrel of crude oil processed, will be evaluated (see SS12). However, other alternative methods might be considered. Since refineries produce several different products (e.g., gasoline, diesel and jet fuel), the standard could be expressed in pounds of CO_2 per gallon of product. A metric such as

[2] The California Air Resources Board has primary regulatory jurisdiction over mobile sources.

gasoline-equivalent-gallon could be used to aggregate all the products into "gallons of product".

After defining a carbon intensity calculation standard for each of these sectors, caps would be set on a facility-by-facility basis at a level consistent with current operations, with reasonable allowance for year-to-year variation.

- ***Phase 2: Source-by-Source Rulemaking***
  - ***Increase Combustion Efficiency***

    Given the wide variety of combustion emissions sources, regulatory approaches to reduce combustion emissions through increased efficiency will have to be tailored to the specific sector and equipment type. Combustion sources will be evaluated in order to identify cost-effective and technically feasible efficiency improvements that would result in GHG and criteria emission reductions. These evaluations will be prioritized based on two factors: 1) the magnitude of facility GHG and criteria emissions from combustion processes, and 2) the energy efficiency opportunities available for each source-type. Combustion GHG and criteria emissions from Bay Area facilities are comprehensively quantified in the Air District Emissions Inventory and in the California Air Resources Board (ARB) Greenhouse Gas Mandatory Reporting Data. The Air District may rely on the energy efficiency and co-benefits assessment of large industrial sources conducted by ARB, among other resources, to assess the energy efficiency opportunities available for each source-type within each sector. These assessments were completed for the refinery, cement, hydrogen, and electricity generation during the years 2013 through 2015.

  - ***Evaluate Alternatives to Combustion-based Abatement Devices***

    A significant portion of industrial combustion emissions come from combustion-based pollution abatement devices. As part of reducing combustion emissions in the region, Air District staff will conduct lifecycle emission and cost-effectiveness analyses to evaluate potential alternatives to reduce GHG emissions from combustion-based abatement devices.

    Incineration is one of the best-known methods of pollution abatement for industrial organic gas waste. It involves the combustion of organic substances contained in waste streams. Thermal oxidizers (or thermal incinerators) are widely used to destroy volatile organic compounds (VOCs) by routing gaseous waste streams into a combustion chamber. Generally, the energy released by the combustion of all the waste organic gases is insufficient to achieve the temperature required for full VOC combustion. Thus, it is necessary to add auxiliary fuel –typically natural gas– to achieve the desired VOC destruction efficiency. Combustion of the waste gases and auxiliary fuel results in GHG emissions.

    There are alternatives that can reduce the amount of supplemental fuel added, such as recuperative and regenerative thermal oxidizers, and catalytic oxidizers. Recuperative and regenerative thermal oxidizers are two different types of thermal incinerator designed for improved energy efficiency. Recuperative incinerators can achieve up to 70% energy recovery by using heat exchangers, which employ the hot exit gases to preheat the incoming gases to the combustion chamber. Regenerative incinerators can recover up to 95% of the energy by using high-performance heat exchangers and combustion chambers. Both types of thermal oxidizers result in auxiliary fuel savings. Catalytic oxidizers use a catalyst[3] to lower the temperature at which VOCs are destroyed, resulting in a much lower need of supplemental fuel for the combustion process.

It is important to take into consideration lifecycle GHG emissions and costs when comparing abatement options. For example, when considering a catalytic oxidizer as an alternative, a thorough analysis is needed to ensure that net GHG emissions are reduced. Certain organic gases, such as methane, cannot be effectively destroyed by all catalyst oxidizers[4]. Controlling methane from industrial waste streams has not been historically required by Federal, State or Air District regulation since it is not considered a VOC (i.e., not a precursor to smog). Thus, methane is not typically included in the calculation of VOC destruction efficiency of oxidizers. However, methane is a much more powerful greenhouse gas than carbon dioxide[5]. As such, there is a possibility that increases in methane emissions could offset reductions in carbon dioxide from reduced combustion of auxiliary fuel. In addition, the catalysts used in catalytic oxidizers typically need periodic regeneration, which may result in additional emissions and operational costs.

In parallel to the efforts mentioned above, the Air District will also explore rulemaking to drive GHG emission reductions from residential and commercial fuel usage, in cooperation with relevant State agencies.

Implementation Actions:
Air District Staff will:
- evaluate carbon intensity caps for the refinery, power generation and cement sectors
- promote energy efficiency improvements through new rules on a source-type by source-type basis
- evaluate combustion sources for emissions and efficiency in order to identify cost-effective and technically feasible improvements that would lead to reductions in fuel use
- prioritize the evaluation of combustion sources based on the magnitude of the emissions and the energy efficiency opportunities for each source-type
- evaluate lower GHG alternatives to combustion-based abatement devices

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[3] A catalyst is a substance that increases the rate of a chemical reaction, or allows it to happen under different conditions, without undergoing any permanent chemical change.
[4] Though there are catalysts that oxidize methane, these catalysts typically require a higher temperature than those that destroy VOCs
[5] Methane is 86 times more potent than CO_2 when compared on a 20-year time horizon, or 34 times on a 100-year basis (IPCC, 2014).

- explore rulemaking to reduce combustion emissions from the residential and commercial sector

Emission Reductions:

Pollutants*	2020	2030
$PM_{2.5}$	604	604
CO_{2e}	1,600,000	1,600,000

**criteria pollutants are reported in lbs/day; CO_{2e} is reported in metric tons/year (100 yr GWP)*

Emission Reductions Methodology:
Implementing a basin-wide combustion strategy is estimated to result in emission reductions, as presented in the table above, assuming a 5 percent emissions reduction across all industrial combustion sources. This value is based on the average GHG emission reductions across all sectors from uncompleted projects, as reported in ARB's energy efficiency and co-benefits assessment of large industrial sources for the refinery, cement, hydrogen, and electricity generation (ARB, 2013-2015). GHG emission reductions from the residential and commercial fuel usage subsectors are difficult to estimate at this time given the complexity of the regulatory landscape affecting energy efficiency in these categories. Reducing fuel combustion through efficiency will also reduce criteria air pollutants and toxic air contaminant emissions, but anticipated emissions reductions will vary by regulation and source and therefore cannot be quantified at this point. $PM_{2.5}$ emission reductions can be estimated using the same assumption as for greenhouse gases (5 percent emissions reduction across all industrial combustion sources). NO_x emission reductions are also anticipated, but have not been quantified at this time.

Emission Reduction Trade-Offs:
This control measure is designed to reduce energy or fuel use, so there would be no direct emission trade-offs. There might be an increase of indirect emissions associated with the production and delivery of some energy efficiency technologies.

Costs:
Upfront costs to implement energy efficiency and fuel reduction projects are expected to be borne by the individual facilities. These costs will vary widely depending on the type of project and source-type, but will be partly or entirely offset by savings in electricity or fuel costs.

Issues / Impediments:
Considering the wide variety of sources impacted, specific issues and/or impediments will be identified during rule making.

Source:

1. ARB (2013-2015) Energy Efficiency and Co-Benefits Assessment of Large Industrial Sources Public Reports. Available at: http://www.arb.ca.gov/cc/energyaudits/publicreports.htm.

SS19: Portland Cement

Brief Summary:
Air District Regulation 9, Rule 13 (Rule 9-13) limits the emissions of nitrogen oxides, particulate matter, and toxic air contaminants from the manufacture of Portland cement. This measure proposes to amend sections of the rule pertaining to ammonia and sulfur dioxide (SO_2) emissions, and may reduce GHG emissions.

Purpose:
Air District Rule 9-13 regulates emissions from cement manufacturing. At present, the Lehigh Hanson Cement Plant (Lehigh) in Cupertino is the only operating cement manufacturing plant in the Bay Area. Since the adoption of the rule in September 2012, there have been changes in production processes at Lehigh, changes to the California Office of Environmental Health Hazard Assessment (OEHHA) Health Risk Assessment guidelines, and possible future regulatory changes. This Portland Cement control measure would amend sections of the rule to reflect these changes in processes, guidelines, and the regulatory environment to further reduce emissions from cement manufacturing.

Source Category:
Stationary source – cement manufacturing

Regulatory Context and Background:
As written, Rule 9-13 assumes consistent levels of ammonia in feedstock. However, since the adoption of the rule, Lehigh has provided ammonia emissions monitoring data documenting the variability in baseline ammonia levels of their feedstock. An amendment of the rule is needed to reflect this variability.

Since adoption of Rule 9-13, OEHHA has updated state guidelines regarding toxicity and cancer potencies. These changes may require changes to Lehigh's existing notification requirements regarding toxic compounds. While this change does not require an amendment to the rule, any rule development effort will need to explain the notification requirements to members of the public.

Air District staff proposes amending Rule 9-13 to include an SO_2 emissions limit for consistency with other Air District rules controlling SO_2 emissions, while accommodating operational changes at the Lehigh facility. Impending Air District rules would impose SO_2 limits on coke calcining and cat cracking units at refineries, and Lehigh, which burns petroleum coke, is the largest uncontrolled source of SO_2 in the Air District. Emissions from Lehigh are considered uncontrolled because the facility does not currently have control devices installed to reduce emissions. While emissions are not "controlled", Lehigh's permit conditions limit SO_2 emissions to 481 pounds per hour (lb/hr) averaged over a 24-hour period. Due to variability in their feedstock, Lehigh has proposed a modified permit limit of 481 lbs/hr averaged over 30 rolling operating days for SO_2 emissions. Federal law determines that this proposed modification to operating conditions would be an increase in emissions and therefore requires new source review. The averaging periods necessary to allow operational flexibility would be reflected in the rule, so long as emission reductions remain consistent and enforceable.

In addition, Lehigh has a long history of public complaints regarding visible plumes, and the potential for increased emissions of ammonia and SO_2 addressed above may lead to greater potential for detached plume events. A detached plume is a plume that forms above the stack release point.

Production of Portland cement is an energy intensive process that relies on burning petroleum coke. Replacing some of the petroleum coke with biomass such as woodchips (e.g., yard waste, clean construction wood) could reduce emissions, including GHG emissions. Lafarge's cement plant in Bath, Ontario, is aggressively pursuing carbon emission reduction strategies through the planting of multiple energy crops that may eventually replace some of the coal and petroleum coke the plant requires as fuel each year. Recently, Lafarge began a multiyear life-cycle assessment study with Kingston, Ontario-based Queen's University's Energy and Environmental Policy Institute, and has been working closely with researchers on planting trials of perennial crops, utilizing about 2,500 acres of land surrounding the cement plant. Further research is needed to determine if biomass can be viable, cost-effective, and would result in emission reductions. Alternatively, the use of supplementary cementitious materials in place of clinker, such as rice hull ash and fly ash could reduce emissions. Further research is needed to determine how much clinker could be replaced, whether the use of rice hull ash or fly ash could pose a toxic risk, and how the change in cement blends would affect emissions.

Implementation Actions:
The Air District will:

- Consider amending sections of existing Air District Rule 9-13 pertaining to ammonia emissions to allow for replacement of the rolling 24-hour average with a different averaging period for ammonia emissions, and
- Amend Rule 9-13 to impose a standard for SO_2 consistent with other Air District rules; amend the rule as necessary to incorporate language regarding detached plumes, and consider amendments to the rule to reduce GHG emissions.

Emission Reductions:

Pollutants*	2020	2030
SO_2	4,493	4,493
CO_{2e}	85,055	85,055

**criteria pollutants are reported in lbs/day; CO_{2e} is reported in metric tons/year (100 yr GWP)*

Emission Reductions Methodology:
To estimate the reduction in SO_2 emissions, a projected 60 percent abatement factor was applied to the operating permit potential to emit. The estimate of CO_2e reductions is based on the assumption that 10 percent of the petroleum coke currently burned would be replaced with biomass, which was assumed to be carbon neutral.

Exposure Reductions:
TBD

Emission Reduction Trade-Offs:
Stricter emissions standards may require modifications to control equipment increasing the potential for a detached plume.

Costs:
Further study is needed to determine cost information and cost effectiveness.

Co-Benefits:
SO_2 is a PM precursor contributing to the formation of sulfate aerosols which directly and indirectly affect warming and cooling in the earth's atmosphere. Long term exposure to SO_2 can cause breathing difficulties, respiratory illness and aggravate exiting heart disease. Reductions in SO_2 emissions will protect public health.

Issue/Impediments:
The cost effectiveness of rule amendments that require further reductions in emissions from Lehigh in Cupertino would need to be investigated.

Sources:

1. Bay Area Air Quality Management District, Regulation 9, Rule 13: Nitrogen Oxides, Particulate Matter, and Toxic Air Contaminants from Portland Cement Manufacturing Scoping Paper, July 2012

SS20: Air Toxics Risk Cap and Reduction from Existing Facilities

Brief Summary:
This control measure seeks to further reduce public exposure to toxic air contaminants (TACs) from existing facilities. New Regulation 11, Rule 18 (Rule 11-18) is expected to substantially reduce health risks from existing facilities that emit TACs, by requiring the implementation of all technically and economically feasible risk reduction measures at significant sources of TACs in these facilities. The rule also incorporates the Office of Environmental Health Hazard Assessment (OEHHA's) recently adopted (2015) Health Risk Assessment Guidelines into its required health risk estimation methodology.

Purpose:
The purpose of this measure is to ensure that existing facilities that emit TACs do not pose an unacceptable health risk to nearby residents, workers, and/or students.

Source Category:
Stationary Sources

Regulatory Context and Background:
Various facilities in the Bay Area region emit toxic air contaminants that can adversely impact public health, including data centers, petroleum refineries, a cement kiln, gasoline dispensing facilities, etc. The Air District's long-standing Air Toxics Program for reducing TAC emissions from stationary sources and statewide programs for reducing emissions from mobile sources have been largely responsible for decreasing these pollutants by at least 87 percent since 1990. However, there is still progress to be made. Many Bay Area residents have expressed concern about the impact of these toxic pollutants on public health.

To directly address concerns about community health risks, Air District staff will propose that the Air District adopt a new Regulation 11, Rule 18 (Rule 11-18): Cap and Reduction of Risk from Air Toxic Emissions at Existing Facilities. Rule 11-18 would enhance the component of the Air District's Air Toxics Program that assesses and reduces health risks from existing facilities. Rule 11-18 would apply to all facilities whose emissions of toxic air contaminants may result in a significant risk to nearby residents and workers, including petroleum refineries.

In order to determine if health risks are significant for each Bay Area facility that emits toxic compounds, Air District staff will first conduct site-specific Health Risk Screening Analysis (HRSA) based on the annual toxic emissions inventories reported to the Air District. The HRSA assesses the potential for adverse health effects from public exposure to routine and predictable emissions of TACs using guidelines adopted by the California Air Resources Board (ARB) and by the California Air Pollution Control Officers Association (CAPCOA). The Air District would determine a priority score (PS) for each facility based on the HRSA results. These scores are influenced by the amount of TACs emitted, the toxicity of these materials, and the proximity of the facility to potential receptors. Site-specific Health Risk Assessments (HRAs) would be conducted and prioritized based on a facility's PS. The results of the HRA would determine whether a facility would be affected by Rule 11-18. HRAs conducted as part of this process will incorporate the latest science, by using the OEHHA's 2015 HRA Guideline Revisions, a major update to these guidelines that focuses on children's health protection.[1]

Rule 11-18 would affect facilities with health risk impact that exceed any of the following risk action level thresholds (risk caps):

- ten per million (10/M) cancer risk
- 1.0 hazard index for chronic risk
- 1.0 hazard index for acute risk

The Air District would notify facilities of their health risk scores. Facilities that pose a health risk in excess of any of these risk caps would be required to reduce that risk below the cap through one of two ways: (1) the implementation of a Risk Reduction Plan approved by the Air District within three years of approval of the plan, or (2) the demonstration that all significant sources of toxic emissions are controlled by Best Available Retrofit Control Technology for Toxics (TBARCT). Risk reduction plans would detail how the facility would reduce its health risk below the risk caps in the specified timeframe and would be expected to include a characterization of each source of toxic emissions, an evaluation of risk reduction measures to be implemented, a schedule for implementing these as quickly as possible, and an estimate of the remaining risk following such implementation. In general, TBARCT is considered to be the most effective or stringent retrofit emission control that is technologically feasible and achieved in practice.

It is anticipated that hundreds of existing facilities may be impacted by Draft Rule 11-18.

Implementation Actions:
Air District staff will:

- Develop Rule 11-18 to include the screening and comprehensive evaluation (if warranted) of health risks from all facilities that emit toxic air contaminants in the Air District, and to require the implementation of all technically and economically feasible risk reduction measures to significant sources of TACs in these facilities.

Emission Reductions:
Specific emission reduction estimates will be estimated during rule development.

Exposure Reductions:
Specific exposure reduction estimates will be estimated during rule development.

Emission Reduction Trade-Offs:
None expected.
Costs:

[1] In March 2015, OEHHA revised the HRA guidelines to include consideration of children's health protection. Advances in science have shown that early-life exposures to air toxics contribute to an increased lifetime risk of developing cancer, and/or other adverse health effects, compared to exposures that occur in adulthood. The revised risk assessment methodology reflects both this greater sensitivity and more refined data in childhood and adult exposure to air toxics.

Specific costs will be developed during rule development.

Co-Benefits:
Reducing TAC emissions will likely result in reduced emissions of TOG, ROG, and particulate matter.

Issue/Impediments:
The regulated community not already subject to the requirements of the Air District Air Toxics "Hot Spots" Program may oppose thresholds that are more stringent. Those already subject to the current Air Toxic ATHS program may oppose increased restrictions as a result of lowering these thresholds.

Sources:
1. Proposed Amendments to Regulation 2, Permits, Rule 5: New Source Review of Toxic Air Contaminants, BAAQMD, Dated December 2009. Available at: http://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/Public%20Hearings/2009/0205_RFC_102109/0205_stfrcomplete_121109.ashx?la=en
2. OEHHA Public Notice for Release of Air Toxics Hot Spots Draft Guidance Manual for Public Comment, March 6, 2015. Available at: http://oehha.ca.gov/air/crnr/notice-adoption-air-toxics-hot-spots-program-guidance-manual-preparation-health-risk-0

SS21: New Source Review of Toxic Air Contaminants

Brief Summary:
Air District Regulation 2, Rule 5 (Rule 2-5) requires a health impact review for new and modified sources that emit toxic air contaminants (TACs) in excess of emissions trigger levels. It also establishes risk thresholds for mitigation and permit approval. The Air District conducts the health impact review in accordance with the California Office of Environmental Health Hazard Assessment (OEHHA) Health Risk Assessment Guidelines and the CARB/CAPCOA Risk Management Guidelines. These guidelines were revised in 2015. This measure would update the toxic New Source Review (NSR) program by incorporating the 2015 Health Risk Assessment (HRA) guideline revisions into the Air District's health impact review procedures. The use of the 2015 guidelines will increase the stringency of the toxics NSR program because the new health risk calculation procedures will result in higher cancer risk estimates for the same level of emissions.

Purpose:
This control measure will ensure that the Air District is using the most up to date scientific information and procedures to assess health impacts for new projects. This will also ensure consistency with the related Air Toxics Hot Spots Program that assesses health impacts due to TAC emissions from all sources at a facility.

Source Category:
This rule applies to all new or modified stationary sources that emit toxic air contaminants.

Regulatory Context and Background:
The Air District's Toxics Control Program includes the following three components: Toxics New Source Review, Air Toxics Hot Spots Program and CEQA. The Toxics NSR Program prevents significant increases in health risks resulting from new and modified sources of TACs through the preconstruction permit review process. As part of the engineering evaluation of a permit application, an assessment of health impacts is required. Site-specific health impacts are determined through preparation of an HRA that is performed in accordance with the OEHHA's guidelines. These guidelines are periodically updated to reflect advances in science.

As mandated under the Children's Environmental Health Protection Act of 1999 or SB25, OEHHA revised the HRA guidelines to include consideration of children's health protection. Advances in science have shown that early-life exposures to air toxics contribute to an increased lifetime risk of developing cancer, and/or other adverse health effects, compared to exposures that occur in adulthood. The revised risk assessment methodology reflects both this greater sensitivity and more refined data in childhood and adult exposure to air toxics.

Implementation Actions:
Air District staff will propose revisions to Air District Rule 2-5 to:

- Revise the Air District's Health Risk Assessment Guidelines based on OEHHA's 2015 risk assessment guidelines and CARB/CAPCOA's 2015 risk management guidelines.

- Revise the Air District's health risk assessment trigger levels for each toxic air contaminant using the 2015 guidelines and most recent health effects values.

Emission Reductions:
This measure will not directly require emission reductions, but the Air District expects it to result in higher level of health protection via evaluations of permit applications. The proposed revisions to the risk calculation procedures will result in higher cancer risk estimates for residential receptors compared to current procedures. As a result, applicants for new or modified sources of TACs will be required to implement risk mitigation measures or limit project risks at lower emission rates compared to current procedures.

Exposure Reductions:
As with emissions, this measure will not directly result in exposure reductions, but new or modified sources of TACs may reduce exposure as one method of meeting the project health risk limits.

Emission Reduction Trade-Offs:
Risk mitigation measures may include lower operating rates, alternative material, and lower emissions for new projects. These mitigation measures may also include abatement devices (afterburners, oxidizers, diesel particulate filters, etc.) and exhaust modifications (stack relocations, taller stacks, flow rate changes, etc.). Small increases in fuel or electricity usage are possible which could increase GHG emissions. However, reductions of black carbon particulate emissions may offset any climate change impacts due to abatement devices or increased electricity use.

Costs:
Specific costs will be developed during rule making.

Co-Benefits:
Risk mitigation measures for new and modified sources will result in reductions of precursor organic compounds and particulate matter emissions and TACs such as benzene and diesel PM. Reductions in diesel PM emissions will also reduce black carbon particulates.

Issue/Impediments:
No major issues have been identified.

Sources:

1. OEHHA 2015 Risk Assessment Guidelines: Guidance Manual for Preparation of Health Risk Assessments
2. CARB/CAPCOA 2015 Risk Management Guidance for Stationary Sources of Air Toxics
3. BAAQMD Regulation 2, Rule 5: New Source Review of Toxic Air Contaminants

SS22: Stationary Gas Turbines

Brief Summary:
In 2006, the Air District amended Regulation 9, Rule 9 (Rule 9-9), *Nitrogen Oxides from Stationary Gas Turbines*, applying the most stringent emission limits for oxides of nitrogen (NO_x) to larger stationary gas turbines. Less stringent limits were applied to small and medium sized units. The Air District is considering whether more stringent limits are warranted for medium-sized gas turbines.

Purpose:
Further reduce NO_X emissions from stationary gas turbines in the Bay Area.

Source Category:
Permitted sources - stationary gas turbines

Regulatory Context and Background:
A gas turbine is an engine that combusts gaseous fuel to generate rotational motion. It consists of three basic parts: a compressor, where air is compressed up to 30 times atmospheric pressure; a combustor, where air and fuel are mixed and burned; and a power turbine, where expanding combustion gases spin rotating blades. The power turbine provides mechanical energy to operate the compressor and to either generate electricity or mechanical energy (e.g. a jet engine or natural gas compressor). To increase efficiency, hot exhaust gases can be used to generate steam to operate a secondary steam turbine and to heat the combustion air so less fuel is needed.

The primary pollutants from gas turbines are the combustion byproducts carbon monoxide and NO_x. Most of the NO_x is emitted as nitrogen monoxide (NO), which oxidizes in air to form nitrogen dioxide (NO_2), a precursor to ozone and fine particulate matter ($PM_{2.5}$). NO_x emissions can be controlled by enhanced water or steam injection, Ultra Dry Low NO_X (DLN) combustion controls, or Selective Catalytic Reforming (SCR) of NO_X to nitrogen through a reaction with ammonia. SCR is the most effective technology but results in some ammonia emissions (ammonia slip).

In 2006, the Air District amended Rule 9-9, *Nitrogen Oxides from Stationary Gas Turbines*, limiting NO_x emissions depending on turbine size and fuel source (natural gas or other). Gas turbines larger than 250 million British thermal units per hour (MMBtu/hr) are required to install SCR and meet the most stringent limit of 9 ppm. Gas turbines between 50-250 MMBTU/hr in size are required control NO_x by other means, such as water injection or DLN, and meet less stringent limits depending on the size of the turbine, the fuel used, and the type of controls available.

Implementation Actions:
The Air District will:

- Consider amendments to Rule 9-9 that will strengthen the NO_X limits for medium and smaller sized gas turbines.

Emission Reductions:

Pollutants*	2020	2030
NO_x	1,500	1,500

**criteria pollutants are reported in lbs/day*

Emission Reductions Methodology:
Emission reductions were estimated by considering the reductions which could be achieved by small and medium gas turbines. Assuming that three small turbines achieve 25 ppm NO_x, the emissions reductions would be 140 lb/day. For medium turbines, assuming that six achieve five ppm NOx, the reductions would be 1,360 lb/day. As a result, the total emissions reductions are estimated to be approximately 1,500 lb/day.

Exposure Reductions:
Reducing NO_x emissions will reduce $PM_{2.5}$ and ozone concentrations. While ammonia slip could contribute to additional $PM_{2.5}$ formation, overall $PM_{2.5}$ concentrations are expected to be lower with this control measure.

Emission Reduction Trade-Offs:
Ammonia slip from SCR systems can increase secondary $PM_{2.5}$ formation. SCR may result in additional GHG emissions from both the reduction in efficiency of the gas turbine, and the increased energy required to operate the SCR equipment.

Costs:
The estimated capital costs for the use of steam injection technology for 3 small gas turbines, SCR technology for 6 medium sized gas turbines (including a 30 percent increase to accommodate retrofit to existing facilities) and modifications of existing SCR's for 7 larger facilities range from $0.1 - 4.0 million. Capital costs for modification on an existing SCR is about $100,000, while installation of a new medium sized SCR can be up to $4 million.

Co-Benefits:
Unknown

Issue/Impediments:
None

Sources:

1. Staff Report, Regulation 9, Rule 9, *Nitrogen Oxides from Stationary Gas Turbines,* November, 2006

2. Regulation 9, Rule 9, *Nitrogen Oxides from Stationary Gas Turbines*, amended: December 6, 2006
3. AP 42, Fifth Edition, Volume I, Chapter 3, Stationary Internal Combustion Sources, Section 3.1, Stationary Gas Turbines, amended: April, 2000.

SS23: Biogas Flares

Brief Summary:
Require that all biogas and non-refinery flares meet lowest available emissions reduction (LAER) level of 0.025 pounds of NO_X per million Btu.

Purpose:
Reduce secondary emissions of NO_X from flares used to abate organic emissions from solid waste landfills and anaerobic digesters.

Source Category:
Stationary Source – landfills and anaerobic digesters

Regulatory Context and Background:
Flares employed at solid waste landfills, publicly owned treatment works, and other anaerobic digesters function as pollution abatement devices and as such are not subject to new source review. Per Air District's permit Regulation 2, Rule 2 (Rule 2-2), section 112, secondary pollutants resulting from abatement devices are exempt from the best available control technology (BACT) requirements of the rule (2-2-301); however, these secondary emissions are still subject to the less stringent reasonable available control technology (RACT) requirements.

BACT is defined (2-2-206) as the most stringent of any control device or technique successfully utilized for that source category, or that is determined to be technically feasible, and it must be at least as stringent as any applicable federal, state or District laws, rules or requirements. Conversely, RACT is defined (2-2-243) as the lowest emission limit that can be achieved taking into account technological feasibility, cost-effectiveness, the specificities of the source in question, or the lowest emission limit achieved by application of control equipment to similar but not necessarily identical categories of sources.

The federal Clean Air Act (section 171(3)) defines the lowest achievable emission rate (LAER) as the most stringent emission limitation achieved in practice for a source category or which is contained in the state implementation plan (SIP) of any state for the same source category. LAER can be equivalent to RACT, but is often equivalent to BACT when stricter standards are required due to nonattainment of national ambient air quality standards for a given jurisdiction. The Air District's definition of BACT is similar to the federal LAER definition; however, BACT is evaluated on a case-by-case basis whereas LAER is uniform for a source category.

Air District staff has determined RACT for enclosed landfill gas flares to be 0.06 pounds of NO_X per million Btu of heat input (lbs/MMBTU), with CO emissions limited to 0.2 lbs/MMBTU. Current LAER for enclosed landfill gas flares achieved in practice is 0.025 lbs/MMBTU for NO_X, and 0.06 lbs/MMBTU for CO.

Implementation Actions:
Given the current exemption in Rule 2-2, imposing LAER level control would require a new rule in Regulation 9 specifically for secondary emissions from non-refinery flares. Air District staff will investigate the potential for more stringent limits on emissions from non-refinery flares.

Emission Reductions:

Pollutants*	2020	2030
NO_x	572	572
CO	2,248	2,248

**criteria pollutants are reported in lbs/day*

Emission Reductions Methodology:
The majority of emissions from biogas and non-refinery flares come from flares subject to RACT level controls. According to the 2011 inventory, landfill flares account for 980 pounds per day of NOX, and 3,212 pounds per day of CO. Changing from RACT to LAER controls would reduce NOx emissions from 0.06 pounds of NOX per million Btu of heat input (lbs/MMBTU) to 0.025 lbs/MMBTU, and would reduce CO emissions from 0.2 lbs/MMBTU to 0.06 lbs/MMBTU. As a result, NOx emissions would be reduced by 572 lb/day, and CO emissions would be reduced by 2,248 lb/day.

Exposure Reductions:
None expected.

Emission Reduction Trade-Offs:
None expected.

Costs:
In a 2013 technical support document for a permit for a landfill in Washington state, South West Clean Air Agency staff determined that a 30 MMBTU per hour flare meeting LAER control would result in reduced NO_X emissions at a cost of approximately $7,000 per ton of NO_X reduced. However, this determination is really a comparison of the installation and maintenance costs of a new LAER compliant flare ($260,000 capital cost) to a new RACT compliant flare ($250,000 capital cost). To retrofit existing flares to meet LAER requirements would be somewhere between this delta and the costs of a completely new flare, assuming that not all components would need to be replaced. More research is required to determine the retrofit costs for a LAER compliant flare, and thereby the emission reduction cost in dollars per ton of NO_X reduced.

Co-Benefits:
Reduction in CO emissions as specified in Emission Reductions section above.

Issue/Impediments:
The regulated community would likely oppose the additional costs imposed by retrofitting their existing equipment.

Sources:

1. Bay Area Air Quality Management District, Regulation 2, Permits, Rule 2: New Source Review, June 15, 2005
2. Bay Area Air Quality Management District, Engineering Evaluation Report, Potrero Hills Landfill, Application #210118, October 13, 2013
3. Technical Support Document, Cowlitz County Headquarters Landfill, Air Discharge Permit Application CO-916, Southwest Clean Air Agency, August 8, 2013
4. California Air Pollution Control Officers Association BACT Clearinghouse Resource Manual, CAPCOA, June 21, 2000. http://www.arb.ca.gov/bact/docs/manual.htm
5. Specifying a Cost Effective Landfill Flare System, John Zink Company LLC, Brandy Johnson, P.E. March 8, 2005 http://www.johnzink.com/wp-content/uploads/tp_cost_effective_landfill_rev.pdf

SS24: Sulfur Content Limits of Liquid Fuels

Brief Summary:
This control measure would propose amendments for Air District Regulation 9, Rule 1 to incorporate several fuel-specific sulfur content limits for diesel and other liquid fuels.

Purpose:
Reduce SO_2 emissions, and as a co-benefit, reduce particulate matter (PM) formation as a secondary pollutant.

Source Category:
Stationary sources.

Regulatory Context and Background:
The California Air Resources Board (ARB) currently limits sulfur content in all diesel fuels. SCAQMD Rule 431.2 reflects the same sulfur content limits of 15 ppm for low sulfur fuel used in stationary sources. The SCAQMD 15 ppm sulfur limit is equivalent to the federal ultra-low sulfur diesel fuel limit.

Sulfur emissions lead to the formation of sulfur dioxide (SO_2) which is a criteria pollutant. Although the Air District is in attainment with federal ambient air quality standards for SO_2 concentrations, it is not in attainment for the federal and state $PM_{2.5}$ standards. SO_2 is a precursor of $PM_{2.5}$. The adoption of low sulfur fuel limits will help make continued progress toward achieving state PM standards and help ensure federal standards are not exceeded.

Currently, Rule 9-1 limits the sulfur content of liquid fuels to 0.5 percent by weight. This standard applies to diesel fuel. The ARB and SCAQMD standards for diesel fuel are more stringent and thus should be evaluated for potential inclusion in Rule 9-1.

Implementation Actions:
The Air District would propose amendments to Rule 9-1 to incorporate a new sulfur content limit for liquid fuels. The terms “liquid fuel” is not currently defined by the rule. In proposing amendments to Rule 9-1, the Air District will be acting pursuant to its authority provided in Health and Safety Code 40447.6 to protect public health by lowering the sulfur content in diesel fuel.

Emission Reductions:
Emission reductions will be estimated during rule amendment process.

Exposure Reductions:
NA

Emission Reduction Trade-Offs:
None.

Costs:
Specific costs will be estimated at time of rule amendment.

Co-Benefits:
Reduction of SO_2 emissions will reduce formation of secondary $PM_{2.5}$ in the form of ammonium sulfate.

Issue/Impediments:
None.

Sources:

1. Bay Area Air Quality Management District, Regulation 9, Rule 1 Inorganic Gaseous Pollutants, Sulfur Dioxide
2. South Coast Air Quality Management District, Rule 431.2 Sulfur Content of Liquid Fuels
3. California Air Resources Board, California Diesel Fuel Regulations

SS25: Coatings, Solvents, Lubricants, Sealants and Adhesives

Brief Summary:
This control measure would seek to reduce the VOC emissions from miscellaneous coatings, adhesive, solvent and lubricant categories by lowering certain product VOC limits. Examples of the miscellaneous categories to be considered include coatings used in aerospace; adhesives used in a variety of sealing applications; solvents for cleaning and preservation or graffiti abatement activities; fountain solutions for printing operations; and lubricants used as metalworking fluids to reduce heat and friction to prolong life of tools, improve product quality and carry away debris.

Purpose:
Reduce emissions of VOCs from coatings, solvents, lubricants and adhesives.

Source Category:
Area - coatings and solvents

Regulatory Context and Background:
The following Air District rules contain VOC limits addressing coatings, solvents, lubricants, sealants, or adhesives: Rules 8-4, 8-11, 8-12, 8-13, 8-14, 8-16, 8-19, 8-20, 8-23, 8-26, 8-29, 8-31, 8-32, 8-35, 8-36, 8-38, 8-43, 8-49, and 8-51. Rules 8-3 and 8-45 also have VOC limits for coatings and solvents; but these rules are modeled on suggested control measures (SCM) developed by the ARB in consultation with the state air districts and the California Air Pollution Control Officers Association (CAPCOA). The SCMs are developed to help ensure consistency in the regulation of architectural and automotive coatings and solvents throughout the state. The Air District's current VOC limits for coatings range from 20 grams per liter (g/l) to 1,800 g/l (Reg. 8-13), 120 to 850 g/l for adhesives, 50 g/l to 880 g/l (Reg. 8-20) for solvents, and, currently, there are not standards for lubricants and vanishing oils. The control measure will examine the potential to reduce the allowable VOC content of coatings, adhesives, and solvents regulated by the above listed Regulation 8 rules. The following table presents a simplified comparison of the potentially affected Air District coatings, adhesives, and solvent rules with comparable rules adopted by the South Coast Air Quality Management District (SCAQMD) and the San Joaquin Valley Air Pollution Control District (SJVAPCD).

TABLE 1
Comparisons of Air District Coatings, Adhesives, and Solvent VOC Limits to Comparable, SCAQMD, and SJVAPCD Rules

Bay Area Rules VOC Limit Range	South Coast Rules VOC Limit Range	San Joaquin Valley VOC Limit Range
8-4: General Solvent and Surface Coating Operations 4,533 kg/yr emission rate or 85 to 90% control or 420 g/l VOC content and 50 g/l solvent limit	Rule 1122: Solvent Degreasers & Rule 1171: Solvent Cleaning Operations 25-50 g/l or 90% and other controls	Rule 4661: Organic Solvents 2,489 kg/yr or 85% control

Bay Area Rules VOC Limit Range	**South Coast Rules VOC Limit Range**	**San Joaquin Valley VOC Limit Range**
8-11: Metal Container, Closure and Coil Coating 20 to 600 g/l	Rule 1125: Metal Container, Closure, and Coil Coating Operations 0 to 800 g/l	Rule 4604: Can and Coil Coating Operations 20 to 750 g/l
8-12: Paper, Fabric and Film Coating 265 g/l or effective 120 g/l control	Rule 1128: Paper, Fabric, and Film Coating Operations 265 g/l or effective 120 g/l control (20 g/l for plastisol)	Rule 4607: Graphic Arts and Paper, Film, Foil and Fabric Coatings 20 to 600 g/l
8-13: Light and Medium Duty Motor Vehicle Assembly Plants 450 to 1,800 g/l or 90% control	Rule 1115: Motor Vehicle Assembly Line Coating Operations 145 to 1,800 g/l	Rule 4602: Motor Vehicle Assembly Coatings 250 to 1,440 g/l or 90% control
8-14: Surface Coating of Large Appliances and Metal Furniture 275 to 420 g/l	Rule 1107: Coating of Metal Parts and Products 275 to 420 g/l	Rule 4603: Surface Coating of Metal Parts and Products, Plastic Parts and Products, and Pleasure Crafts 275 to 420 g/l
8-16: Solvent Cleaning Operations 50 g/l or 90% and other controls	Rule 1122: Solvent Degreasers & Rule 1171: Solvent Cleaning Operations 25-50 g/l or 90% and other controls	Rule 4662 Organic Solvent Degreasing Operations & Rule 4663: Organic Solvent Cleaning, Storage, and Disposal 25 to 800 g/l or 85% control
8-19: Surface Coating of Miscellaneous Metal Parts and Products 275 to 420 g/l or 85% control 50 g/l for surface prep solvent	N/A	N/A
8-20: Graphic Arts Printing and Coating Operations 25 to 400 g/l	Rule 1130: Graphic Arts 16 to 300 g/l	Rule 4607: Graphic Arts and Paper, Film, Foil and Fabric Coatings 20 to 600 g/l
8-23: Coating of Flat Wood Paneling and Wood Flat Stock 250 g/l or 90% control	Rule 1104: Wood Flat Stock Coating Operations 250 g/l or 90% capture /95% control (85% overall) control & 50 ppm emission limit	Rule 4606 Wood Products and Flat Wood Paneling Products Coating Operations 120 to 750 g/l or 15 lbs/day pre controls
8-26: Magnet Wire Coating Operations 200 g/l or 90% control	Rule 1126: Magnet Wire Coating Operations 200 g/l or 90% control	N/A
8-29: Aerospace Assembly and Component Coating Operations 250 to 850 g/l or 85% control	Rule 1124: Aerospace Assembly and Component Manufacturing Operations 120 to 1000 g/l or 90% capture /95% control (85% overall control)	Rule 4605: Aerospace Assembly and Component Coating Operations 120 to 1000 g/l or 90% capture /95% control (85% overall control)
8-31: Surface Coating of Plastic Parts and Products 420 to 800 g/l coatings and 50 g/l solvent or 85% control	Rule 1145: Plastic, Rubber, and Glass Coatings 50 to 800 g/l or 90% capture /95% control (85% overall control) & 50 ppm emission limit	Rule 4603: Surface Coating of Metal Parts and Products, Plastic Parts and Products, and Pleasure Crafts 275 to 880 g/l

Bay Area Rules VOC Limit Range	South Coast Rules VOC Limit Range	San Joaquin Valley VOC Limit Range
8-32: Wood Products Coatings 150 to 550 g/l & 50 g/l solvent limit	Rule 1136: Wood Products Coatings 120 to 750 g/l	Rule 4606 Wood Products and Flat Wood Paneling Products Coating Operations 120 to 750 g/l or 15 lbs/day pre controls
8-35: Coating, Ink and Adhesive Manufacturing 200 g/l solvent limit	Rule 1141.1. Coatings and Ink Manufacturing No VOC limits	Rule 4652: Coatings and Ink Manufacturing No VOC limits
8-36: Resin Manufacturing 95% control or 4.5 kg/day VOC emissions limit	Rule 1141: Control of Volatile Organic Compound Emissions From Resin Manufacturing 95-98% control or 0.12 to 0.5 lb VOC emitted per 1000 lbs resin produced.	Rule 4684: Polyester Resin Operations 10 to 48 wt% VOC content & 25 g/l cleaning solvent
8-38: Flexible and Rigid Disc Manufacturing 85% control	N/A	N/A
8-43: Surface Coating of Marine Vessels 275 to 610 g/l	Rule 1106: Marine Coating Operations 275 to 780 g/l	Rule 4603: Surface Coating of Metal Parts and Products, Plastic Parts and Products, and Pleasure Crafts 275 to 880 g/l
8-49: Aerosol Paint Products 60 to 95 g/l	ARB Aerosol Coating Products Regulation 60 to 95 g/l	ARB Aerosol Coating Products Regulation 60 to 95 g/l
8-51: Adhesive and Sealant Products 30 to 850 g/l	Rule 1168: Adhesive and Sealant Applications 30 to 850 g/l	Rule 4653: Adhesive and Sealants 25 to 850 g/l

Implementation Actions:
The Air District will:
- Review applicable Air District rules for coatings, solvents, and adhesives and compare the VOC limits with limits in other Bay Area Air District rules and comparable VOC limits in other California air districts rules, such as the SCAQMD and SJVAPCD, and propose revised limits as appropriate. The table above is a cursory comparison of coating, adhesive, and solvent rules from the Air District to similar rules from the SCAQMD and SJVAPCD.
- A more comprehensive comparison of VOC limits for specific coating, adhesive, and solvent categories would be undertaken to determine which areas are most likely to present opportunities for additional emission reductions.

Emission Reductions:
Emission reductions will be calculated at time of rule-making.

Exposure Reductions:
N/A

Emission Reduction Trade-Offs:
N/A
Costs:
Specific costs will be estimated at time of rule-making.

Co-Benefits:
N/A

Issue/Impediments:
None.

Source:

1. South Coast Air Quality Management District, 2012 Air Quality Management Plan

SS26: Surface Preparation, Cleanup, and Equipment Cleaning Solvents

Brief Summary:
Lower the VOC limits for solvents used for surface preparation, cleanup, and equipment cleaning in Air District Rules 8-24, 8-29, 8-30, 8-35 and 8-38.

Purpose:
Reduce emissions of VOC from various surface preparation, cleanup, and equipment cleaning activities.

Source Category:
Stationary Source and Area Source: Evaporative emissions

Regulatory Context and Background:
Most Air District rules addressing surface preparation and cleanup and equipment cleaning solvents include a VOC limit for these materials. Air District Rules 8-4: General Solvent and Surface Coating Operations, 8-19: Surface Coating of Miscellaneous Metal Parts and Products, 8-31: Surface Coating of Plastic Parts and Products all have a VOC limit of 50 grams per liter (g/l) for surface preparation and cleanup, which is the most stringent in the Air District. However, there are several other Air District rules addressing solvent use that either do not contain solvent limits for surface preparation, cleanup, and equipment cleaning or have solvent limits in excess of 50 g/l. These Air District rules are Rules 8-24, 8-29, 8-30, and 8-35, and 8-38.

Air District Rule 8-24: Pharmaceutical and Cosmetic Manufacturing Operations only includes evaporation minimization measures. In comparison, South Coast AQMD Rule 1171, Sacramento Metropolitan AQMD Rule 466: Solvent Cleaning, and San Joaquin Valley APCD Rule 4663 include a VOC limit of 800 g/l for addressing surface preparation and cleanup for pharmaceutical production. Both Sacramento Metropolitan AQMD Rule 466 and San Joaquin Valley Rule 4663 include a 600 g/l limit for equipment cleaning for pharmaceutical production. Because Feather River APCD Rule 3-14: Surface Preparation and Clean-up does not have an explicit limit or exemption for cosmetic manufacturing, the default of 50 g/l limit would apply.

Air District Rule 8-29: Aerospace Assembly and Component Coating Operations contains no VOC limit for surface preparation and cleanup. South Coast AQMD Rule 1124: Aerospace Assembly and Component Manufacturing Operations and San Joaquin Valley APCD Rule 4605 Aerospace Assembly and Component Coating Operations both have VOC limits of 200 g/l for cleaning solvents and 300 g/l for stripping solvents.

Air District Rule 8-30: Semiconductor Wafer Fabrication Operations includes a VOC limit of 10 percent by weight for wipe cleaning in semiconductor manufacturing. This limit was established in 1998 and is higher than the Air District's most stringent solvent limit of 50 g/l VOC. South Coast AQMD Rule 1164: Semiconductor Manufacturing contains a 200 g/l limit for equipment cleaning. Sacramento Metropolitan AQMD, Rule 466 contains a 100 g/l limit for electronic components manufacturing, which could be interpreted to include semiconductor wafer fabrication.

Air District Rule 8-35: Coating, Ink and Adhesive Manufacturing includes a VOC limit of 200 g/l for equipment cleaning solvent. This limit was established in 1994 and is higher than the most stringent solvent limit of 50 g/l VOC found in many district regulations in other regions. San Joaquin Valley APCD Rule 4663 Organic Solvent Cleaning, Storage, and Disposal and South Coast AQMD Rule 1171 have a VOC limit of 25 g/l for general product cleaning and surface preparation and cleaning of coating or adhesive application equipment.

Most District rules addressing cleanup solvent include a VOC limit for these materials. Air District Rule 8-38: Flexible and Rigid Disc Manufacturing, Section 8-38-116 provides a blanket exemption for VOC emissions from "cleaning of disc coating or polishing equipment." Further, Air District Rule 8-4 also exempts surface preparation operations for flexible and rigid disc manufacturing operations subject to Rule 8-38. A review of Air District permit records indicates that there is only one operation that may be subject to this rule.

Implementation Actions:
The Air District will:

- Draft amendments to Rules 8-29, 8-30, and 8-35 that would reduce the VOC limit for general product cleaning, surface preparation, and equipment cleaning solvents to no more than 50 g/l or, if compliant products are suitably available, no more than 25 g/l.
- Consider possible removal of VOC emission exemptions from Rule 8-38.

Emission Reductions:
The four source categories addressed by these rules emit approximately 2.4 tons of VOCs per day (2.2 tons attributable to wipe cleaning); however, it is unknown what fraction of these emissions would be available to be reduced through the implementation of this control measure.

Exposure Reductions:
N/A.

Emission Reduction Trade-Offs:
None.

Costs:
Specific costs will be estimated during rule amendments.

Co-Benefits:
N/A.

Issue/Impediments:
Training of workers in the use of alternative solvents. Undetermined health or odor issues associated with potential alternatives.

Sources:

1. Bay Area Air Quality Management District, Rule 8-4: General Solvent and Surface Coating Operations.
2. Bay Area Air Quality Management District, Rule 8-16: Solvent Cleaning Operations.
3. Bay Area Air Quality Management District, Rule 8-19: Surface Coating of Miscellaneous Metal Parts and Products.
4. Bay Area Air Quality Management District, Rule 8-24: Pharmaceutical and Cosmetic Manufacturing Operations.
5. Bay Area Air Quality Management District, Rule 8-31: Surface Coating of Plastic Parts and Products.
6. Bay Area Air Quality Management District, Rule 8-35: Coating, Ink and Adhesive Manufacturing.
7. Bay Area Air Quality Management District, Rule 8-38: Flexible and Rigid Disc Manufacturing.
8. Feather River Air Quality Management District, Rule 3-14: Surface Preparation and Clean-Up.
9. San Joaquin Valley Air Pollution Control District, Rule 4663: Organic Solvent Cleaning, Storage, and Disposal.
10. South Coast Air Quality Management District, Rule 1171: Solvent Cleaning Operations.

SS27: Digital Printing Operations

Brief Summary:
This control measure would reduce VOC emissions from digital printing operations, most likely by one of two approaches:

- Adopting VOC limits on inks and solvents used, or
- Adopting control technology requirements.

Purpose:
Reduce emissions of VOC from digital printing operations.

Source Category:
Area Source-digital printing operations

Regulatory Context and Background:
District Regulation 8, Rule 20 (Rule 8-20): Graphics Arts Printing and Coating Operations limits organic emissions from traditional graphic arts operations during printing, coating, adhesive, and cleaning activities. Traditional printing technologies include lithographic, letterpress, gravure, flexographic, and screen printing. VOC emissions from such operations are reduced by the rule via VOC limits on various inks, coatings and solvents.

Maryland's Code of Regulations (Section 26.11.19.18F), for example, addresses VOC emissions from screen printing and digital printing. The regulation applies to persons, owners, or operators that perform screen printing, manufactures plastic cards, coats plywood used for signs, or digital imaging and causes VOC emissions of 20 pounds or more per day. The regulation sets requirements on the maximum VOC content of inks used for screen printing. As a general requirement, persons, owners, or operators of digital imaging subject to the regulation may not cause VOC emissions exceeding 100 pounds per day from all digital printing at the premises. Those subject to the regulation must maintain records for not less than 3 years on the use of inks, and VOC content of each type of ink.

Digital printing (DP) is a fairly new, non-traditional printing process that is emerging in virtually every segment of the graphic arts industry as well as other industries. In traditional printing and graphic arts, images are transferred from a press to a paper or paper-like product. In a small percentage of operations, images are applied to limited types of textiles. In the DP process a digital image that is stored on a computer is converted into an image that can be printed on a wide variety of substrates besides paper, such as many types of textiles, and three dimensional objects. This differs from traditional graphic arts printing, which uses fixed-image masters or "plates." One primary reason DP is gaining greater acceptance is that DP has a faster turnaround time because it requires considerably less setup time for each job compared to other printing processes. Furthermore, last minute revisions are easily carried out without having to make significant changes, and may have environmental advantages, such as reduced waste. The nine basic types of digital printing technology include liquid inkjet printing; thermal transfer printing; laser printing, liquid electrophotographic printing; electrostatic printing; solid ink printing; magnetographic printing; ionographic printing; and dye sublimation printing. Some digital printing operations utilize hydrocarbon mediums and some do not. Of all the digital printing operations, inkjet printing and electrophotographic printing appear to have the largest market share in the graphic arts industry on a world-wide basis. Although DP accounted for only about three percent of the total U.S. printing industry output in 1991, it is forecast to have at least a 20 percent market share by 2018.

A newer type of non-traditional printing process, known as 3D printing, is also emerging. 3D printing (or additive manufacturing) is a process of making three dimensional solid objects from a digital file. The creation of a 3D printed object is achieved using additive processes. In an additive process an object is created by laying down successive layers of material until the entire object is created. Each of these layers can be seen as a thinly sliced horizontal cross-section of the eventual object. There are many variations of 3D printing technologies. It is yet to be determined whether 3D printing should be classified as a digital printing category. The prevalence of 3D printing in the Bay Area is not yet known. The extent of organic vapor emissions from this industry is not known. However, some of the resin materials used to create 3D images is known to contain monomers which release organic vapors when polymerized.

Emissions from the DP industry are not regulated by the Air District's rule to control emissions from printing presses, Rule 8-20. However, the 2008 amendments to Rule 8-20 require certain large commercial digital printing operations to keep records of the usage of ink and other VOC-containing materials. Staff has identified two DP technologies that are believed to have significant emissions, Air District-wide: liquid electrophotographic printing and solvent-based inkjet printing. Solvent-based inkjet printers can produce images on the widest formats in the printing industry and use inks with high VOC contents. Inkjet printing and electrophotographic printing appear to be the most likely DP processes to emit significant ROG emissions.

Implementation Actions:
The Air District will:

- Determine VOC emission rates from various DP technologies in order to establish a DP emissions inventory. Determine the feasibility to control such emissions and whether the controls should be incorporated into the current graphic arts rule or a new DP rule.
- Consider establishing a limit for VOC emissions from DP facilities, such as Maryland's 100 pounds per day limit for example. Consider add-on controls or equipment requirements to control emissions.
- Consider establishing emission limits for each DP technology, allowing a combination of low-VOC materials and add-on controls, as necessary.

Emission Reductions:
It is estimated that 40 to 50 large, liquid electrophotographic presses may exist in the Bay Area. The number of large, commercial inkjet printers as well as other commercial DP operations is not known.

Exposure Reductions:
N/A

Emission Reduction Trade-Offs:
N/A

Costs:
Costs are unknown at this time. Some DP operations may reduce emissions through internal controls of ink usage, making ink and/or solvents available for re-use.

Co-Benefits:
- Reduction in ROG emissions may reduce emissions of toxic organic compounds.

Issue/Impediments:
Unlike traditional printing, technical barriers to the development of low-VOC inks may exist due to the nature of how the DP creates images. Inkjet printing relies on ink with a very low viscosity to be sprayed through tiny nozzles. Electrophotographic printing relies on the polarity of ink molecules to be attracted to charged plates.

Sources:
1. EPA Office of Compliance Sector Notebook Project: Profile of the Printing & Publishing Industry, 1995 http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/printpt1.pdf
1. EPA Design for the Environment Printing Industry Profile, http://www.p2pays.org/ref/01/00936/execsum.htm
2. Digital Printing: The Reference Handbook, 2004, Uri Levy & Gilles Biscos
3. Today's Digital Imaging: Version 5.0, 2005, Smart Papers
4. Conference call with Sandra Lowe-Leseth, Rule Developer, San Joaquin Valley Air Pollution Control District, 5/2/07
5. Code of Maryland Regulations: 26.11.19.18. 18 Control of Volatile Organic Compound Emissions from Screen Printing and Digital Imaging
6. Digital Printing Market Forecast to 2018: Smithers Pira https://www.smitherspira.com/market-reports/news/printing/digital-printing-trends-market-analysis-2018.aspx

SS28: LPG, Propane, Butane

Brief Summary:
Investigate potential ROG reductions by regulating filling of, and leakage from LPG, propane and butane tanks.

Purpose:
Reduce ROG emissions that occur when venting LPG, propane, and butane storage vessels during the filling process.

Source Category:
Area Source

Regulatory Context and Background:
The Air District already enforces tight gas requirements at stationary sources for a variety of operations, including refineries and bulk terminals. This control measure would set leakage allowance standards for Liquid Petroleum Gases (LPG), propane and butane tanks and connections, as well as prohibit or control venting during filling of such tanks.

Typically, LPG should occupy no more than 80 to 85 percent of the volume of a tank to allow for liquid expansion if a tank gets heated (such as by sunlight). These tanks have a bleed valve that indicates to the person filling the container when the level of liquid in the tank is at the “full” level (80 to 85 percent by volume). The current standard practice is to bleed LPG vapor from the tank while filling, and then stop filling when liquid LPG “spits” from the bleed valve. However, these tanks can be safely refilled without venting by filling to a final weight or by filling to a final liquid volume using a tank gage. A research project at CARB in 2009 indicated that technological solutions were available and cost effective.

California LPG demand is 652 million gallons per year. Bay Area demand is approximately 20 percent, based on population. Approximately 40 percent of the LPG is used for residential heating and cooking, 40 percent industrial, 13 percent commercial, and 7 percent transportation uses. ROG fugitive emissions from LPG in the Bay Area are estimated to be 7,200 pounds per day.

South Coast Air Quality Management District (SCAQMD) adopted a rule (Rule 1177) in June 2012 that requires:

- A vapor tight vapor recovery system for LPG bulk loading facilities,
- Use of new filling technology, or a low emission Fixed Liquid Level Gauge (FLLG) at LPG transfer and dispensing facilities.
- New cargo tanks manufactured after 7/1/2013 must be fitted with a low emission FLLG.
- A cylinder or portable storage tank must be fitted with a low emission FLLG by 7/1/2017.
- The owner/operator must develop and implement and Leak Detection and Repair (LDAR) program.
- Appropriate record keeping.

Provisions do not apply to any container less than 4 gallons, or LPG cylinders used with recreational vehicles.

Implementation Actions:
The Air District will:

- Investigate the potential for a new rule to regulate VOC emissions from LPG storage facilities, equivalent to SCAQMD Rule 1177.

Emission Reductions:

Pollutants*	2020	2030
ROG	5,000	5,000

**criteria pollutants are reported in lbs/day*

Emissions Reduction Methodology:
ROG fugitive emissions from LPG in the Bay Area are estimated to be approximately 7,200 pounds per day. ROG emission reductions are estimated to be 5,000 pounds per day, based on expected reduction of about 70 percent fugitive LPG emissions with the proposals in Rule 1177.

Exposure Reductions:
None

Emission Reduction Trade-Offs:
None

Costs:
Costs for vapor tight vapor recovery system for LPG bulk loading facilities, low emissions connectors, and low emissions Fixed Liquid Level Gauge (FLLG) will total about $9.1M capital, amortized to $1.4M annually, and $0.4M annually for operating costs.

Co-Benefits:
None

Issue/Impediments:
None.

Sources:

1. South Coast Air Quality Management District Rule 1177, and Staff Report, June 1, 2012
2. Maximus™ SFI – Measurement and Reduction of Gas Outage Gauge Emissions, the ADEPT Group, Inc. California Air Resources Board, Chair's Air Pollution Seminar, March 19, 2009

SS29: Asphaltic Concrete

Brief Summary:
Cutback and emulsified asphalts are used to seal and repair roads, parking lots, walkways and airport runways. Other locations in the US have more restrictive petroleum distillate (solvent) limits for these liquid asphalt products than is currently required in the Bay Area. Some locations have limits for emulsified or cutback asphalt set at no more than 0.1 wt. percent ROG. This measure is intended to reduce ROG emissions from asphalt.

Purpose:
Reduce reactive organic emissions that are precursors to ozone formation

Source Category:
Area source – emulsified asphalt

Regulatory Context and Background:
The 2008 Massachusetts State Implementation Plan (SIP) identified Asphalt Paving as an area of opportunity to reduce ROG, however it does not appear that Massachusetts took any action on that initiative. The current Massachusetts limit for ROG in cutback asphalt is 5 weight percent. Maine established a requirement in 2010 limiting ROG content during summer months for both cutback and emulsified asphalt to no more than 0.1 wt. percent ROG. South Coast and San Joaquin Valley air districts limit ROG content of cutback asphalt to 0.5 volume percent, and limit ROG content of cutback asphalt to 3 volume percent. Similarly, Air District Regulation 8, Rule 15 currently allows 0.5 volume percent distillates (described as petroleum solvents) in Slow-Cure Liquid Asphalt, and 3.0 volume percent distillates in emulsified asphalt.

In a related issue, a recent study by the Institute for Research and Technical Assistance (IRTA) determined that asphalt contractors were using diesel fuel to clean their equipment.[1] IRTA found that recycled vegetable oil worked just as well with reduced concerns about toxicity.

Implementation Actions:
Air District staff will:

- Evaluate the cost effectiveness, and feasibility of limiting solvent content of emulsified asphalt.
- Evaluate the availability of substitutes to diesel to clean asphalt related equipment.

Emission Reductions:

Pollutants*	2020	2030
ROG	400	400

**criteria pollutants are reported in lbs/day*

[1] "Alternative Low-VOC Release Agents and Mold Cleaners for Industrial Molding, Concrete Stamping and Asphalt Applications", IRTA, October 2013.

Emissions Reduction Methodology:
Current emissions estimated for emulsified asphalt is 600 pounds of ROG per day. The control measure would reduce the solvent limit in cutback asphalt from 0.5 percent to 0.1 percent, and in emulsion asphalt from 3.0 percent to potentially as low as 0.1 percent. However, because a new limit would likely include some exemptions for solvents higher than 0.1 percent, staff conservatively estimated that emissions could be reduced by two thirds, which would be a reduction of 400 lb/day. Actual reductions could be higher, depending on the specific details of the new limit.

Exposure Reductions:
None

Emission Reduction Trade-Offs:
None

Costs:
Solvents / distillates are generally the most expensive component of emulsified asphalt, except for the emulsifying agent. Reducing ROG content may reduce the costs to manufacture. These costs may be offset by higher product testing and quality assurance costs during the transition to the lower ROG content materials.

Co-Benefits:
None

Issue/Impediments:
None

Sources:

1. EPA AP-42: Emission factors for Asphalt Paving Operations, Chapter 4.5
2. CARB Attachment C: Asphalt Paving and Roofing, from STI's Area Source Emissions Updates, March 2003.
3. Rita Leahy, Consultant for California Asphalt Pavement Association
4. Massachusetts Department of Environmental Protection, 310 CMR 7.18
5. Maine Department of Environmental Protection, Chapter 131, Cutback Asphalt and Emulsified Asphalt
6. South Coast Air Quality Management District, Rule 1108, 1108.1
7. San Joaquin Valley Air Pollution Control District, Rule 4641

SS30: Residential Fan-Type Furnaces

Brief Summary:
This control measure would reduce oxides of nitrogen (NO_X) emissions from fan type central furnaces by reducing allowable NO_X emission limits on new furnace installations in Regulation 9, Rule 4 (Rule 9-4). Also, Rule 9-4 would be amended to apply to non-residential furnaces in the same size range.

Purpose:
Reduce emissions of NO_X from fan-type central furnaces.

Source Category:
Combustion

Regulatory Context and Background:
The Air District's Rule 9-4 is a "point-of-sale" type regulation, requiring that any new residential furnace rated up to 175,000 BTU/hr be certified to meet 40 nanograms (ng) of NO_X per joule of delivered heat, which is equivalent to an emission concentration of about 55 ppmv at 3 percent oxygen. Rule 9-4 was adopted and last amended in 1983. In 2009, the South Coast Air Quality Management District (SCAQMD), which previously imposed the same 40 ng/joule NO_X limit as Rule 9-4 in their Rule 1111, adopted a future NO_X limit of 14 ng/joule for most categories of central furnace rated up to 175,000 BTU/hr (conventional units, high-efficiency condensing units, mobile-home units), with the first category subject to the reduced limit in October 2014. As of the beginning of 2014, SCAQMD staff reported to their governing board that manufacturers had developed and tested prototype furnaces in each device category that comply with the 14 ng/joule NO_X limit, but that commercial versions of these devices were not yet available, and that Rule 1111 might be amended in 2014 to address this timing issue. In September 2014, Rule 1111 was indeed amended to delay the compliance date for condensing (high efficiency) units until April 1, 2015, and to allow up to three years' delay for residential furnace manufacturers to meet the 14 ng/joule emission limit with payment of a mitigation fee.

The intent of this control measure is to reduce NOx and CO emissions. In a broader context, the Air District is working with local governments and others to phase out the use of fossil fuel-based technologies in buildings, as part of the Air District's large-scale effort to reduce greenhouse gas emissions (see BL2: Decarbonize Buildings). When it is not feasible to install a non-fossil fuel-based furnace, this control measure ensures that the furnace installed uses best available retrofit control technology (BARCT). This control measure establishes maximum allowable NOx and CO emission levels for a specified type and size range of furnace. Any future greenhouse gas reduction rules the Air District may develop as part of its climate protection strategy may restrict commerce in or use of certain types of fossil fuel combustion devices, including devices addressed in NOx and CO BARCT rules.

Implementation Actions:

The Air District will:

- Develop amendments to Rule 9-4 to include the 14 ng/joule NO_X limit that appears in SCAQMD Rule 1111 and extend the rule to non-residential applications.
- Explore opportunities regarding the use of fossil fuel-based technologies in residential and non-residential space heating (see BL2: Decarbonize Buildings).

Emission Reductions:

Pollutants*	2020	2030
NO_x	13,200	13,200

**criteria pollutants are reported in lbs/day*

Emission Reductions Methodology:

Because the amended rule will apply only to new devices and because central furnaces have an average life of about 20 years, the emission reductions from this measure will be phased in as existing furnaces are replaced. Emissions reductions will be 12,000 to 14,400 pounds per day after the measure is fully implemented (emission reductions in the table above represent an average of these two estimates). This estimate is based on a 65 percent reduction (14 ng/joule versus 40 ng/joule) of the 2011 NO_X inventory for domestic space heating using natural gas fuel (17,220 pounds/day), plus some portion of commercial natural gas use (4,820 pounds/day). The inventory also includes industrial natural gas use (5,880 pounds/day), but this is assumed to not be used for space heating.

Exposure Reductions:

Not applicable to NO_X emissions.

Emission Reduction Trade-Offs:

Depending on the technology selected, NO_X reductions may increase GHG emissions, specifically CO_2, by reducing efficiency of the combustion process. This trade-off is unlikely for this control measure, however, because efficient low-NO_X burners have been developed for similar types of appliances. New forced air heaters will probably be more efficient than the ones they replace, reducing GHG emissions.

Costs:

In the staff report for Rule 1111, South Coast AQMD estimated that compliance with a 14 ng/joule NO_X limit would cost from $9,400 to $20,750 per ton of NO_X reduced and would result in an additional consumer cost of $118 to $223 per furnace, all in 2014 dollars.

Co-Benefits:

Because NO_X compounds in the atmosphere contribute to the formation of secondary particulate matter (PM), any NO_X emission reduction will also result in a reduction of $PM_{2.5}$. Secondary PM is formed from the conversion of NO_X to ammonium nitrate (NH_4NO_3). District staff has estimated the ratio between NH_4NO_3 formation to NO_X emissions to range between 1:6 and 1:10. Assuming a NO_X emission reduction of 12,000 to 14,400 pounds/day, and a particulate formation factor of 1:8, secondary particulate matter will be reduced by 1,600 to 1,800 pounds/day by the control measure.

Issue/Impediments:
No specific issues or impediments have been identified.

Sources:
1. South Coast Air Quality Management District, Rule 1111
2. Bay Area Air Quality Management District (BAAQMD), Regulation 9, Rule 4

SS31: General Particulate Matter Emission Limitation

Brief Summary:
Reduce the Air District's emissions limits for particulate matter.

Purpose:
Reduce particulates, especially PM2.5.

Source Category:
Permitted stationary sources

Regulatory Context and Background:
There are currently seven Air District rules directly addressing particulate matter (PM) emissions:

- Regulation 5: Open Burning
- Regulation 6, Particulate Matter, Rule 1: General Requirements
- Regulation 6, Particulate Matter, Rule 2: Commercial Cooking Equipment
- Regulation 6, Particulate Matter, Rule 3: Wood Burning Devices
- Regulation 6, Particulate Matter, Rule 4: Metal Recycling and Shredding Operations
- Regulation 9, Inorganic Gaseous Pollutants, Rule 13: Nitrogen Oxides, Particulate Matter, and Toxic Air Contaminants from Portland Cement Manufacturing
- Regulation 12, Miscellaneous Standards of Performance, Rule 4: Sand Blasting
- Regulation 12, Miscellaneous Standards of Performance, Rule 13: Foundry and Forging Operations

Regulation 6: Particulate Matter was originally adopted by the Air District on October 18, 1973, and then amended on December 17, 1975 to allow enforcement of limits on smoking motor vehicles. Regulation 6 was amended on January 5, 1983, and again on July 11, 1990 to be consistent with the California Health and Safety Code regarding emissions from pile driving equipment. On December 19, 1990, Regulation 5: Open Burning was amended, and minor adjustments were made to Reg. 6 for consistency. On December 5, 2007, Regulation 6: Particulate Matter was renumbered and retitled to Regulation 6, Particulate Matter, Rule 1: General Requirements. This was done to accommodate a new rule for commercial charbroilers, titled Regulation 6: Particulate Matter, Rule 2: Commercial Cooking Equipment. Regulation 6, Particulate Matter, Rule 3: Wood Burning Devices was adopted on July 9, 2008 to address $PM_{2.5}$ from wood stoves and fireplaces during the winter. On September 19, 2012 the District adopted Regulation 9, Rule 13, which controls nitrogen oxides, particulate matter, and toxic air contaminants from Portland cement manufacturing. On May 1, 2013, the District adopted two rules: Regulation 6, Rule 4: Metal Recycling and Shredding Operations, and Regulation 12, Rule 13: Foundry and Forging Operations. Both of these rules require plans to control fugitive emissions of particulate matter. Regulation 5 Open Burning was amended on June 19, 2013.

The general requirement limits for particulate matter emissions in Rule 6-1 are:

- Particulate emissions (TSP) must be less than 343 milligrams per dry standard cubic meter (mg/dscm), or 0.15 grains per dry standard cubic foot (gr/dscf); and
- No more than 20 percent opacity for stack emissions (or no more than Ringelmann 1.0 for uncontained plumes) for no more than 3 minutes in any hour.

Many existing stationary sources with PM emissions have been modified over the years. Permit conditions have been established to require Best Available Control Technology (BACT) when these sources were installed, modified, or replaced, requiring more stringent levels of control than required by Rule 6-1. These permit conditions often also define testing, monitoring, reporting and recordkeeping requirements.

<u>Comparison of Air District PM Regulations to other air districts</u>

Air District rules controlling particulate matter are less stringent in certain respects than similar rules in other urban air districts in the state. Rule 6-1 limits PM to 0.15 gr/dscf, where the limit is 0.10 gr/dscf in several other air districts. Rule 6-1 limits based on "process weight" are less restrictive than in South Coast, San Joaquin Valley and Sacramento air districts. In addition, South Coast also establishes a PM concentration limit, in both milligrams per dry cubic meter (mg/dscm), and grains per dry standard cubic foot (gr/dscf) based on volumetric flow rate, culminating in a limit of 0.01 gr/dscf for volume flows exceeding 70,000 cubic meters per minute (~ 2.5 million standard cubic feet per minute).

Requirements for visible emissions are very similar throughout California's air districts. Most visible emissions are limited based on the Ringelmann scale or within a specific opacity limit using an opacity sensing device. Visible limits are often based on a "not to exceed" limit of three or four minutes within any 60-minute period. Visible emissions are also sometimes limited to remaining within the source's property boundaries.

One difference among local air district rules for PM is that the Bay Area Air District has just a few all-inclusive PM rules, where other air districts have recognized several specific industries or categories of PM sources, and have developed specific PM rules for each industry or category. As the Air District moves forward in further controlling PM emissions, staff will consider the largest source categories of PM emissions and determine the best approach to control each category.

The 2017 Plan control strategy will also have control measures that limit PM emissions through its source specific proposed rules and control measures, e.g. enforce ARB regulations to reduce PM emissions from diesel engines in the Bay Area communities most impacted by PM emissions (SS39: Enhanced Air Quality Monitoring); continue and enhance its program to reduce residential wood-burning (SS34: Wood Smoke); and provide grants and incentives to reduce emissions of particulate matter and BC from heavy-duty vehicles (TR19); PM from trackout (SS36); and PM from asphalt operations (SS37).

State and Federal PM Requirements

California air pollution control laws address particulate matter from stationary sources in several specific ways. They set standards for diesel pile-driving hammers, and for sandblasting so that they are consistent throughout the state. State law also addresses requirements on portable equipment for consistency. State law provides guidelines for the local air districts to regulate agricultural burning. Almost all other state PM related regulations are directed at mobile sources – primarily diesel engines.

Federal regulations from the United States Environmental Protection Agency limiting particulate matter encompass a wide variety of stationary sources. The Air District enforces these federal requirements. Air District requirements can be more stringent, as needed, to achieve National and California Ambient Air Quality Standards.

Implementation Actions:

The Air District will

- Investigate the potential for a new or amended rule that considers application of available control technology to reduce or revise allowable weight rate limitations on existing PM emissions sources.

Emission Reductions:

Pollutants*	2020	2030
$PM_{2.5}$	300	300
PM_{10}	600	600

**criteria pollutants are reported in lbs/day)*

Emission Reductions Methodology:

The emissions reductions were conservatively calculated for only the four BART car cleaning stations, which are the largest facilities that would be affected by this control measure. Adding baghouses or electrostatic precipitators would reduce total suspended particulate (TSP) and PM_{10} emissions at each of these facilities by 210 pounds per day. The facilities operate five days per week, and the emissions reductions are averaged out over a seven-day week. Approximately half of these estimated 600 pounds of TSP and PM_{10} reductions would consist of $PM_{2.5}$

Exposure Reductions:

Particulate matter from stationary sources can also contain toxics, depending on the specific source.

Emission Reduction Trade-Offs:

Minor – some additional energy required to operate cyclones/baghouses, or roto-clones/ESP's due to increase in pressure drop across these devices.

Costs:

Both initial capital cost and annual cost (based on EPA Cost Models, in 2012 dollars) can vary depending on control technology and size. A wet scrubber can cost between $85,000 to $488,000, with annualized costs ranging from $25,000 to $146,000. Cyclones range from $64,000 to over $600,000, and have varying annual costs. Baghouses range from $278,000 to just over $900,000; while ESPs are the most expensive and cost anywhere from 1.8 million to nearly $4.4 million.

Cost effectiveness is dependent on the loading of particulates at the inlet.

Co-Benefits:
None identified.

Issue/Impediments:
None Identified.

Source:

1. Bay Area Air Quality Management District, 2014 amendments to Rule 6-1, workshop report.

SS32: Emergency Back-up Generators

Brief Summary:
Emergency back-up generators (BUGs) provide power when primary sources are unavailable (e.g. during blackouts or brownouts). Most BUGs are powered by diesel fired engines that emit diesel particulate matter (DPM), a toxic air contaminant (TAC), and black carbon which contributes to climate change. Beginning with the year 2000, the federal government and the State of California have enacted progressively stricter emissions standards for diesel engines that power BUGs, but thousands of BUGs that do not meet current standards remain in operation. Draft Regulation 11, Rule 18 (Rule 11-18) will address health risks resulting from all significant sources of TAC emissions, including emergency BUGs.

Purpose:
This measure will reduce emissions of DPM and black carbon from BUGs through Draft Rule 11-18, resulting in reduced health risks to impacted individuals, and in climate protection benefits. Black carbon's short atmospheric lifetime, combined with its strong warming potential, means that targeted strategies to reduce black carbon emissions can provide climate benefits within the next several decades.

Source Category:
Stationary sources – emergency back-up generators

Regulatory Context and Background:
Stationary diesel engines are regulated at the federal, state and local level. DPM is not classified as a hazardous air pollutant by US EPA, but many components of diesel emissions are identified as such. Federal requirements for diesel engines are contained in the National Emission Standard for Hazardous Pollutants (NESHAP) from Stationary Reciprocating Internal Combustion Engines and the New Source Performance Standards (NSPS) for stationary diesel engines. The NESHAP issued in 2004 targets toxic emissions (formaldehyde, acrolein, methanol, acetaldehyde, among others) from stationary compression and spark ignited engines located at major facilities and area sources of hazardous air pollutants. In 2006, US EPA promulgated the NSPS establishing emission standards for criteria pollutants from new engines, modeled after US EPA standards for non-road and marine diesel engines. These included progressively more stringent emissions standards phased in over several years (tiers one through three), with the most stringent tier (tier four) for prime (non-emergency) engines requiring add-on controls such as selective catalytic reduction (SCR) for NO_x and diesel particulate filters (DPF) for PM.

State requirements for diesel engines stem from identification of DPM as a TAC by the California Air Resources Board (CARB) in 1998. In 2000, CARB approved a risk reduction plan to reduce PM emissions from diesel fueled engines and vehicles with a recommendation for an 85 percent reduction in cancer risk from these sources by 2020. In 2004, the stationary compression ignition engine Air Toxics Control Measure (ATCM) was adopted to limit public exposure to diesel PM, establishing emission limits for new and in-use stationary diesel engines. Emissions standards are linked to state off-road compression ignition engine standards and implementation schedules based on model year and size of the engine. Emissions certification standards are phased in as tiers one through four becoming more stringent and coming into effect in 4 to 5 year increments, similar to federal standards. In 2007, the ATCM was amended to establish standards for in-use stationary diesel engines used in agricultural applications. The ATCM was further amended in 2011 to eliminate the need for new emergency standby engines to meet the tier four standards which require add-on controls and align direct drive fire pump engines with NSPS standards.

In response to CARB's identification of DPM as a TAC in conjunction with problems with the California energy grid, the Air District amended Regulation 2, Rule 1 in 2001 to eliminate a permit exemption for engines used for stand-by power. In addition, as part of that rulemaking, Regulation 9, Rule 8 (Rule 9-8) was amended to clarify the conditions under which standby engines may be operated during emergencies. In 2007, Rule 9-8 was further amended to regulate emissions of NO_X from diesel engines along with other amendments for internal combustion engines fired by gaseous fuels and liquid fuels other than diesel.

No air district has implemented add-on controls or emission standards (aside from limiting hours for maintenance and testing) to reduce emissions from existing BUGs, and most air districts implement the ATCM adopted in 2004 by CARB for controls on new engines. South Coast Air Quality Management District places slightly more stringent requirements on new engines located near sensitive receptors.

Over 6,700 diesel fired engines are permitted in the Air District for emergency standby power (electrical power generation and pumps). This represents over one quarter of all permitted sources in the Air District. Of the 6,700 permitted BUGs in the Bay Area, 40 percent predate US EPA emissions standards as well as emissions certification by CARB, and so they are known as tier zero engines. Less than 15 percent of the permitted BUGs meet the current level of control required for new engines (tier 4), and approximately 400 engines have installed add on emission controls.

Annual DPM emissions from all permitted BUGs are relatively small in total mass. According to the 2011 inventory, BUGs operating in the Air District account for 18 tons per year of total particulate. Annual black carbon emissions from BUGs account for less than 14 tons per year district-wide. Some older, higher-emitting BUGs may present health risks if they are used in proximity to residential or other sensitive receptors.

Implementation Actions:
Air District staff will implement Rule 11-18, once adopted. See SS20: Air Toxics Risk Cap and Reduction from Existing Facilities for more detail on this rule and its implementation.

Emission Reductions:

Pollutants*	2020	2030
CO_{2e}	0	1.8

**CO_{2e} is reported in metric tons/year (100 yr GWP)*

Emission Reductions Methodology:
Emissions reductions from back-up generators were estimated by assuming that replacement of old generators with newer, cleaner generators, including solar-powered generators, could reduce emissions by approximately 25 percent from current emission levels.

Emission Reduction Trade-Offs:
None

Costs:
The cost to implement this measure varies by age and size of engine, and by control device. The oldest engines, tier zero engines which predate USEPA standards, would likely face replacement costs. CARB has yet to certify any control device for use with tier zero engines. Therefore, any application of control devices on a tier zero engine would require some sort of additional verification. In most cases, replacement of the engine would be a more likely outcome considering years of service and the additional costs of source testing for compliance verification. The cost to replace a back-up generator is approximately $121 dollars per horsepower ($121/hp). Engines can vary in size from less than 50 to over 4,600hp. A small engine (50 hp) would face a cost of $6,050, while the replacement cost of a 2,000hp engine could equal $556,600. The majority of engines in the Bay Area that are Tier 0 are less than 610hp, and therefore would cost approximately $73,810. (Source #1 adjusted from 2003 to 2015 dollars)

Newer engines can implement control devices. Control devices to reduce emissions include active and passive diesel particulate filers, known as DPFs. An active DPF cost approximately $113/hp, and a passive DPF is estimated to be $67/hp. Active filters are more commonly installed, as a passive DFP would require additional maintenance costs. Filter costs can range from $5,650 to over $519,000 – depending upon engine size. The average engine in the Bay Area, that is over Tier 0, is less than 750hp – an active DPF would cost $84,750 for a 750hp engine. (Source #5 adjusted from 2012 to 2015 dollars).

Co-Benefits:
In addition to having lower emission rates of DPM, newer engines emit less carbon monoxide (CO), reactive organic gases (ROG), and oxides of nitrogen (NOx). Back-up generators do not represent a large percentage of the Air District inventory for these pollutants, however. Some operators may choose to replace older BUGs with cleaner technologies, such as fuel cells or propane-fired engines instead of purchasing new diesel-fired units.

Issues/Impediments:
There is a large inventory of permitted tier zero BUGs, and there may be additional unpermitted BUGs. In developing and implementing Rule 11-18, the Air District will conduct extensive outreach to communicate all regulatory changes to the large number of affected stakeholders, which span many different industries.

Sources:

1. CARB; Staff Report; Initial Statement of Reasons for Adoption of the Proposed Airborne Toxic Control Measure for Stationary Compression-Ignition Engines, Emissions Assessment Branch, Stationary Source Division, CARB; September 2003
2. California Air Resources Board; Staff Report; Final Statement of Reasons for Rulemaking: Proposed Amendments to the Airborne Toxic Control Measure for Stationary Compression-Ignition Engines; October 2010
3. Regulatory Impact Analysis for Existing Stationary Reciprocating Internal Combustion Engines (RICE) NESHAP, Final Report; US EPA Office of Air Quality Planning and Standards, Air Benefit and Cost Group; February 2009
4. Regulatory Impact Analysis for Reconsideration of Existing Stationary Reciprocating Internal Combustion Engines (RICE) NESHAP; US EPA Office of Air Quality Planning and Standards, Health and Environmental Impact Division, Air Economics Group and Risk and Benefits Group; January 2013
5. South Coast Air Quality Management District; Revised Staff Report; Proposed Amended Rule 1110.2 –Emissions from Gaseous- and Liquid- Fueled Engines; August 2012
6. Bay Area Air Quality Management District; HRSA Streamlining Policy Report for Stationary Emergency Standby and Fire Pump Diesel Engines; May 2015
7. Bay Area Air Quality Management District; Backup Generator Emission Factor Study; January 2015

SS33: Commercial Cooking Equipment

Brief Summary:
Air District Regulation 6, Rule 2 (Rule 6-2) requires installation of certified control devices for chain driven and underfired charbroilers (grills). At this time, no control devices have been certified for underfired charbroilers. This measure would amend Rule 6-2 so that the Air District can approve control devices for underfire charbroilers.

Purpose:
To further reduce particulate matter (PM) emissions from commercial cooking operations.

Source Category:
Stationary Sources

Regulatory Context and Background:
In 2007, the Air District passed Rule 6-2, which limits PM emissions when cooking beef at chain driven charbroilers and underfired charbroilers. Chain driven charbroilers are semi-enclosed, mechanically driven cookers commonly used at fast food establishments. Underfire charbroilers are generally recognized as grills. Food preparation contributes a significant proportion to the PM inventory in the Bay Area.

Because chain driven charbroilers can be delivered with ready-made control devices, many units in the Bay Area are controlled. To date, however, there are no approved control devices for underfired charbroilers. The current version of Rule 6-2 establishes an emission limit of 1.0 lbs PM/1000 pounds of meat cooked. Recent evidence from the University of California, Riverside shows that this limit is not attainable because the original emission factors were not realistic (too low). In order to certify control equipment for underfire charbroilers, another certifying criterion, such as percent control efficiency, will be required.

Implementation Actions:
The Air District will determine adequate criteria for approving add-on equipment to control PM emissions from underfire charbroilers, amend Rule 6-2, and develop an implementation plan for the amended rule.

Emission Reductions:

Pollutants*	2020	2030
$PM_{2.5}$	n/a	340

**criteria pollutants are reported in lbs/day*

Emission Reductions Methodology:
Emissions reductions are calculated by first estimating current emissions based on the amount of beef and other meat cooked on a commercial charbroiler per day and then applying appropriate emissions factors. With 20 percent of charbroilers producing 80 percent of emissions, emissions reductions were calculated by assuming that half of those emissions could

be eliminated with appropriate devices. This was a conservative assumption given that some devices show 80 percent effectiveness.

Exposure Reductions:
Restaurants often operate in or near residential and commercial areas. Reductions in PM and associated air toxics will occur near peoples' homes and in or near shopping and recreation areas.

Emission Reduction Trade-Offs:
Modest additional electricity required to operate the control devices.

Costs:
Specific costs will be estimated during rule amendment.

Co-Benefits:
Related reductions in organic compounds and air toxics.

Issue/Impediments:
None identified.

Sources:

1. Bay Area Air Quality Management District, Regulation 6, Rule 2, *Commercial Cooking Equipment*, December 5, 2007
2. Bay Area Air Quality Management District, Draft Staff Report, Regulation 6, Rule 2, *Commercial Cooking Equipment*, November, 2007
3. University of California, Riverside, College of Engineering-Center for Environmental Research and Technology, "Comparison of Particulate Matter Emissions Measurement for a Commercial Charbroiling Process with and without Controls," Final Draft Report, prepared for Bay Area Air Quality Management District

SS34: Wood Smoke

Brief Summary:
The Air District amended Regulation 6 Particulate Matter and Visible Emissions, Rule 3: Wood-Burning Devices in late 2015 to impose additional significant restrictions on wood burning. However, wood smoke continues to be a significant contributor to $PM_{2.5}$ exceedances during the winter, when low winds can result in the formation of an inversion layer over the Bay Area. Exemptions currently in place in Rule 6-3 allow homes without any other form of permanent heat to burn wood in an EPA certified wood burning device. This control measure considers banning wood burning completely during Spare the Air episodes.

Purpose:
Reduce wood smoke during Winter Spare the Air alerts

Source Category:
Area Source – wood burning devices

Regulatory Context and Background:
The Air District adopted Rule 6-3 in 2008, and later amended it on October 21, 2015. This rule has been very effective at reducing wood smoke emissions. During the winter season from November through February, $PM_{2.5}$ emissions from wood smoke are estimated to average 34,000 pounds per day. When the Air District calls a Winter Spare the Air Alert, $PM_{2.5}$ emissions from wood smoke are estimated to be reduced to approximately 720 pounds per day. The Bay Area still periodically exceeds air quality standards for fine particulates. Therefore, staff is identifying further opportunities to reduce $PM_{2.5}$ emissions, including considering a complete ban of wood burning during Winter Spare the Air Alerts.

Implementation Actions:
Air District staff will:
- Investigate further limits on wood burning, including additional limits to exemptions from existing Rule 6-3, Wood Burning Devices.

Emission Reductions:

Pollutants*	2020	2030
$PM_{2.5}$	60	60

**criteria pollutants are reported in lbs/day*

Emission Reductions Methodology:
$PM_{2.5}$ emissions from wood smoke are estimated to average 34,000 pounds per day during the winter season. During Winter Spare the Air Alerts, when Rule 6-3 restrictions are in effect, $PM_{2.5}$ emissions from wood smoke are approximately 720 pounds per day. Complete ban of wood burning during Winter Spare the Air Alerts will reduce $PM_{2.5}$ emissions by 60 pounds per day for each Winter Spare the Air Alert (typically 15 – 25 nights each winter), or approximately 72,000 pounds per year.

Exposure Reductions:
Rule 6-3 reduces $PM_{2.5}$ exposure, especially in certain locations where wood smoke may accumulate. A large and growing body of scientific evidence indicates that both short-term and long-term exposure to fine particles can cause a wide range of health effects, including: aggravated asthma and bronchitis; hospital visits for respiratory and cardiovascular symptoms; and contributes to strokes and heart attacks, some of which result in premature deaths. The evidence also shows that reducing PM emissions can reduce mortality and increase average life span. Therefore, measures that reduce PM emissions may have a significant impact on public health.

Emission Reduction Trade Offs:
None, although some perceive wood as a renewable source of energy. The Environmental Impact Report (EIR) completed in 2008 during the development of the original Rule 6-3 indicated that most firewood comes from old-growth trees and land clearing, not from managed tree farms.

Costs:
Individuals with homes without an alternative permanent source of heat may need to install one. Many of these homes are in rural areas, so natural gas is not available. The simplest approach is to add electric space heaters. Electric heat is quite expensive, but would be required only during Winter Spare the Air Alerts. Other forms of permanent alternative heat, such as a heat pump and associated air ducts are much more expensive, estimated at $10,000 capital. Heating costs are dependent on the type of alternate heat. Heat pumps are very efficient, so electric heat pump on-going costs are comparable with natural gas costs. Propane heat is efficient, but propane is expensive. Further cost impacts would be evaluated during rule development.

Co-Benefits:
Wood smoke contains some black carbon, which is a short-lived climate pollutant; further reduction of wood burning would decrease black carbon emissions.

Issue/Impediments:
Some members of the public are strongly in support of a complete ban on wood burning, while other members of the public may not support further limits on wood burning.

Sources:
1. Bay Area Air Quality Management District, staff report for amendments to Rule 6-3, 2015
2. US Environmental Protection Agency, Report to Congress on Black Carbon, 2012. Available at: http://www3.epa.gov/blackcarbon/2012report/fullreport.pdf

SS35: Particulate Matter from Bulk Material Storage, Handling and Transport, Including Coke and Coal

Brief Summary:
The Air District has been receiving complaints about black dust from petroleum coke and coal storage and transfer operations. This dust is leaving black residue on residential property and business equipment. South Coast AQMD Rule 1158 addresses coke, coal (and elemental sulfur) storage and handling. The intent of this measure is to develop a new regulation to control fugitive dust from bulk material operations throughout the Bay Area, including petroleum coke and coal storage and handling operations.

Purpose:
Reduce public nuisance complaints and $PM_{2.5}$ emissions from storage, handling and transport of all bulk materials with potential to create fugitive dust, particularly petroleum coke and coal storage and handling operations.

Source Category:
Point Sources – bulk material handling including petroleum coke and coal storage and transfer operations

Regulatory Context and Background:
Regulation 6, Particulate Matter, Rule 1: General Requirements (Rule 6-1) currently has a provision that does not allow particulates from a source to cross the property line and impact neighbors. Enforcement of this provision of Rule 6-1 is difficult when trying to identify the specific source of excessive dust. Bulk materials including petroleum coke and coal dust are easier to trace, but more explicit requirements and performance standards are needed to reduce impacts from bulk material storage and handling operations.

Implementation Actions:
Air District staff will develop a new rule, Regulation 6, Particulate Matter, Rule 8: Bulk Material Storage, Handling and Transport to prevent and control wind-blown fugitive dust from these types of storage and handling operations. Establish enforceable visible emission limits to support preventive measures such as water sprays, enclosures to surround the bulk materials, and wind barriers. Consider enhanced controls where sources are located near sensitive populations or areas currently impacted by cumulative sources of air pollution.

Emission Reductions:

Pollutants*	2020	2030
$PM_{2.5}$	4	4
PM_{10}	32	32

**criteria pollutants are reported in lbs/day*

Emission Reduction Methodology
PM emissions of fugitive dust from coke and coal storage and handling operations are currently estimated to be 0.21 tpd TSP, 0.064 tpd PM_{10}, and 0.007 tpd $PM_{2.5}$. Controls for fugitive dust include enclosures or wind brakes to reduce wind-blown dust, and water sprays or wetting agents to improve moisture content and bind silt to the bulk coke or coal. Enclosures with secondary controls (baghouses) of dust emissions are 95 percent effective. Wind screens and water sprays may be more practical for existing facilities, and are expected to be 50 – 75 percent effective. Based on conservative assumption that control requirements are applied to 50 percent of sources, emission reductions are estimated to be 32 pounds/day PM_{10}, and 4 pounds per day $PM_{2.5}$.

Exposure Reductions:
The main threat to urban populations near bulk material storage facilities is the very small particles from dust that may develop from wind erosion or through handling of these solid materials. Particles from coal and petroleum coke piles are highly visible and the source of many complaints from the surrounding community. Small particles (less than 2.5 microns) have been found to cause a wide range of health impacts. In addition, coke oven workers have been found to have higher incidents of lung cancer, bronchitis, and chronic obstructive pulmonary disease (COPD).

Petroleum coke is known to contain polycyclic aromatic hydrocarbons (PAH's), and high levels of nickel and vanadium. The nickel and vanadium were found in water runoff, but further study is needed to identify risks to aquatic life. Plants using water with high metals are found to also contain high metals. Toxicity studies relevant to human health found PAH's do not leach into the water streams. Petroleum coke exposure does not lead to higher incidents of types of cancer, and showed low reproductive and developmental toxicity. Coal is lower in silt content, as well as lower in PAH's, but metals levels in coal can be higher.

Emission Reduction Trade-Offs:
Enclosures and wind screens are one-time projects, so the only emissions impacts occur during construction. If secondary controls (baghouses) are required for the enclosures, they require energy but typically not more than 100 HP. Water consumption is a concern during drought periods, however many facilities can recycle water used for wetting the storage piles and transfer systems. Occasionally reclaimed water may be available.

Costs:
Enclosures can cost as much as $500,000 in capital expenses, depending on difficulty of retrofit with the existing facilities. Secondary controls on the enclosures, like baghouses can cost an additional $250,000 in capital. Wind screens are much lower cost – typically no more than $50,000 for a large facility. Transfer systems (conveyors) need wind screens and spillage control added, usually less than $20,000 per conveyor. Water spray systems can be quite inexpensive – less than $10,000 each. If water spray mist is needed, an air compressor to generate the mist can cost an additional $10,000. Water control and recycle systems can be significant, as much as $250,000.

Co-Benefits:
Fugitive dust control will help reduce regional haze, and can also help reduce black carbon particulate matter that contributes to climate change.

Issue/Impediments:
None identified.

Sources:
1. BAAQMD proposed amendments to 6-1, and new 6-8 associated workshop reports.
2. "Petroleum Coke in the Urban Environment: A Review of Potential Health Effects", International Journal of Environmental Research and Public Health, 29May2015

SS36: Particulate Matter from Trackout

Brief Summary:
The intent of this measure is to develop a new regulation, Regulation 6, Particulate Matter; Rule 6: Trackout (Rule 6-6), to address mud and dirt that can be "tracked out" from construction sites, bulk material storage, and disturbed surfaces onto public paved roads where vehicle traffic will pulverize the mud and dirt into fine particles and entrain them into the air.

Purpose:
Reduce $PM_{2.5}$ emissions from trackout of mud and dirt onto paved public roadways.

Source Category:
Area Sources – construction sites, bulk material storage

Regulatory Context and Background:
Particulate matter emissions due to trackout at construction sites is not currently subject to Air District regulations. However, PM from trackout is subject to state requirements for large construction sites. These requirements mandate the preparation of a Storm Water Pollution Prevention Plan; the plan includes provisions for reducing trackout.

Trackout dust can contain much higher levels of fine particulate matter – because mud and dirt that are tracked out onto paved roads can be subsequently pulverized by passing vehicles into silt, then entrained into the air as fine particulate by the wind currents from the passing vehicles.

Implementation Actions:
The Air District will:
- Develop a new rule to prevent trackout onto paved roads, establish visible emission limits to prevent trackout, require cleanup if the trackout is significant, and limit visible emissions of dust during cleanup of any material that is tracked out.

Emission Reductions:

Pollutants*	2020	2030
$PM_{2.5}$	360	360
PM_{10}	2,460	2,460

**criteria pollutants are reported in lbs/day*

Emission Reductions Methodology:
The Air District's 2011 emissions inventory indicates the following emissions from road dust on paved local streets: 16.7 tons per day (tpd) TSP, 9.8 tpd PM_{10} and 5.8 tpd $PM_{2.5}$. Road dust from freeways, major roads, or collector roads are not included in the inventory, since bulk material sites and other disturbed surface sites typically do not exit directly on these types of roads. These emission reduction estimates assume that 50 percent of local road dust comes from track-out, and that better enforcement will reduce that road dust by 25 percent. As a

result, there would be a 12.5 percent reduction in road dust on local roads, resulting in a reduction of 2.69 tpd TSP (5,380 lb/day), 1.23 tpd PM_{10} (2,460 lb/day), and 0.18 tpd $PM_{2.5}$ (360 lb/day).

Exposure Reductions:
A large and growing body of scientific evidence indicates that both short-term and long-term exposure to fine particles can cause a wide range of health effects, including: aggravated asthma and bronchitis; hospital visits for respiratory and cardiovascular symptoms; and contributes to strokes and heart attacks, some of which result in premature deaths. The evidence also shows that reducing PM emissions can reduce mortality and increase average life span. Therefore, measures that reduce PM emissions may have a significant impact on public health.

Emission Reduction Trade-Offs:
Possible exhaust emissions and dust from street sweepers during the cleanup of trackout materials. Cleanup by hand, or using a PM_{10} efficient regenerative street sweeper, can minimize this dust during cleanup.

Costs:
Trackout prevention typically consists of using grizzly bars or rumble grates, or a truck wheel wash system. Most facilities are currently equipped with grizzly bars, but the bars often fill with mud and stop working effectively. Truck wheel wash systems can cost $150,000 in capital, and $1,000 per month in operating costs. Cleanup can typically be completed with two workers and hand tools.

Co-Benefits:
Fugitive dust control will help reduce regional haze.

Issue/Impediments:
None identified.

Source:
1. Bay Area Air Quality Management District, proposed amendments to 6-1, and new Regulation 6-6 workshop reports

SS37: Particulate Matter from Asphalt Operations

Brief Summary:
This measure would develop a new regulation, Regulation 6, Particulate Matter, Rule 7: Asphalt Operations (Rule 6-7), to prevent condensable particulate matter when paving asphalt is loaded into storage bins on a delivery truck. Similarly, this measure would prevent condensable particulate matter when chip seal asphalt is sprayed onto a roadway. These particulate matter (PM) emissions are condensed asphalt aerosols known as “blue smoke”. This regulation will require blue smoke abatement, and establish visible emissions limits for these operations. In addition, this measure would establish a requirement to use low fuming asphalt for all roofing asphalt operations.

Purpose:
Reduce $PM_{2.5}$ emissions from paving asphalt, chip seal asphalt, and roofing asphalt.

Source Category:
Point Sources – Particulate Matter for Asphalt Plants
Area Sources – Particulate Matter for Chip Seal Paving and Roofing Asphalt operations

Regulatory Context and Background:
Visits to asphalt plants identified vapors coming from paving asphalt as it is loaded into delivery trucks as significant sources of visible smoke. This smoke consists of small condensed aerosols from asphalt vapors, commonly referred to as “blue smoke”. Chip seal operations are also large sources of “blue smoke”. In addition, roofing asphalt is heated to application temperatures in a heating device known as an asphalt kettle. Hot roofing asphalt and asphalt kettles also produce smoke, and since application is usually in populated areas, odors are also a concern.

Implementation Actions:
The Air District will:
- Develop a new rule to prevent blue smoke emissions from paving asphalt and chip seal operations and to require “low fuming” roofing asphalt for roofing asphalt operations.
- Investigate whether more use of Warm Mix Asphalt rather than Hot Mix Asphalt is a viable method to reduce PM emissions.

Emission Reductions:

Pollutants*	2020	2030
$PM_{2.5}$	175	175

**criteria pollutants are reported in lbs/day*

Emission Reductions Methodology:
PM emissions of blue smoke from paving asphalt operations are estimated to be 240 pounds per day $PM_{2.5}$ (50 pounds per day from each of three large paving asphalt plants) for approximately eight months of the year (during the paving season). Similarly, PM emissions of blue smoke from chip seal operations are estimated to be 120 pounds per day of $PM_{2.5}$ for six

months of the year. Controls for blue smoke emissions from these sources are expected to be 75 percent effective, resulting in emission reductions of 270 pounds per day of $PM_{2.5}$ or 30 tons per year (tpy). PM emissions of smoke and fumes from roofing asphalt is estimated to be 250 pounds per day, and control from the polymer in low fuming asphalt is conservatively expected to be 70 percent, resulting in emission reductions of 175 pounds per day of $PM_{2.5}$ for approximately 8 months each year (21 tpy).

Exposure Reductions:
A large and growing body of scientific evidence indicates that both short-term and long-term exposure to fine particles can cause a wide range of health effects, including: aggravated asthma and bronchitis; hospital visits for respiratory and cardiovascular symptoms; and contributes to strokes and heart attacks, some of which result in premature deaths. The evidence also shows that reducing PM emissions can reduce mortality and increase average life span. Therefore, measures that reduce PM emissions may have a significant impact on public health.

Emission Reduction Trade-Offs:
Operations of blue smoke abatement will require some energy use, estimated to be less than 50 horsepower for each abatement device. No trade-offs for the polymer used in low fuming roofing asphalt.

Costs:
Blue smoke abatement facilities are estimated to cost $200,000 capital, amortized to $30,000 per year plus $10,000 per year operating costs. Low fuming asphalt raises the cost of roofing asphalt approximately $1.00 above the base of $40 - $45 per 100 lb. plug.

Co-Benefits:
Low fuming roofing asphalt for asphalt operations is approximately 75 percent less odorous than regular roofing asphalt.

Issue/Impediments:
None.

Source:

1. Bay Area Air Quality Management District, proposed amendments to Regulation 6-1, and proposed Regulation 6-7, workshop reports

SS38: Fugitive Dust

Brief Summary:
Air District staff are currently developing amendments for Regulation 6, Particulate Matter, and Rule 1: General Requirements (Rule 6-1). In addition, Air District staff are developing specific targeted fugitive dust and particulate matter controls for proposed Rule 6-6: Trackout; proposed Rule 6-7: Asphalt Operations, and proposed Rule 6-8: Bulk Material Storage and Handling, Including Coke and Coal. This control measure proposes that Air District staff review and recommend controls for a broader range of more general sources of fugitive dust, such as large construction sites, and disturbed surfaces larger than 1 acre.

Purpose:
Reduce particulate matter (PM_{10} & $PM_{2.5}$) fugitive dust emissions from traffic and other operations on construction sites, large disturbed surfaces, and other sources of fugitive PM emissions.

Source Category:
Area Sources

Regulatory Context and Background:
Air District staff are developing amendments to Rule 6-1, and developing new rules for three sources of fugitive dust: trackout of mud and dirt onto paved public roads; smoke and fumes from paving and roofing asphalt operations; and dust from petroleum coke and coal storage and handling.

Fugitive dust from construction sites and bulk material handling operations are sources of PM_{10}, and to a lesser extent sources of $PM_{2.5}$. In addition, control of fugitive dust from these sources will reduce regional haze. This measure will evaluate potential control strategies in preparation of future rulemaking opportunities.

Implementation Actions:
Air District staff will:
- Evaluate the availability of cost-effective control strategies for these sources of particulate matter and consider future rulemaking.
- Consider applying the proposed fugitive dust visible emissions limits to a wider array of sources.
- Consider enhanced controls where sources are located near sensitive populations or areas currently impacted by cumulative sources of air pollution.

Emission Reductions:

Pollutants*	2020	2030
$PM_{2.5}$	500	500
PM_{10}	5,750	5,750

**criteria pollutants are reported in lbs/day*

Emission Reductions Methodology

Total current PM emissions of fugitive dust from construction sites and from disturbed surfaces are estimated to be 46,000 pounds per day of TSP, 23,000 pounds per day of PM_{10} and 2,000 pounds per day $PM_{2.5}$. Staff assumes that half of all fugitive dust comes from large sources, greater than 1 acre. Controls for fugitive dust from large sources are estimated to result in a 50 percent reduction in PM emissions, or a reduction of 11,500 pounds per day TSP, 5,750 pounds per day PM_{10} and 500 pounds per day $PM_{2.5}$.

Exposure Reductions:

None

Emission Reduction Trade-Offs:

None, although concern about additional water usage to control fugitive dust may raise questions about the priority of air quality versus water conservation. These concerns are valid if water sources used for fugitive dust control are mostly potable water rather than reclaimed water.

Costs:

Fugitive dust control costs are typically minor. In many cases, these resources / costs are already in place to comply with existing Storm Water Pollution Prevention Plan requirements. Incremental costs to comply with proposed fugitive dust requirements are very low. Costs for application of fugitive dust requirements to sources that are not currently controlled are dependent of the size and nature of the source, but can be as high as $100,000 capital and total $30,000 per year amortized and operating costs to reduce 3 tons per year of PM.

Co-Benefits:

Fugitive dust control will help reduce regional haze.

Issue/Impediments:

Concern that additional source will require additional water resources during severe drought seasons.

Source:

1. Bay Area Air Quality Management District, proposed amendments to Regulation 6-1, and proposed Regulations 6-6, 6-7, and 6-8 associated workshop reports.

SS39: Enhanced Air Quality Monitoring

Brief Summary:
The Air District will evaluate and enhance its capabilities, as resources permit, to monitor air quality on a region-wide basis, as well as on a localized basis in the impacted communities identified under the Air District's Community Air Risk Evaluation (CARE) program.

Purpose:
The purpose of this measure is to provide the Air District with sufficient ambient air quality monitoring data needed to inform: 1) its efforts to improve air quality in impacted communities and 2) its air quality planning and modeling programs.

Source Category:
Not applicable.

Regulatory Context and Background:
In 2015, the Air District had 32 air monitoring stations operating in the Bay Area. An additional air monitoring station (Point Reyes) is operated by the California Air Resources Board. The air monitoring network is designed to: 1) provide the data required to determine the Bay Area's attainment status for both National and State ambient air quality standards; 2) provide air quality data to the public in a timely manner; and 3) support air pollution research and modeling studies. Additionally, a network of air toxic monitors collects data to ensure permit conditions are met at stationary sources and for State and National regulatory programs. The Air District's 2014 Air Monitoring Network Plan describes recent and planned changes and improvements to the Air District's air monitoring network.

In recent years, the Air District has undertaken initiatives, such as the Community Air Risk Evaluation (CARE) program and the Clean Air Communities Initiative, to analyze pollution exposure at a more localized level and identify communities that are disproportionately impacted by air pollution. In many cases, these communities correspond to areas identified as priority development areas (PDAs) under Plan Bay Area - the region's Sustainable Communities Strategy. Plan Bay Area encourages infill development in PDAs to promote smart growth and reduce sprawl, thus reducing automobile use and emissions. The data and information generated from these initiatives allows the Air District to implement more targeted policies and programs to reduce emissions and exposures in these communities.

The Air District has developed limited enhanced monitoring capabilities of key pollutants to gather more complete data to better assess local air quality conditions based upon the resources available. As an example, the Air District has conducted special air monitoring studies in areas impacted by wood smoke, deployed air toxics monitoring at a proposed school site in Newark, and in past years has implemented similar monitoring sites in Berkeley, Cupertino, and Benicia to address local air quality concerns. Such efforts generally require a minimum of one year of data collection to effectively characterize an area's air quality, but can require longer periods to properly assess local air quality trends. These efforts are resource intensive, requiring expensive instrumentation, specialized operators, coordination among many Air District staff, and long site-development and set-up times.

Additionally, as part of the implementation of Regulation 12-15 (See SS10: Petroleum Refining Emissions Tracking), the Air District will require enhanced fenceline air monitoring at refineries. Rule 12-15 requires refinery owner/operators to prepare and submit to the Air District an air monitoring plan for establishing an air monitoring system and, upon Air District approval of the plan, to install and operate fenceline monitors.

The Air District will also site and operate additional community air monitors via a Community Monitoring Program. The goal of the community monitoring program is to establish air monitoring stations in areas where major stationary sources may contribute to impacts in local communities. Data from these newly established monitoring locations would be used to compare air quality in potentially impacted communities with air quality measurements at other Air District sites. While it is important to recognize that sampling results from ambient air monitoring stations cannot usually be attributed to air pollutants from specific sources, monitoring in areas with large stationary sources will allow residents to determine if air quality in their neighborhoods is significantly different than other Bay Area locations. The first communities to have monitoring stations established will be those with refineries and other significant sources in their vicinity.

Implementation Actions:

Air District will:

- Ensure representative air quality data is being collected in the impacted communities identified under the CARE program. This effort would require review of the existing monitoring network with respect to the impacted communities to ensure that appropriate long term air quality data is being collected.
- Enhance monitoring of local air quality by collecting more information about pollutant concentrations and exposure at localized levels. This effort would be focused around microenvironments that may have significant local emission sources that could be assessed through the use of temporary monitors.
- Partner with County Health Departments to identify areas of poor air quality and collaborate with the community on ways to potentially measure and reduce exposure and emissions from local and regional sources.
- Require petroleum refineries to prepare and submit to the Air District an air monitoring plan for establishing an air monitoring system. Upon plan approval, require installation and operation of fenceline monitors.
- Implement the Community Monitoring Program.

Emission Reductions:
Control measure does not directly reduce emission; however, it does support emissions reduction programs.

Emission Reduction Methodology:
Not applicable.

Exposure Reduction:
Control measure does not directly reduce exposure but supports exposure reduction efforts.

Emission Reduction Trade-offs:
None identified.

Cost:
Costs would vary depending on the extent of enhanced monitoring implemented. Available resources would be determined through the Air District's budget process.

Co-benefits:
Not applicable.

Issues/Impediments:
Enhanced air quality modeling will require additional resources, including purchase of new instrumentation, equipment maintenance, and additional staff with technical expertise in atmospheric chemistry, and background and familiarity with monitoring equipment.

Sources:

1. Bay Area Air Quality Management District, *2014 Air Monitoring Network Plan*, July 2015, http://www.baaqmd.gov/~/media/files/technical-services/2014_network_plan.pdf?la=en
2. Bay Area Air Quality Management District, Staff Report, Proposed Air District Regulation 12, RULE 15: Petroleum Refining Emissions Tracking, April 2016
   Bay Area Air Quality Management District, Staff Report, Proposed Amendments to District Regulation 3: Fees, April 2016

SS40: Odors

Brief Summary:
This control measure would revise Air District Regulation 7 to reduce emissions of odorous substances and place emission limits on odor compounds. Revisions to Regulation 7 would also incorporate industry requirements to develop and identify odor management practices and control measures, and integrate odor detection technologies and evaluation methods. The rule amendment process would include reviewing the effectiveness of the current standards and consider best available technologies to reduce odors.

Purpose:
Reduce emissions from odorous compounds and improve enforceability of Regulation 7.

Source Category:
Stationary source and area source: industrial and commercial operations

Regulatory Context and Background:
In 1970, the Air District was directed by the State Legislature to establish standards for the emission of identifiable odorous substances. On August 2, 1972, the Air District adopted Regulation 2, Division 15 - Odorous Substances, which set emissions limits for five odorous compounds. The rule was originally intended to reduce odorous emissions from operations such as refineries, sewage treatment plants, and rendering plants. In 1976, the regulation was amended to alter the applicability to sources that generated citizen odor complaints, to establish general limitations on odorous substances to be evaluated by an odor panel, and to set limitations on total reduced sulfur (TRS) from kraft pulp mills.

Later the rule was renamed Regulation 7 – Odorous Substances. Between 1976 and 1982, the Air District restructured the regulations which resulted in two substantive amendments to Regulation 7 including, removing the sampling and analysis procedures for odorous substances and including those in a Manual of Procedures, and removing kraft pulp mill requirements and creating a new regulation entitled TRS from Kraft Pulp Mills. Through the Air District's Compliance and Enforcement Program odorous facilities are identified and those facilities are placed on a list of plants subject to Regulation 7.

Since adoption of Regulation 7 in 1972, changes in the Bay Area's population density and the closer proximity of industrial and manufacturing processes to residential areas and public spaces has resulted in significant odor impacts in certain communities. In 2015, the Air District received and responded to 4,946 odor complaints. Seventy-three percent of those odor complaints came from a single community in the Bay Area, alleging odors from solid waste and other organic waste related facilities in the area.

In 2011, in response to the California Legislature's goal of reducing solid waste going to landfills by 75 percent, CalRecycle recommended a statewide strategy to divert organic wastes from landfills. As a result, cities and counties across the Bay Area began utilizing old and new technologies to divert organic wastes and to convert organic wastes to energy and reusable materials. The decomposition of organic waste, once almost exclusively occurring at landfills and sewage treatment plants, is now creating odors at diverse operations of all sizes. These process changes to existing operations and addition of new types of operations have the potential to cause significant increases and changes in odors throughout nearby communities.

Strengthening the requirements and odor standards of the rule will help further reduce odor nuisances and allow the Air District to enforce limits on odorous compounds that negatively impact air quality in the Bay Area.

Implementation Actions:
The Air District will:

- Propose amendments to Regulation 7 to strengthen odor standards and enhance enforceability. An evaluation of newer air monitoring technologies will be aimed at increasing enforceability of the rule with respect to a wider range of odorous compounds and sources.

  Amending Regulation 7 will include the following emission reduction strategies and objectives:
  - Evaluate the complaint threshold that triggers applicability of the regulation.
  - Evaluate and identify source types that can attribute to odor complaints.
  - Identify odorous compounds that are associated to industrial and commercial operations.
  - Review the effectiveness of existing odor thresholds and emissions limits.
  - Evaluate methods of detection and monitoring practices of odorous compounds.
  - Amend regulatory requirements to ensure best management practices for the control of odorous emissions, such as the requirement of odor mitigation plans.

Emission Reductions:
N/A

Emission Reduction Methodology:
N/A

Costs:
N/A

Co-Benefits:
There are a wide range of chemical compounds that are odorous, some of which are toxic air contaminants (TAC), and others which are non-methane organic compounds (NMOC) that contribute to the creation of ground level ozone. Beyond reducing odor nuisances and impacts to surrounding communities, reducing odorous compounds reduces the emission of TACs and NMOCs.

Issue/Impediments:
There may be opposition from industries that have odorous sources of operations that have received a substantial number of odor complaints and are subject to the rule.

Source:
1. California Department of Resources Recycling and Recovery (CalRecycle). August 2015. *AB341 Report to the Legislature.* Publication # DRRR-2015-1538.

TR1: Clean Air Teleworking

Brief Summary:
The primary objective of the Clean Air Teleworking measure is to increase the number of employees who telework in the Bay Area, especially on Spare the Air days, by providing outreach and assistance to employees and employers.

Purpose:
This measure will reduce emissions of the key ozone precursors, ROG and NOx, particulate matter, toxic air contaminants and greenhouse gases by reducing vehicle use associated with commuting throughout the Bay Area, especially on poor air quality days.

Travel Market Affected:
This measure would affect intraregional and inter-regional commute travel for people who work in the Bay Area.

Regulatory Context and Background:
Since July 1, 1995, each state agency has been required to implement a telecommuting plan as part of its telecommuting program in work areas where telecommuting is identified as being both practical and beneficial to the organization. In 2008, state policy went further when then Governor Schwarzenegger signed Executive Order S-04-08 encouraging telecommuting to ease congestion in the Sacramento area during the temporary closure of Interstate 5.

The state's policies on telecommuting are based on the theory that "appropriately planned and managed, telework is a viable work option that can benefit managers, employees, and customers of the State of California." According to the state's Executive Order, a good telework program increases the state's ability to respond to emergencies, amplifies effective use of new technologies within state service, and improves employee morale, which results in increased job effectiveness.

At the regional level, in 1995 the Association of Bay Area Governments (ABAG) operated a regional telecommuting assistance program. The program was funded through a grant of $185,000 from the Air District. The objective of the program was to eliminate automobile trips by increasing the number of people telecommuting to work. The Bay Area Telecommuting Assistance Project was a partnership of ABAG and the Alameda County Transportation Commission (then called the Alameda Congestion Management Agency), who provided matching funds.

ABAG's Telecommuting Assistance Project targeted employers with 100 or more employees to reduce the number of automobile trips to their work site. The project provided regional information and referral service to all employers and public agencies interested in telecommuting. The project also included one-on-one implementation assistance to selected employers. ABAG staff also developed and provided training for employee transportation coordinators on how to implement a telecommuting program. After a couple years of funding, ABAG's telecommuting program ended due to limited staff funding.

Bay Area Commuter Benefits Program; Alternative Benefit Option
The Bay Area Commuter Benefits Program includes a provision for employers to propose an alternative commuter benefit (Option 4). The alternative option may be especially relevant for employers whose work sites are not well served by transit. In March of 2015, the Air District and MTC developed an Option 4 Guide, which is intended to assist employers in developing and implementing an alternative commuter benefit, pursuant to Option 4.

Option 4 includes teleworking as a primary measure for employers in the region. For the purpose of administering a telework program, the Air District and MTC recommends that employers implement a companywide telework policy, and suggest that employees who participate in teleworking do so at least once per week on a regular basis.

Implementation Actions:
MTC will:
- Continue to provide support to employers for regional telecommuting programs in partnership with 511 Rideshare and the Bay Area Commuter Benefits Program.
- Continue to fund MTC's Regional Climate Initiatives Program: Innovative Grants.
- Initiate a Telecommute Pilot Project as part of the 2040 Plan Bay Area.

The Air District will:
- Include Spare the Air notifications to all Employer Program members that include the promotion of teleworking/telecommuting on Spare the Air Days.

Emission Reductions:

Pollutants*	2020	2030
ROG	1,474	620
NO_x	886	389
$PM_{2.5}$	157	118
PM_{10}	374	282
DPM	475	390
TACs	0.20	0.15
CO_{2e}	430,675	319,517

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:
MTC's regional travel demand model (Version 0.3 of Travel Model One) was used to estimate the VMT impacts of this measure. The California Air Resources Board emission model (EMFAC 2014) calculated pollutant impacts. CO_2 conversion/equivalency factors were used to estimate the emission reduction benefits for the criteria pollutants and mobile source air toxics (MSATs). MTC's regional travel demand model provides the framework for simulating the impacts of

telecommuting, including assumptions regarding employment status and whether or not individuals choose to work at home or not on a given day.

Exposure Reduction:
This measure will reduce air pollution emitted by vehicles and therefore will reduce the concentration of air pollution that people are exposed to on a daily basis. Impacted communities near freeways and roads with significant auto and truck traffic will benefit.

Emission Reduction Trade-offs:
None identified.

Cost:
Cost estimates are not available for this measure.

Co-benefits:
Telecommuting benefits both the employer and the employee. Employers gain an increase in productivity, a reduction in office space costs, improved employee retention, and a reduction in recruiting and training costs. Telecommuters benefit from having less stress associated with commuting, and spending more time with family and friends, rather than commuting.

Issues/Impediments:
The most common challenges to implementing a telecommuting program are convincing management to support the necessary scheduling and technological changes required for telecommuting and navigating through a number of legal issues relating to federal and state wage and hour laws. With the worker off-site, it becomes difficult to track time worked, overtime liability, and compliance with meal and rest periods.

Sources:

1. Noonan, Mary C., Glass, Jennifer L., *The Hard Truth about Telecommuting,* Monthly Labor Review, July 2012, http://www.bls.gov/opub/mlr/2012/06/art3full.pdf
2. California Government Code, Chapter 1389 Statutes of 1990, Section 14200 -14203 (as authorized by AB 2963 – Klehs)
3. Lewis, Patricia, A Feasibility Study of Implementing a Telecommuting Program at Booz-Allen and Hamilton, 1994 http://pfigliola.tripod.com/project.html
4. The Association of Bay Area Governments, the Bay Area Telecommuting Assistance Project, http://www.abag.ca.gov/abag/overview/pub/newsletter/svm295.html
5. Global Workplace Analytics, http://www.globalworkplaceanalytics.com/telecommuting-statistics
6. Maryland Department of the Environment, *Plan to Improve Air Quality in the Baltimore an, MD Region: State Implementation Plan (SIP) "Serious Area SIP",* July 2013

TR2: Trip Reduction Programs

Brief Summary:
The Trip Reduction measure includes a mandatory and voluntary trip reduction program. The regional Commuter Benefits Program, resulting from SB1339, and similar local programs in jurisdictions with ordinances that require employers to offer pre-tax transit benefits to their employees are mandatory programs. Voluntary programs include outreach to employers to encourage them to implement strategies that encourage their employees to use alternatives to driving alone.

Purpose:
This measure will reduce emissions of the key ozone precursors, ROG and NOx, greenhouse gases, particulate matter and toxic air contaminants by reducing commute trips, vehicle miles traveled, and vehicle emissions.

Travel Market Affected:
This measure would affect commute trips for people who work in the Bay Area.

Regulatory Context and Background:
While commute trips make up less than a third of personal trips they tend to be longer distance trips and they make up most peak hour trips when traffic congestion is the worst. For these reasons, reducing commute vehicle trips can have a significant impact on reducing congestion and improving air quality.

Employees may choose to drive alone to work for a variety of reasons:

- Workplaces are not near transit or home locations.
- Barriers to ridesharing, e.g. information, personal preferences, lack of other riders, etc.
- Lack of pedestrian or bicycle connectivity to transit.
- Lack of “first mile” or “last mile” connectivity at origin or destination.
- Lack of bicycling amenities such as bicycle racks/lockers or showers at transit stations or workplaces.
- Availability of free (or underpriced) vehicle parking.

Mandatory Programs
Senate Bill 1339 authorized the Air District and the Metropolitan Transportation Commission to adopt and implement a Bay Area Commuter Benefits Program on a pilot basis through the end of 2016. The bill was modeled on local commuter benefit ordinances that have already been adopted by several Bay Area cities in recent years, including the cities of Berkeley, Richmond, and San Francisco (as well as San Francisco International Airport). In response to Senate Bill 1339, the Air District adopted Regulation 14, Rule 1: Mobile Source Emissions Reduction Measures, Bay Area Commuter Benefits Program. Shortly thereafter, MTC ratified the rule. Senate Bill 1128, approved September 2016, extended the Commuter Benefits Program indefinitely.

SB 1339 requires employers with greater than 50 employees to provide one of four alternative commute friendly strategies: 1) establish the option for employees to set aside pre-tax salary to pay for their transit or vanpool costs, 2) provide at least a $75/month transit subsidy to all employees, 3) provide a shuttle service from a transit hub to the work location, or 4) provide another approved alternative.

While it is assumed that all employers subject to SB1339 will implement a Commuter Benefits Program, MTC and the Air District support compliance through web-based self-help tools and other employer outreach efforts. Through 511.org, employers may access detailed employer assistance materials to select a commuter benefit option and an on-line registration process. Employer services representatives are also available in each county to offer employers with additional assistance through the 511 Regional Rideshare Program or local county programs.

Compliance with the Commuter Benefits Program is also monitored by Air District staff through verification of on-line registrations against lists of all Bay Area employers with greater than 50 employees. Air District staff conducts outreach to companies and government agencies subject to this Rule and participates in regular meetings with partners MTC and 511.org regarding implementation and management of the registration database. Staff also reviews alternative compliance plans from employers and complaints from employees for compliance with the Commuter Benefits Rule.

Voluntary Programs

The 511 Program has evolved to keep pace with the changing needs of consumers, advances in technology, and the availability of travel data. MTC has delivered traveler information since the mid-1990s, when it launched a multi-modal telephone service and a separate regional transit information website. 511 is now a consolidated, comprehensive, multi-media, multi-modal traveler information service. While Bay Area 511 information is available via phone and web, there are slight differences in how the information is presented due to limitations of the media. Because of web capabilities, the 511.org website is able to offer broader information and more detailed and interactive information to users than what could reasonably be provided via the 511 phone service.

511 Rideshare is one component of the 511 Program. Historically, 511 Rideshare has reached out to employers to encourage them to implement strategies to reduce vehicle trips to their worksites. However, 511 Rideshare's mission is carpool and vanpool formation. Therefore, beginning in approximately mid-2016, 511 Rideshare will move from employer-focused outreach to commuter-focused outreach. The program will leverage partnerships with private sector carpool matching applications for ridematching, instead of maintaining its own ridematch system. 511 Rideshare will also include a permanent Vanpool Support Program to offset ongoing vanpool capital and/or operating costs, incentivizing vanpool service providers to form more vanpools.

The purpose of changing 511 Rideshare is to improve carpool and vanpool formation, embrace private sector innovation/tools, and get the biggest ‘bang for the buck’ out of limited program funds.

In 1991, the California State Legislature authorized the Air District to impose a $4 surcharge on motor vehicles registered within the San Francisco Bay Area to fund projects that reduce on-road motor vehicle emissions. The Air District has allocated these funds to its Transportation Fund for Clean Air (TFCA) program to fund eligible projects. The statutory authority for the TFCA and requirements of the program are set forth in California Health and Safety Code Sections 44241 and 44242.

Sixty percent of TFCA funds are awarded directly by the Air District to eligible projects and programs implemented directly by the Air District (e.g., Spare the Air, Plug-in Electric Vehicle Program) and to a program referred to as the TFCA Regional Fund. The remaining forty percent of TFCA funds are forwarded to the designated agency within each Bay Area county and distributed by these through the County Program Manager program. Approximately $4 million is allocated through the Regional Fund each year to support trip reductions projects, including shuttle and rideshare service, which reduce single-occupancy vehicle commute-hour trips by providing the short-distance connection between a mass transit hub and employment centers and rideshare projects that reduce single-occupancy commute-hour vehicle trips by encouraging mode-shift to other forms of shared transportation.

Trip Cap Programs
Multiple trip cap programs have been developed in Stanford, Menlo Park, Mountain View, Sunnyvale, and Cupertino. A “trip cap” restricts the number of commute trips into an employment site or into an employment area. For example, in Menlo Park, the trip cap at the Facebook East Campus restricts the number of vehicle trips allowed to the campus during peak commute periods, “Between 7AM and 9AM, Facebook East Campus may have no more than 2,600 vehicle trips. Hourly trip measurement must be provided to the City of Menlo Park, using sensors at driveway entrances. For each trip above the cap, Facebook shall pay a penalty of $50 per day per trip. After noncompliance over 6 months, the fee increases to $100 per day per trip.”

Implementation Actions:
MTC will:
- Refocus 511 Rideshare on carpool and vanpool formation.
- Create a Vanpool Support Program.
- As part of the Climate Initiatives Innovative Grants program, continue to fund travel demand management projects.
- Study new opportunities for Trip Cap program development in Plan Bay Area 2040.

The Air District will:
- Work with employers to support implementation and compliance with the Commuter Benefits Program.

- Continue to provide grants through the Transportation Funds for Clean Air (Regional Fund and County Program Manager Fund) to support trip reduction efforts.
- Encourage local governments to require mitigation of vehicle travel as part of new development approval, adopt transit benefits ordinances in order to reduce transit costs to employees, and to develop innovative ways to encourage rideshare, transit, cycling, and walking for work trips.
- Encourage transit agencies and shuttle providers to continue to implement and expand shuttle and feeder bus services to complement fixed route transit service and reduce the demand for parking at transit stations.

Emission Reductions:
Emission reductions for Commuter Benefits Program portion of this control measure are estimated as follows:

Pollutants*	2020	2030
ROG	61	41
NO_x	54	24
$PM_{2.5}$	10	10
PM_{10}	24	24
CO_{2e}	28,739	20,066

**criteria pollutants are reported in lbs/day; CO_{2e} is reported in metric tons/year (100 yr GWP)*

Emission Reductions Methodology:
Emission reduction estimates are based on a 2015 analysis of the results of the Commuter Benefits Program over the first twelve months of the pilot project, *Commuter Benefits Program: Evaluation of Trip, VMT and Emission Impacts* Report, including participation rates in the program. That report is available here: http://www.baaqmd.gov/~/media/files/planning-and-research/commuter-benefits-program/reports/true-north-employee-survey-report_commuter-benefits-program_6_19_15-pdf.pdf?la=en) Reductions in vehicle miles traveled were estimated based on the results of a survey of employees who work for employers that are subject to the regulation, in combination with employer registration information. Years 2020 and 2030 emission factors were applied to estimated year 2015 vehicle trip reduction estimates, assuming continuation of the program into 2030.

Exposure Reduction:
This measure will reduce region-wide population exposure to air pollutants based on the estimated reduction in emissions.

Emission Reduction Trade-offs:
None identified.

Cost:
Air District Commuter Benefits Program costs are estimated at $1.4 million per year. For TFCA funded projects, approximately $4 million is allocated per year to provide funding for existing shuttle/feeder bus and regional ridesharing services.

For MTC programs, Plan Bay Area funds trip reduction programs, including the 511 Rideshare program, Vanpool Support, and travel demand projects via the Innovative Grants program. Funds are programed through 2020, and equal approximately $2.6 million. Beyond 2020, $52.7 million is allocated toward these trip reduction programs.

Co-benefits:
- Reduced travel costs for employees.
- Reduced costs in provision of parking for employers.

Issues/Impediments:
Employers can experience the following barriers to Employer-Based Trip Reduction program implementation: insufficient employee interest, minimal perceived benefits to organization, lack of upper management support, and worksite's distance to public transit.

Sources:
1. Metropolitan Transportation Commission, Association of Bay Area Governments, Plan Bay Area, Regional Transportation Plan and Sustainable Communities Strategy, July 2013
2. Bay Area Air Quality Management District, Regulation 14, Rule 1: Bay Area Commuter Benefits Program, March 19, 2014
3. True North Research, Inc., Bay Area Commuter Benefits Program: Evaluation of Trip, VMT and Emission Impacts, June 19 2015
4. Transportation Fund for Clean Air, California Health and Safety Code, Sections 44241 and 44242 2

TR3: Local and Regional Bus Service

Brief Summary:
The Local and Regional Bus Service Improvements control measure will improve existing transit service on the region's core transit systems, and include new bus rapid transit lines in San Francisco, Oakland and Santa Clara County.

Purpose:
This measure will reduce emissions of the key ozone precursors, ROG and NOx, particulate matter, air toxics and greenhouse gases by improving bus service throughout the Bay Area.

Travel Market Affected:
This measure would affect intraregional travel, including commute travel, shopping, personal business, school trips, as well as social and recreational travel.

Regulatory Context and Background:
Over the next 28 years, operating and capital replacement costs for Bay Area transit providers are projected to total \$161 billion. This includes \$114 billion in operating costs plus \$47 billion for capital replacement to achieve an optimal state of repair. Committed revenues over the same period are expected to total only \$131 billion (\$110 billion for operations and \$21 billion for capital). The result is \$30 billion in initial unfunded needs, approximately \$26 billion of which is needed to bring the capital assets up to an optimal state of repair.

To address transit operating and capital needs, Plan Bay Area invests \$13 billion in discretionary revenues. This includes more than \$2 billion in discretionary revenue plus almost \$2 billion in revenues that are expected to come from the new extension of the transportation sales tax in Alameda County to eliminate the \$4 billion forecasted operating shortfall over the plan period. Another \$9 billion in discretionary revenue will be invested in transit capital, leaving unfunded capital needs of \$17 billion to achieve a state of optimal repair.

Plan Bay Area assumes that the region can attract approximately \$2.5 billion in additional federal New Starts and Small Starts funding through 2040. Building on the successful delivery of Resolution 3434, and the results of the Performance Assessment and transit-specific project evaluation, Plan Bay Area's priorities for the next generation of federal New Starts and Small Starts funding include major rail and bus rapid transit (BRT) investments.

Along with identifying these significant future transit investments, Plan Bay Area also retains \$660 million in financial capacity for projects that are in the planning stages. The \$660 million New and Small Starts reserve, or a regional investment equivalent, is proposed to support transit projects that are located in or enhance transit service in the East and North Bay counties.

The Core Capacity Challenge Grant program commits \$7.5 billion — including \$875 million from Cap and Trade funds, \$402 million in bridge toll revenues, and over \$3 billion in federal transportation funds — over 15 years for capital improvements to the region's largest transit systems: San Francisco Muni, BART and AC Transit. Over 80 percent of the region's transit riders, and 75 percent of low-income and minority riders, are accommodated by these three systems. The program would fund transit vehicle replacement, fleet expansion and key facility upgrades. To receive the money, operators would need to meet certain performance and efficiency objectives, and match 30 percent of the grant money with their own funds.

The Transit Performance Initiative (TPI) has two components – the Incentive program and the Investment program. The TPI Incentive program has an annual funding distribution of $15 million, based on a formula related to annual passenger increase, annual passengers per hour increase, and annual passengers, with large operators receiving 85 percent of total funding and small operators receiving 15 percent. The TPI Investment program is a competitive grant program with $82 million total split over three rounds. To date, two rounds have been awarded to fund projects to improve bus and light rail service, with a third round expected in 2015 or 2016.

Implementation Actions:
MTC will assist in the funding of:

- Operations of existing bus services where feasible with available funding ($2 billion)
- Regional Measure 2 Express Bus North Improvements ($20 million)
- Transit Performance Initiative – ongoing annual Incentive program, third round of Investment program ($500 million)
- Bus Rapid Transit Service on the Telegraph Avenue/International Boulevard/E. 14th Street Corridor ($217.8 million)
- Sustain all bus service and operations, including Express Buses, at existing level of service where feasible with available funding ($2.3 billion)
- Replace and/or rehabilitate buses, vans and electric trolley buses ($1.95 billion)
- Bus Rapid Transit Service on the Grand-MacArthur Corridor ($41 million)
- Bus Rapid Transit project on Van Ness Avenue to include dedicated transit lanes, signal priority and pedestrian and urban design upgrades ($125.6 million)
- In Santa Clara County, implement:
    - BRT improvements in the Santa Clara/Alum Rock route ($146.6 million)
    - King Road Rapid Transit Project ($61.9 million)
    - BRT improvements on El Camino Real/The Alameda Corridor ($233.7 million)
    - Bus Rapid Transit improvements along in the Stevens Creek Corridor ($165.8 million)

Supporting Actions by Partner Entities:

- Transit agencies and CMAs to work with MTC, as appropriate, to implement service improvement

Emission Reductions:

Pollutants*	2020	2030
ROG	7.65	2.98
NO_x	5.92	1.87
$PM_{2.5}$	0.86	0.57
PM_{10}	2.03	1.36
DPM	2.61	1.88
TACs	<0.01	<0.01
CO_{2e}	2,365	1,536

**criteria pollutants and TACS are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:

The emission reduction estimate for this measure is based on various transit projects. Projects include: AC Transit's BRT route from Uptown Station to 20th Street and the Grand-MacArthur corridor; BRT on Van Ness corridor; Regional Measure 2 Express Bus North Improvements, and various BRT projects in Santa Clara County, including the Santa Clara/Alum Rock route, King Road, El Camino Real/The Alameda Corridor, and Steven Creek Corridor. AC Transit's East Bay BRT Final Environmental Impact Statement/Environmental Impact Report (Jan. 2012) methodology was used to estimate emission reduction benefits for both AC Transit's and Muni's BRT routes. This approach included the use of CARB's EMFAC model series to calculate CO2 emissions for motor vehicles by average operating speed for use in estimating total corridor on-road transportation CO2 emissions associated with the BRT projects. Emission reduction data was updated to reflect the current version of the EMFAC model, EMFAC2014.

Exposure Reduction:

This measure will reduce region-wide population exposure to air pollutants based on the estimated reduction in emissions.

Emission Reduction Trade-offs:

None identified.

Cost:

See above implementation actions.

Co-benefits:

- Improved connectivity between transit services and destinations
- Travel time savings from new express/enhanced bus projects that provide faster and/or more direct service between trip origins and destinations
- New transit options may allow some households to own fewer or no automobiles
- Community enhancements through the creation of higher quality transit options and services

Issues/Impediments:
Implementation requires funding to be available for programs. Bay Area transit providers continue to face challenges in maintaining and sustaining their existing systems and, in light of financial constraints, are cutting transit budgets and service and increasing fares, and/or are delaying capital maintenance and service enhancements. Therefore, simply maintaining the existing fleet, sustaining service, and restoring service will require new funding sources. New revenues may come from higher gas taxes, bridge tolls and/or county-wide voter-approved sales tax revenues.

Source:

1. Metropolitan Transportation Commission, Association of Bay Area Governments, Plan Bay Area, Regional Transportation Plan and Sustainable Communities Strategy, July 2013

TR4: Local and Regional Rail Service Improvements

Brief Summary:
Improve rail service by sustaining and expanding existing services and by providing funds to maintain rail-cars, stations, and other rail capital assets. Specific projects for implementation include BART extensions, Caltrain electrification, Transbay Transit Center building and rail foundation, Capital Corridor intercity rail service, and Sonoma Marin Area Rail Transit (SMART) District commuter rail project.

Purpose:
The purpose of this measure is to reduce emissions of the key ozone precursors, ROG and NOx, as well as particulate matter, air toxics and greenhouse gases by sustaining and improving rail service throughout the Bay Area.

Travel Market Affected:
This measure would affect intra and inter-regional commute and non-commute travel.

Regulatory Context and Background:
Plan Bay Area relied on a transportation Project Performance Assessment, which, together with public involvement, helped identify priorities for the next generation of transit investments. These include improvements to the region's core transit systems, new bus rapid transit lines in San Francisco and Oakland, rail extensions that support and rely on high levels of future housing and employment growth, and an early investment strategy for high-speed rail in the Peninsula corridor.

MTC's Resolution 3434, a 2001 framework that identified regional priorities for transit expansion projects, has guided transit investments in the Bay Area. Resolution 3434 established the region's priority projects for federal New Starts and Small Starts funds, creating a unified regional strategy to secure commitments from this highly competitive national funding source. In 2012, the Bay Area secured commitments for nearly $2 billion in federal funding for its two most recent New Start projects — San Francisco's Central Subway and the extension of BART to Berryessa in Santa Clara County. These successes pave the way for a new generation of projects that can leverage current and future development patterns to create financially stable transit service in these corridors.

The Bay Area's rail system includes light-rail (such as Muni Metro and VTA Metro), rapid rail (such as BART), and commuter rail (such as Caltrain, Capitol Corridor and ACE) services. During weekday peak hours in 2010, heavy and commuter rail transit (combined) provided 58.6 million seat miles on a typical weekday in the Bay Area.

Originally adopted as part of the 2001 Regional Transportation Plan, MTC's Resolution 3434 Regional Transit Expansion Program is a long-term, and multifaceted funding strategy for directing local, regional, state and federal dollars to nearly two dozen high-priority bus, rail and ferry expansion projects.

MTC's Resolution 3434 – or Regional Transit Expansion Program – identifies the top priorities for new Bay Area transit projects. And it helps the region compete with other metro areas for state and federal funding.

Several Regional Transit Expansion Program projects are now under construction:
- AC Transit Oakland-San Leandro Bus Rapid Transit
- BART to Warm Springs/Milpitas/San Jose
- e-BART extension in East Contra Costa County
- Transbay Transit Center (Phases 1 and 2)
- Muni Central Subway
- Sonoma-Marin Area Rail Transit (open for service in late 2016)
- Transbay Transit Center

Among the many Regional Transit Expansion Program projects already in service are:
- BART-Oakland Airport Connector
- Caltrain Baby Bullet
- Capitol Corridor and ACE Service Expansions
- San Francisco Bay Ferry Service Expansion
- Regional Express Bus

A handful of Resolution 3434 projects are still several years away from completion:
- Caltrain electrification
- Caltrain extension to Transbay Transit Center
- Dumbarton Rail
- Muni Bus Rapid Transit

Implementation Actions:
MTC to fund:
- Extension of BART/East Contra Costa Rail (eBART) eastward from the Pittsburg/Bay Point BART station into eastern Contra Costa County ($493 million)
- Transbay Terminal Phase 1: construct the new Transbay Transit Center Building and rail foundation ($1.6 billion)
- Caltrain electrification, including replacement of railcars and an advanced signal system ($451 million)
- Transit operations needs through 2040 at existing service levels ($2 billion for operating costs)
- Rail expansion and enhancement projects ($2.2 billion)
- Transit access improvements to BART in the Tri-Valley ($168 million)
- Sonoma-Marin Rail lnitial Operating Segment ($360 million)
- Extension of BART from Fremont (Warm Springs) to San Jose/Santa Clara ($6.3 billion)
- Extension of Caltrain Express service (Phase 2) ($427 million)
- Transbay Terminal Phase 2: extend Caltrain to the new Transbay Terminal ($2.6 billion)
- Capitol Corridor: Phase 2 enhancements ($254 million)
- MUNI Third Street Light Rail Transit Project – Central Subway ($1.6 billion)

- Implement Bus Rapid Transit in Santa Clara County and provide light rail extensions ($1.1 billion total):
    - To the Eastridge Transit Center in East San Jose
    - From the Winchester Station to Route 85 - Vasona Junction
- Revenues forecasted to be available for High-Speed Rail within the region ($1.5 billion)

The Air District will:
- Assist with funding for the electrification of the Caltrain corridor ($20 million)

Emission Reductions:

Pollutants*	2020	2030
ROG	318	134
NO_x	155	68
$PM_{2.5}$	34	26
PM_{10}	81	61
DPM	103	84
TACs	0.04	0.03
CO_{2e}	93,099	69,070

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year (100 yr GWP)*

Emission Reduction Methodology:
Travel Model One produced all of the key outputs used in assessing the significance of local and regional rail service transportation impacts, including outputs such as vehicle miles traveled, vehicle hours of delay, and accessibility, as well as other outputs such as volume to capacity ratios and level of service.

This analysis uses existing ridership projections for rail developed by transit operators for each project. Growth factors, based on increases in each transit operator's ridership modeled as a part of the Travel Model One travel forecasts for Plan Bay Area, are applied to bring the ridership estimates to analysis year 2020. Using local data, estimated new ridership is reduced to factor in new riders that are transit dependent and those who drive to access rail, resulting in the number of vehicle trips reduced.

This analysis excludes estimates of emissions reduced from maintaining existing rail services and transit access improvements to BART, Caltrain, Sonoma-Marin Area Rail Transit (SMART), Capitol Corridor, ACE commuter rail systems and supporting infrastructure for high-speed rail. In addition, CO2 conversion/equivalency factors were used to estimate the emission reduction benefits for the criteria pollutants and mobile source air toxics (MSATs).

Exposure Reduction:
This measure will reduce air pollution emitted by vehicles and therefore will reduce the concentration of air pollution that people are exposed to on a daily basis. Impacted communities near freeways and roads with significant auto and truck traffic will benefit.

Emission Reduction Trade-offs:
None identified.

Cost:
See above Implementation Actions.

Co-benefits:
- Improved connectivity between transit services and destinations
- Travel time savings from providing new rail services that provide faster and more direct service between trip origins and destinations
- Transportation cost savings by providing new rail transit options that may allow some households to own fewer or no cars
- Community enhancements through the creation of more and higher quality transit options

Issues/Impediments:
Implementation requires available funding. Bay Area transit providers continue to face challenges in maintaining and sustaining their existing systems and, in light of financial constraints, are cutting transit budgets and service and increasing fares, and/or are delaying capital maintenance and service enhancements. Therefore, simply maintaining the existing fleet, sustaining service, and restoring service will require new funding sources. New revenues may come from higher gas taxes, bridge tolls and/or county-wide voter-approved sale tax revenues. Environmental clearance, right-of-way availability and the level of public support are major impediments to sustain, improve, upgrade, and expand regional rail service.

Source:
1. Metropolitan Transportation Commission, Association of Bay Area Governments, *Plan Bay Area, Regional Transportation Plan and Sustainable Communities Strategy*, July 2013

TR5: Transit Efficiency and Use

Brief Summary:
This measure will improve transit efficiency and make transit more convenient for riders through continued operation of 511 Transit, full implementation of Clipper® fare payment system and the Transit Hub Signage Program.

Purpose:
This measure will reduce emissions of the key ozone precursors, ROG and NOx, particulate matter, air toxics and greenhouse gases by improving transit efficiency and use through financial incentives, improved real-time transit service information, coordinated fare payment and collection, and improved transit connectivity.

Travel Market Affected:
This measure would affect intra and inter-regional commute and non-commute travel.

Regulatory Context and Background:
Launched by MTC in 2002, 511 is a 24-hour, toll-free phone and Web service (511.org) that consolidates Bay Area transportation information into a one-stop resource. 511 provides up-to-the-minute information on traffic conditions, incidents and driving times; schedule, route and fare information for dozens of public transportation services; instant carpool and vanpool referrals; and bicycle routes and more.

MTC, in close coordination with the region's over two dozen Bay Area transit operators, continues to operate, maintain, and further develop the 511 Transit information system, which includes the 511 Transit website and its features: the 511 Transit Trip Planner, 511 Departure Times, 511 Popular Destinations, as well as schedule, fare, route and agency-specific information for the region's numerous transit operators.

511 Transit also provides special service announcements for changes to services or transit disruptions and promotion of special services for events. Transit information and tools are also provided via the 511 SF Bay Transit applications for smart phones as well as the 511 Mobile site at m.511.org. Users can also receive transit departure times via text message, e-mail alert, or on a personalized Transit Tracker display. A new feature, the Enhanced Trip Planner, compares transit-only trips with drive-to-transit trips and drive-only trips. The 511 Transit Trip Planner generates approximately 800 thousand to 1 million itineraries per month.

Clipper offers transit riders a convenient and secure way to pay fares on multiple transit agencies. The reloadable Clipper card stores value in the form of electronic cash. Clipper is currently available on Muni, BART, AC Transit, Caltrain, SamTrans, Golden Gate Transit & Ferry, VTA and SF Bay Ferry. Clipper can also be used on transit agencies in Napa and Solano counties and on Livermore-Amador Valley Transit Authority (WHEELS) in Alameda County, County Connection, WestCAT and Tri-Delta Transit in Contra Costa County. The Clipper network expanded again in the spring of 2016 to include Santa Rosa City Bus, Sonoma County Transit, and Petaluma Transit in Sonoma County. Clipper also will be the fare payment method used by Sonoma-Marin Area Rail Transit (SMART) when it begins operation.

In 2010, Clipper began operating a pre-tax transit benefit program called Clipper Direct. Clipper Direct works with employers in the Bay Area to put cash value and transit passes directly onto Clipper cards using employees' pre-tax dollars. Clipper also has agreements with other pre-tax transit benefit providers so that customers of those programs can also use their transit benefits to put value onto their Clipper cards.

Currently, MTC and the participating transit agencies are beginning the planning process for the next version of Clipper. The current contract ends in 2019, and so the design phase for the new contract requirements has begun.

MTC, in partnership with transit operators, implemented the Hub Signage Program to address wayfinding signage, transit information and real-time transit information recommendations at 21 transit hubs and 3 airports. The design work for the Hub Signage Program at all 24 regional transit hubs was completed in 2012 and the entire program has been installed at all 24 Hubs.

Implementation Actions:
MTC will:

- Implement ridesharing measures (includes ride matching, vanpool services, and commute trip planning/consulting) ($14 million)
- Deploy, operate and maintain Clipper® on Bay Area transit agencies. Clipper® capital replacement costs for all operators are included and a portion of Clipper's operating costs ($584 million)
- Implement, operate and maintain wayfinding signage, transit information displays and real-time departure displays via the Hub Signage Program (HSP) ($10 million)
- Complete the Core Capacity study and fund grant projects via the Core Capacity Grant Challenge Program.

Supporting Actions by Partner Entities:

- Local governments and transit agencies to work with MTC on the Transit Hub Signage Program.
- Local governments, CMAs, transit agencies and other agencies to work with MTC to deploy, operate and maintain Clipper® and 511 Transit.
- Local governments are encouraged to implement programs that offer residents, students and employees free or discounted transit passes, such as Santa Clara's Ecopass program, and other innovations to encourage transit use.

Emission Reductions:

Pollutants*	2020	2030
ROG	15	6.23
NO_x	13	5.58
$PM_{2.5}$	0.23	0.17
PM_{10}	0.41	0.31
DPM	4.32	3.55
TACs	<0.01	<0.01
CO_{2e}	3,917	2,906

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:
MTC developed a methodology to evaluate the expected emission reductions due to the expansion of the Clipper® program. The methodology calculates emissions reduction benefits based on time savings from using Clipper®. Time savings are realized from more efficient boarding resulting in shorter vehicle dwell times. While not explicitly captured by the analysis, there would be additional emission reductions resulting from Clipper® such as more reliable transit service through less vehicle bunching and shorter idling time at bus stops. The reduction in transit travel time increases transit ridership, thereby reducing emissions by offsetting automobile trips.

Route level transit operational characteristics from MTC's travel demand model provided average transit passenger miles per boarding, average transit travel time per boarding and average transit boarding per hour statistics which were input into the elasticity equations. In addition, current transit ridership (by operator) and current and projected Clipper® boardings were also put into emissions benefit calculations.

Exposure Reduction:
This measure will reduce region-wide population exposure to air pollutants based on the estimated reduction in emissions.

Emission Reduction Trade-offs:
None identified.

Cost:
$608 million, see above implementation actions for details

Co-benefits:
- Improved transit customer experience
- Travel time savings

Issues/Impediments:
Implementation of this measure requires that funding is available for these programs. In addition, technological issues, institutional support, and market penetration are factors that may impede full implementation of 511 and Clipper®.

Source:

1. Metropolitan Transportation Commission, Association of Bay Area Governments, Plan Bay Area, Regional Transportation Plan and Sustainable Communities Strategy, July 2013

TR6: Freeway and Arterial Operations

Brief Summary:
This measure improves the performance and efficiency of freeway and arterial systems through operational improvements, such as implementing the Freeway Performance Initiative (FPI), the Bay Area Freeway Service Patrol (FSP), and the Arterial Management Program.

Purpose:
Implementation of this measure will reduce emissions of the key ozone precursors, ROG and NOx, particulate matter, air toxics and greenhouse gases by improving the efficiency of existing freeways and roadways throughout the Bay Area.

Travel Market Affected:
This measure would affect intra and inter-regional commute and non-commute travel.

Regulatory Context and Background:
Plan Bay Area supports MTC's Freeway Performance Initiative (FPI), which is designed to maximize the efficiency and improve the operations and safety of the existing freeway, highway and arterial network. FPI addresses both recurrent daily traffic that comes from the surge of commuters using the freeways during rush hours and nonrecurring congestion that results from unanticipated incidents and blockages of highway lanes. Half of all traffic congestion experienced in the Bay Area is caused by vehicle breakdowns, vehicular accidents, material spills and other incidents.

FPI investments made through Plan Bay Area have expanded the number of metered ramps throughout the Bay Area, directly resulting in reduced travel times and improved safety on major freeway corridors while managing the impact on local arterial operations. FPI investments also support the Program for Arterial System Synchronization (PASS), which was previously called the Regional Signal Timing Program, through which an average of 500 traffic signals is re-timed each year.

The role of MTC in the PASS is to provide program administration, project management, and facilitation of inter-agency communication and coordination. The primary responsibility for the operation and retiming of traffic signals resides with the agency that owns them. Under this regional program, technical assistance will be focused on traffic signal systems that: 1) interact with freeways and state highways, 2) involve traffic signals from multiple jurisdictions, 3) operate on corridors with established regional significance, 4) provide priority for transit vehicles, and 5) developed in conjunction with other regional programs.

FPI funding for the FSP and call boxes has enhanced the region's ability to quickly identify and respond to planned and unplanned freeway incidents. Currently, FSP includes 78 tow trucks that cover 552 miles of Bay Area freeways and respond to an average of 130,000 incidents per year. The 2,200 call boxes in place along the region's freeways and bridges receive an average of 22,000 calls per year.

The Bay Area Freeway Service Patrol is a fleet of tow trucks deployed during peak travel times (typically, 6-10am and 3-7pm) as part of an incident management program to detect and clear accidents, assist motorists and remove dangerous debris from freeways which cause more than 50 percent of traffic congestion. The Freeway Service Patrol is free at the time of service, funded through the state highway fund and supplemented by the SAFE motorist aid driver registration fee.

The MTC Arterial Operations Program provides assistance to Bay Area jurisdictions in their efforts to improve traffic operations on arterial streets by sponsoring various projects that address signal coordination and other arterial operations issues; developing and implementing initiatives to promote improved arterial operations; and supporting the Arterial Operations Committee (AOC) as a forum for discussion of shared issues and lessons learned for both public and private agencies. The program provides direct benefits through projects that reduce travel time and emissions and enhance traffic safety on arterial streets; as well as indirect benefits through projects that help local traffic engineers do their job more efficiently and effectively.

Implementation Actions:
MTC will:

- Through FPI, install additional ramp meters at entrance ramps, and monitor and adjust meter timing as appropriate.
- Through the PASS program, coordinate additional traffic signals and continue to update timing plans.
- Expand Freeway Service Patrol on I-280 from SR 92 to SR 85 in San Mateo and Santa Clara counties.

Emission Reductions:

Pollutants*	2020	2030
ROG	46	19
NO_x	63	18
$PM_{2.5}$	11	8
DPM	41	33
TAC	<.01	<.01
CO_{2e}	36,883	27,364

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:
Emission reductions for the Program for Arterial System Synchronization (PASS) program and the expanded Freeway Service Patrol (FSP) service (on I-280 from SR 92 to SR 85 in San Mateo and Santa Clara counties) were calculated by two separate approaches.

For the PASS program emissions calculation, the synchronization of signals along an extended route was analyzed by using EMFAC 2011 emission factors. Emission factors dependent on the before-project (lower speeds, higher emission factors) and after-project (higher speeds, lower emission factors) average traffic speeds were applied to the corresponding before and after project vehicle miles traveled (VMT) to calculate the emission reductions for this component of measure. EMFAC 2011 emission factors were updated to reflect the current version of the EMFAC model, EMFAC2014 and CO2 conversion/equivalency factors were used to estimate the emission reduction benefits for the mobile source air toxics (MSATs).

For the expanded FSP service, CO2 emissions were calculated by applying an updated fuel consumption rate (from the Caltrans Mobility Performance Report 2011) and the other pollutant emission rates were estimated using ARB's emission model EMFAC 2007 were updated to reflect the current version of the EMFAC model, EMFAC2014. FY 13/14 FSP expanded service emission reductions were adjusted and forecasted to the 2020 and 2030 analysis years. As with the PASS program component of the transportation measure, CO2 conversion/equivalency factors were used to estimate the emission reduction benefits for the mobile source air toxics (MSATs).

Emission reductions generated from the FPI program were not generated in this analysis.

Exposure Reduction:
This measure will reduce air pollution emitted by vehicles and therefore will reduce the concentration of air pollution that people are exposed to on a daily basis. Impacted communities near freeways and roads with significant auto and truck traffic will benefit.

Emission Reduction Trade-offs:
None identified.

Cost:
Approximately $2.7 billion.

Co-benefits:
- Health (congestion can lead to stress, and increases drivers and nearby resident's exposure to harmful air pollutants) and economic savings for both businesses and travelers from reduced congestion
- Shorter travel times, reduced fuel consumption and fewer collisions secondary accidents.

Issues/Impediments:
By making more efficient use of existing capacity, the FPI should help to improve air quality by reducing peak period congestion, as well as incident-related delay, on the Bay Area's freeways. But, past research has shown (Levinson and Zhang, 2006) that ramp-metering may provide a greater travel time savings for vehicles making longer trips. Reducing travel time for long distance commuters could, at least in theory, encourage longer commutes from residential locations in the periphery of the region. If this were to occur, it could erode the air quality benefits of this measure over time.

Local jurisdictions may be concerned that ramp meters will spill over onto local streets and disrupt their arterial operations (although these impacts are most often mitigated prior to the operation of the ramp meters through protocols for the ramp metering timing or local street improvements to accommodate the ramp queues).

Where arterial signal coordination requires cooperation of multiple jurisdictions, the negotiations can take time to resolve both technical and policy issues.

Sources:

1. Metropolitan Transportation Commission, Program for Arterial System Synchronization (PASS), http://www.mtc.ca.gov/services/arterial_operations/pass.htm
2. Metropolitan Transportation Commission, Association of Bay Area Governments, Plan Bay Area, Regional Transportation Plan and Sustainable Communities Strategy, July 2013
3. Metropolitan Transportation Commission, Arterial Operations Program, http://www.mtc.ca.gov/services/arterial_operations/
4. Metropolitan Transportation Commission, Freeway Service Patrol, http://www.mtc.ca.gov/services/fsp/

TR7: Safe Routes to Schools and Transit

Brief Summary:
This measure will facilitate safe routes to schools and transit by providing funds and working with transportation agencies, local governments, schools, and communities to implement safe access for pedestrians and cyclists. Likely projects will include implementation of youth outreach and educational programs to encourage walking and cycling, the construction of bicycle facilities and improvements to pedestrian facilities.

Purpose:
The purpose of this measure is to reduce emissions of the key ozone precursors, ROG and NOx, particulate matter, air toxics and greenhouse gases by improving bicycle and pedestrian access to schools and transit throughout the Bay Area.

Travel Market Affected:
This measure would affect intraregional travel for students traveling to and from school and for transit riders throughout the Bay Area.

Regulatory Context and Background:
Safe Routes to School is a state, regional and local program that encourages children to walk or bicycle to school by removing barriers. Barriers include lack of infrastructure, unsafe facilities that result in uninviting walking and bicycling conditions, and lack of education and enforcement programs aimed at children, parents and the community at large. Another important component is outreach and education in schools to encourage students to bike and walk to school, leading to mode shifts away from automobile trips and therefore VMT reductions. In 2010, grade school trips in the Bay Area accounted for nearly 2.2 million trips/day, or 9.5 percent of total personal trips. Safe Routes to School reduces vehicle trips to school and parents' vehicle trips to work, to the extent that parents may be able to switch to another mode if they do not need to drop their children off at school.

Safe Routes to Transit (SR2T) is a program that funds bicycle and pedestrian planning and capital projects that facilitate walking and bicycling to regional transit, thereby reducing vehicle trips to transit. The SR2T Program originally received Bay Area voter approval in March 2004 through Regional Measure 2, the $1 bridge toll increase for transit. By improving the safety and convenience of biking and walking to regional transit, SR2T encourages commuters to leave their cars at home and reduce emissions.

In May 2012, MTC approved a new funding approach that directs specific federal funds to support more focused growth in the Bay Area. The OneBayArea Grant (OBAG) program commits $320 million of federal surface transportation funding through 2017. The OBAG program allows communities flexibility to invest in transportation infrastructure that supports infill development by providing funding for bicycle and pedestrian improvements, local street repair, and planning activities, while also providing specific funding opportunities for Safe Routes to Schools projects.

Through the Air District's Bikeways, Roads, Lanes and Paths program, up to $3.84 million is available (fund made available in FYE 2016) for bicycle parking and bikeway projects. Funding is offered on a first-come, first-served basis, until all funds have been spent. In order to be eligible for funding projects must be included in an adopted countywide bicycle plan, Congestion Management Plan (CMP), or MTC's Regional Bicycle Plan. Funding is available for new Class-1 bicycle paths; new Class-2 bicycle lanes; new Class-3 bicycle routes; and new Class-4 cycle tracks or separated bikeways. Bike projects may support or be paired with a Safe Routes to School or Safe Routes to Transit projects.

Implementation Actions:

MTC will:

- Continue to award the Regional MTC County Safe Routes to School Program at Cycle 1 and Cycle 2 annual funding levels of $5 million a year through 2017 ($20 million)
- Explore new funding and program opportunities for Safe Routes to School and Safe Routes to Transit in Plan Bay Area 2040.

The Air District will:

- Distribute funding and manage grants distributed through the Bikeways, Roads, Lanes and Paths program. ($3.8 million)

Emission Reductions:

Pollutants*	2020	2030
ROG	0.94	0.39
NO_x	0.56	0.25
$PM_{2.5}$	0.10	0.08
PM_{10}	0.24	0.18
DPM	0.30	0.25
TACs	<0.01	<0.01
CO_{2e}	274	203

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:

Shifting school trips away from family vehicles reduces start-up emissions and per-mile trip emissions. In addition, an increase in active transportation in the region resulted in a reduction in vehicle miles traveled in all counties analyzed. This translates to a reduction in GHG emissions, based on trip length as well as number of trips (i.e. student enrollment and mode split).

MTC's Climate Initiatives Program evaluation estimated that the Regional Safe Routes to School Program projects resulted in an annual GHG emission reduction of over 420,000 pounds (210 tons), an average 10.7 percent reduction in GHG emissions for trips one mile or less from school.

The emission reduction estimates for the Regional Safe Routes to School Program projects are the per student daily changes multiplied by 175 (the typical number of school days) and then by the follow up period enrollment to reflect changes over an entire school year for all counties included. Note that this analysis includes trips within one mile of school only. GHG-CO_2 conversion/equivalency factors were used to estimate the emission reduction benefits for the criteria pollutants and air toxics (all emission reductions, except CO_2, are nominal).

Exposure Reduction:
This measure will reduce region-wide population exposure to air pollutants based on the estimated reduction in emissions.

Emission Reduction Trade-offs:
None identified.

Cost:
MTC: $20 million; Air District $3.8 million

Co-benefits:
- Improved safety/reduced pedestrian-motor vehicle and bicycle-motor vehicle accidents.
- Improved public health/reduced obesity.
- Reduced travel costs.

Issues/Impediments:
Implementation of this measure requires that funding is available for these programs. The Safe Routes to School and Safe Routes to Transit programs receive a high volume of grant applications and have only limited amount of funds to award to projects. While funding for these programs has been identified in the short-term, many of these sources will sunset in the future. Future federal transportation legislation could include additional funding for Safe Routes to School and Transit. New funds may also be available from higher gas taxes, bridge tolls, and voter approved sales tax measures in individual counties.

Source:
1. Metropolitan Transportation Commission, Association of Bay Area Governments, Plan Bay Area, Regional Transportation Plan and Sustainable Communities Strategy, July 2013

TR8: Ridesharing and Last-Mile Connections

Brief Summary:
The Ridesharing and Last-Mile Connections measure will promote ridesharing services and incentives through the implementation of the 511 Regional Rideshare Program, as well as local rideshare programs implemented by Congestion Management Agencies. These activities will include marketing rideshare services, operating a rideshare information call center and website, and provide vanpool support services. In addition, this measure includes provisions for encouraging car sharing programs.

Purpose:
This measure will reduce motor vehicle emissions of key ozone precursors, ROG and NOx, particulate matter, air toxics, and greenhouse gases by reducing single occupancy vehicle trips through the promotion of rideshare services and incentives.

Travel Market Affected:
This measure would affect intra and inter-regional commute and non-commute travel.

Regulatory Context and Background:
The Bay Area has had an organized vanpool program since 1981. The current program is managed by local, county, and regional partners including MTC's 511 program. The region's vanpool program helps people with long commutes that are not well-served by transit. Plan Bay Area enhances the appeal of vanpooling by dedicating $6 million to reduce the cost of van pool vehicle rentals and encouraging more people to participate in the vanpool program.

The 511 Regional Rideshare Program is operated by MTC and is funded by grants from the Federal Highway Administration, U.S. Department of Transportation, the MTC, the Air District, and county Congestion Management Agencies.

Barriers to ridesharing include:
- Difficulty for individuals in identifying others who both live and work proximate to them.
- Difficulty in setting up the logistics of a vanpool (such as establishing driver(s), shared payment for gas and other costs, identifying parking places).
- Additional travel time needed to pick up other carpoolers.
- Difficulty to change travel schedule due to emergencies.

The 511 Regional Rideshare Program provides a suite of services to facilitate carpooling and vanpooling online (511.org) and by telephone (511). These programs help remove some barriers to ridesharing identified above, and provide additional incentives for ridesharing. 511 is managed by a partnership of public agencies led by MTC, the California Highway Patrol, and the California Department of Transportation. 511 was developed with the mission to provide comprehensive, accurate, reliable and useful multimodal travel information to meet the needs of Bay Area travelers.

Additional 511 partners include:

- 511 Contra Costa
- Bishop Ranch Transportation Center
- City of Menlo Park, Transportation Department
- City of Pleasanton
- Contra Costa Centre Association
- Emeryville Transportation Management Association
- Hacienda Owners Association
- Moffett Park Business and Transportation Association
- Peninsula Traffic Congestion Relief Alliance
- San Francisco Department of Environment
- San Francisco Municipal Transportation Agency (SFMTA)
- San Jose State University
- Solano Napa Commuter Info
- Transportation Management Association of San Francisco

The Innovative Grants Program funds demonstration projects to test innovative strategies to promote changes in driving and travel behaviors. For Ridesharing Services and Incentives projects, the Innovative Grants Program includes the Dynamic Rideshare Programs, a pilot project which will coordinate the efforts of Contra Costa, Marin and Sonoma counties to offer a new form of carpooling, called “dynamic ridesharing.”

Carpooling has declined precipitously since 1980 due to workers’ increasingly variable work schedules, which are incompatible with the fixed plans required for traditional carpooling. Dynamic ridesharing – also called real-time ridesharing – addresses this problem using technology to match drivers and riders in real time right before their trips.

Dynamic, or real-time, ridesharing involves the use of information technology—namely a mobile app—to match drivers and riders in real time. This form of ridesharing does not require commuters to commit to a particular carpool with fixed routes and schedules; instead, it facilitates the matching of riders and drivers on an ad-hoc basis through a smartphone user platform offered by the vendor, Carma, which has developed a ridesharing app for use in a number of U.S. markets.

While the pilot project in Contra Costa, Marin and Sonoma counties share a software platform (custom-designed for the project by the vendor), the ridesharing effort has been managed somewhat differently in each county. The programs have used different outreach approaches; targeted different “affinity groups” (for example, employers/businesses or colleges and universities); contracted with different parties to provide support for program deployment and delivery; and, at times, offered different incentives to participants (to recruit participants, the programs have offered incentives to both drivers and riders and also have relied on payments from riders to drivers).

An evaluation of the Dynamic Rideshare Programs revealed that this measure, while still limited in its application, has a place in the transportation demand management (TDM) toolbox; unlike most TDM programs which rely on self-reported data, this type of program generates robust data that tracked use in detail.

In March 2016, MTC, through its 511 Rideshare program, began a partnership with Lyft to launch a new carpooling option for commuters. The partnership brings together Lyft's peer-to-peer ridesharing platform and MTC's established efforts to promote carpooling to make it easier for commuters to share rides.

Lyft's new carpooling service will allow commuters to offset the costs of driving on their regular commute routes. The partnership with Lyft represents MTC's first official partnership with a Transportation Network Company. MTC also has partnerships with the carpool-matching apps Carma (gocarma.com (link is external)) and Scoop (takescoop.com).

Car Sharing
Car sharing allows individuals to rent vehicles by the hour, thus giving them access to an automobile without the costs and responsibilities of individual ownership. Car sharing is growing rapidly in the Bay Area in traditional for profit/non-profit services (City CarShare, Zipcar, U Car Share, WeCar), new peer-to-peer car sharing (Getaround, RelayRides), and 1-way car share services (BMW DriveNow).

Traditional car sharing businesses operate on a membership basis. Users pay an annual or monthly fee in addition to hourly and/or per mile rates. Gas, maintenance, parking, insurance, and 24-hour access is all included in the membership and usage rates for car sharing. The pricing scheme encourages the use of the vehicles for short duration trips, such as running errands. For trips longer than one day, it is usually less expensive to rent a vehicle through a traditional car rental agency. Traditional car sharing works best for households in neighborhoods that are highly served by transit where vehicles are only infrequently needed, where parking is limited, and for households that share a primary car and have an occasional need for a second car. After joining a car sharing program, households in transit-dense neighborhoods can often shed all vehicles and just participate in car sharing. In less dense neighborhoods, car sharing may allow a two or three car family to shed one car and then use car sharing for the rare times that multiple vehicles are needed. Businesses are also signing up for business memberships to avoid maintaining a company fleet of vehicles.

Acknowledging the importance of car sharing on both the community and the environment, Plan Bay Area invests $13 million in car sharing over the course of the plan to achieve a 2.6 percent per capita reduction in greenhouse gas emissions. To support the car sharing goals identified in Plan Bay Area, in April 2014, MTC approved the Car Sharing Program - a $2 million grant program that helps expand car sharing services throughout the region. In July 2014, MTC released a call for projects for the Car Sharing Program to expand car sharing in the following areas:

- Suburban or urban communities that do not currently have robust car sharing service
- Underserved minority or low-income communities
- Business parks and transit connections
- Innovative/new technologies, i.e. point-to-point car sharing, electric vehicle (EV) fleets, etc.

In April 2015, MTC programmed the following car sharing projects into the 2015 Transportation Improvement Program (TIP) which allowed sponsors to obtain federal authorization (obligation) for their projects:

- Santa Rosa Car Share (Sonoma County Transportation Authority)
- CarShare4All (Contra Costa Transportation Authority)
- Car Sharing – A Catalyst for Change (City of San Mateo)
- Oakland Car Share and Outreach Program (City of Oakland)
- City of Hayward RFP for Car Sharing Services (City of Hayward)
- Car Share CANAL (Transportation Authority of Marin)

The Air District is also currently exploring options for expanding use of its TFCA funding to provide incentives for pilot projects that implement car sharing and other innovative last-mile solution trip reduction strategies. Beginning in FYE 2016, the Air District will increase the annual funding allocation for trip reduction programs by approximately $500,000 (to $4.5 million from $4 million).

Implementation Actions:
MTC will:
- Reduce cost of vanpooling through dedicated funding used to reduce cost of van rentals and to encourage more people to participate in vanpools ($6 million)
- Fund the Climate Initiatives Innovative Grants Ridesharing Services and Incentives project to support Dynamic Rideshare Programs, Contra Costa Transportation Authority, Sonoma County Transportation Authority, Transportation Authority of Marin ($2.4 million)
- Continue to provide 511 RideMatch services
- Continue to provide rideshare support services, including call center services, program marketing and materials
- Implement incentive programs sponsored by the congestion management agencies, county transportation authorities, cities and counties, and transit agencies.

The Air District will:
- Encourage employers to promote ridesharing to their employees through the Commuter Benefits Program.
- Provide incentive funding to pilot projects to determine feasibility of implementing cost-effective car sharing and other innovative last-mile solution trip reduction strategies.
- Encourage local governments to require ridesharing as a potential CEQA mitigation and/or explore the possibility of requiring new projects to include dedicated ridesharing parking spaces and car sharing services in-lieu of required parking spaces.

Supporting Actions by Partner Entities:

- Local government and Congestion Management Agencies to encourage ridesharing and create incentives to promote ridesharing and car sharing

Emission Reductions:

Pollutants*	2020	2030
ROG	0.81	0.34
NO_x	0.49	0.22
$PM_{2.5}$	0.09	0.07
PM_{10}	0.21	0.16
DPM	0.26	0.22
TACs	<0.01	<0.01
CO_{2e}	237	176

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:

The Ridesharing and Last-Mile Connections measure emission reduction calculation was separated into three strategies:

- Dynamic Rideshare Demonstration Project
- Local Government EV Fleet Project
- eFleet: Car Sharing Electrified

Dynamic Rideshare Demonstration Project - Vehicle trips reduced were used to estimate starting-exhaust emissions (from cold starts) while VMT reduced was used to estimate running-exhaust emissions. Vehicle trips and VMT are translated into emissions using emission factors from EMFAC2011, the 2011 update of the computer model for estimating emissions from on-road vehicles in California. The factors used for the calculations are averages of the factors for light-duty autos operating in Contra Costa, Marin and Sonoma Counties, and weighted by each county's share of the number of shared rides (we assume that light-duty autos is the category that best represents the vehicles used).

Local Government EV Fleet Project - GHG emissions were quantified for the 90 vehicles purchased through the MTC grant program and were compared to the baseline control group vehicles to estimate emission reductions resulting from this project. The emissions were assessed on a lifecycle basis, which includes emissions related to processes upstream of the point of use in the vehicle, in addition to the direct emissions resulting from fuel combustion in the vehicle. Therefore, for electric vehicles, emissions from the generation and transmission of electricity were included in the analysis. For conventional gasoline and hybrid vehicles, this accounting included the production and delivery of the fuel and the combustion of the gasoline in the vehicle.

eFleet: Car Sharing Electrified - To compare project BEV and PHEV criteria pollutant emissions to baseline vehicle types, six months of activity data was analyzed from City CarShare (CCS) to determine the number of miles driven on all-electric mode and gasoline mode - for each vehicle model. For the miles driven in all-electric mode, there are no tailpipe emissions. For PHEVs, the CCS activity data does not distinguish between electric and gasoline powered VMT. Therefore, the vehicle models' estimated fuel economy was applied in all electric mode (kWh/mi) to the ChargePoint data for electricity consumption to determine the number of miles driven in all electric mode. The remaining mileage balance (total VMT minus electric VMT) then represents the gasoline-only VMT estimate.

Once the VMT was broken out by fuel type, criteria pollutant emissions factors were applied to the gasoline powered VMT to quantify the total amount of ROG, NOx, and PM emitted during the six-month data period. This quantity was then divided by the total VMT (both electric and gasoline) to determine the average amount of criteria pollutant emitted for each vehicle mile driven.

Exposure Reduction:
This measure will reduce region-wide population exposure to air pollutants based on the estimated reduction in emissions.

Emission Reduction Trade-offs:
None identified.

Cost:
See above implementation actions

Co-benefits:
- Reduced travel costs for employees through ridesharing and for Bay Area residents, businesses and visitors through car-sharing.
- Reduced costs in provision of employee parking, due to reduced single-occupancy driving.

Issues/Impediments:
Ridesharing
Many commuters need flexibility in their daily trips to conduct errands, or pick-up and drop-off children, and this can reduce the market for carpooling and vanpooling as traditional participation requires fixed schedules among participants. In addition, legal challenges such as Americans with Disabilities Act compliance, local regulations, insurance policies can also limit the growth of ridesharing as a travel option.

Car Sharing
Car sharing works best in dense urban areas; it may not be viable in all parts of the Bay Area.

Sources:

1. Metropolitan Transportation Commission, Program for Arterial System Synchronization (PASS), http://www.mtc.ca.gov/services/arterial_operations/pass.htm
2. Metropolitan Transportation Commission, Association of Bay Area Governments, Plan Bay Area, Regional Transportation Plan and Sustainable Communities Strategy, July 2013
3. Metropolitan Transportation Commission, Association of Bay Area Governments, Plan Bay Area, Regional Transportation Plan and Sustainable Communities Strategy - Summary of Predicted Traveler Responses, July 2013, http://planbayarea.org/pdf/final_supplemental_reports/FINAL_PBA_Predicted_Traveler_Responses.pdf
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5. Metropolitan Transportation Commission, Freeway Service Patrol, http://www.mtc.ca.gov/services/fsp/
6. Metropolitan Transportation Commission, Programming and Allocations Committee (December 2014 Meeting), http://apps.mtc.ca.gov/meeting_packet_documents/agenda_2327/3a_Car_Sharing_Program_Reso-4035.pdf
7. Metropolitan Transportation Commission (April 2015 Meeting), http://apps.mtc.ca.gov/meeting_packet_documents/agenda_2401/6_Reso-4175_TIP_Amendment-2015-09.pdf

TR9: Bicycle and Pedestrian Access and Facilities

Brief Summary:
The bicycle component of this measure will expand bicycle facilities serving employment sites, educational and cultural facilities, residential areas, shopping districts, and other activity centers. Typical improvements include bike lanes, routes, paths, and bicycle parking facilities. The bicycle component also includes a bike share pilot project that was developed to assess the feasibility of bicycle sharing as a first- and last-mile transit option.

The pedestrian component of this measure will improve pedestrian facilities and encourage walking by funding projects that improve pedestrian access to transit, employment sites, and major activity centers. Improvements may include sidewalks/paths, benches, reduced street width and intersection turning radii, crosswalks with activated signals, curb extensions/bulbs, buffers between sidewalks and traffic lanes, and street trees.

Purpose:
This measure will reduce motor vehicle emissions, including key ozone precursors ROG and NOx, particulate matter, air toxics, and greenhouse gases by sustaining and improving bicycle and pedestrian access and facilities, and encouraging walking and bicycling throughout the Bay Area.

Travel Market Affected:
This measure would affect all intraregional travel.

Regulatory Context and Background:
Bicycles are an inexpensive and widely available type of zero emissions vehicle. They promote health and in urban contexts, bicycles compete well with cars and transit in terms of door-to-door travel time. Bikes can be combined with public transit for longer trips and trans-Bay trips. Walking is the least expensive way of travelling and also provides benefits of improved health.

The average trip length for all personal trips in the Bay Area is just under 3 miles, a distance short enough for travelling by bicycle. Of the total personal weekday trips in 2010, 1 percent used bicycles and had an average travel distance of 2.4 miles. In 2010, 10 percent of total weekday personal trips were in exclusively the walk mode and 3.8 percent of total weekday personal trips were walk trips to transit.

Many barriers exist that prevent people from taking more bicycling and walking trips. In particular, parts of the Bay Area lack bicycle routes that include features such as lower speed limits, bicycle lanes, loop detectors that detect bicyclists waiting at red lights, and other complete street features. Low levels of pedestrian travel can be attributed to low population density, single-use land use patterns and development of streets, roads and land uses that lack adequate attention to the pedestrian environment.

Improved bicycle facilities can increase perceived and actual safety of travel by bicycle as well as its overall attractiveness, encourage mode shift for shorter trips, and encourage park-and-ride users to shift modes to bike-and-ride. Providing safe and convenient bicycle access on Bay Area bridges supports cycling for commute trips, recreation and other purposes. Similarly, improved pedestrian facilities can increase perceived and actual safety of walking trips as well as the overall attractiveness of walking, encourage more mode shift for shorter trips, especially those less than a mile, and encourage park-and-ride users to shift modes to walk-and-ride.

Funding Sources

Transportation Fund for Clean Air (TFCA). From 2005 through 2015, TFCA has provided more than $31 million in funding to support the expansion of bicycle facilities. This investment has resulted in the installation of 176 miles of new bike paths and lanes, the creation of more than 14,000 new bicycle rack parking spaces and electronic locker parking spaces, and the Bay Area Bike Share Pilot Program. Funding for the TFCA program is provided by a $4 surcharge on motor vehicles registered within the Bay Area as authorized by the California State Legislature. To obtain TFCA funding, local jurisdictions must have the project identified in an adopted countywide bicycle plan, Congestion Management Plan (CMP), or within MTC's Regional Bicycle Plan. In addition, bicycle facilities must serve a major activity center (e.g. transit station, office building, or school) and be publicly accessible and available for use by all members of the public.

Since 2013, the Air District has administered an annual allocation of approximately $900,000 in TFCA Regional Fund monies for projects that expand access to bicycle parking and bikesharing. In 2013, the Air District launched the Bicycle Rack Voucher Program (BRVP) and the Electronic Locker Program to reduce motor vehicle emissions by cost-effectively expanding availability of new bicycle parking facilities in the nine-county Bay Area. The BRVP is a streamlined voucher-based program that provides local public agencies with access to discounted and no-cost bicycle rack equipment.

In 2013, the Bay Area Bike Share pilot project was launched as the nation's first regional bike sharing initiative. The pilot (funded in part by the Air District and MTC's Innovative Grants Program described below) was developed to assess how bicycle sharing could result in mode shifts that eliminate vehicle miles traveled (VMT) by single occupancy vehicles. One of the program's key goals is to offer a first- and last-mile transit option for public transit riders, with docking stations at train and ferry terminals and at locations 1-2 miles from public transit, enabling riders to bike to their destination without having to take a bicycle on the entire trip.

The Air District served as the lead administrator for the pilot project, which was conducted in partnership with MTC, the City and County of San Francisco, the San Mateo County Transit District, the City of Redwood City, the County of San Mateo, and the Santa Clara Valley Transportation Authority. In the summer of 2015, MTC took on the role of system administrator for Bay Area Bike Share. In upcoming years, the system is planned to expand the fleet to 7,000 bicycles.

Looking ahead, the Air District's TFCA Regional Fund will continue to be an eligible source of funding for bicycle facility improvement projects. Based on prior year funding awards for bicycle parking projects, it is anticipated that between 2015-2020 more that $7 million in TFCA Regional Funds will be available to help support the expansion of bicycle parking and bikeways.

OneBayArea Grant Program. The OneBayArea Grant Program is a new funding approach that better integrates the region's federal transportation program with the Sustainable Communities Strategy, or Plan Bay Area. OneBayArea grants provide funds for a wide range of bicycle and pedestrian improvements including bicycle facilities, bicycle education, outreach, sharing and parking, sidewalks, ramps, pathways and pedestrian bridges, user safety and supporting facilities, and traffic signal actuation.

OneBayArea also provides funds for Transportation for Livable Communities (TLC) projects to support community based transportation projects that bring new vibrancy to downtown areas, commercial cores, high density neighborhoods, and transit corridors, enhancing their amenities and ambiance and making them places where people want to live, work and visit. The TLC program supports Plan Bay Area by investing in improvements and facilities that promote alternative transportation modes rather than the single-occupant automobile.

Innovative Grants Program. MTC's Innovative Grants Program funds demonstration projects to test innovative strategies to promote changes in driving and travel behaviors. For Bicycle and Pedestrian Access and Facilities Improvements projects, the Innovative Grants Program includes the following strategies.

- Bay Area Bike Share Pilot Program - the nation's first regional bike sharing initiative included 700 bicycles and 70 kiosk stations in five cities: San Francisco, Redwood City, Palo Alto, Mountain View, and San Jose.
- Innovative Bicycle Detection Systems - The City of San Jose aims to reduce bicycle accidents by testing and adopting bicycle signal detection technologies and installing them on key corridors in the city's Primary Bikeway Network. It will test four types of technologies: video detection, radar, inductive loop and wireless magnetometer.
- Alameda County Bikemobile - The Bikemobile makes visits to schools and other sites, offering three specific services: Bike Safety Education, Bike Repair Education and Bike Riding Encouragement.

Transportation Development Act. The California Transportation Development Act (TDA) provides two major sources of funding for public transportation: the Local Transportation Fund and the State Transit Assistance fund. These funds are for the development and support of public transportation needs in California and are allocated to areas of each county based on population, taxable sales and transit performance. A share of the TDA goes to fund pedestrian and bicycle projects. To obtain TDA funding from MTC, local jurisdictions must have a Bicycle Advisory Committee to plan and prioritize funding for bike projects. TDA funds are assumed to grow at rates that take into account demographic and economic factors such as median income, regional employment and population growth.

Implementation Actions:

MTC will:

- Fund the Climate Initiatives Innovative Grants program for Bicycle and Pedestrian Access and Facilities Improvement projects ($500,000)
- Fund regional bike share program ($8.7 million)
- Fund bicycle and pedestrian improvement projects through State Transportation Development Act (TDA) and local sales tax funds ($4.6 billion)
- Fund complete streets projects, including stand-alone bicycle and pedestrian paths, bicycle lanes, pedestrian bulb-outs, lighting, new sidewalks, and Safe Routes to Transit and Safe Routes to Schools projects (see TR7) to improve bicycle and pedestrian safety and travel via the OneBayArea Grant program. ($14.6 billion One Bay Area Grant program total)

The Air District will:

- Continue to fund bike lanes, routes, paths, and bicycle parking facilities with TFCA funds through Bicycle Facilities Program ($7.2 million)
- Continue to encourage planning for bicycle and pedestrian facilities in local plans, e.g. general and specific plans

Emission Reductions:

Pollutants*	2020	2030
ROG	41	17
NO_x	32	14
$PM_{2.5}$	4	3
PM_{10}	10	8
DPM	14	11
TACs	0.01	<0.01
CO_{2e}	12,303	9,128

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:

Emission reductions were estimated using data collected for bicycle and pedestrian projects in the Merced County Association of Governments (MCAG) planning area. In addition, emission benefits calculations are based on the applicable pollutants for the region, including the components of ozone (NOx and ROG) and particulate matter (PM). The emission reductions result from the decrease in emissions associated with auto trips replaced by bicycle trips for commute or other non-recreational purposes. Pedestrian facilities reduce emissions when auto trips are replaced by walking. ARB's emission model EMFAC 2014 was used to calculate emission reductions.

Exposure Reduction:

This measure will reduce region-wide population exposure to air pollutants based on the estimated reduction in emissions.

Emission Reduction Trade-offs:
None identified.

Cost:
Through 2020, $7.7 million; beyond 2020, over $4.6 billion

Co-benefits:
- Improved safety/reduced bicycle-motor vehicle accidents.
- Improved safety/reduced pedestrian-motor vehicle accidents
- Improved public health/reduced obesity.
- Reduced vehicle trips.
- Reduced travel costs.

Issues/Impediments:
Pedestrian travel and bicycle use is limited by factors such as physical ability, terrain, weather, and the need to carry cargo. Personal safety concerns may also prevent some people from switching modes to bicycle and pedestrian travel. Improving bicycle and pedestrian facilities and public education for pedestrians, bicyclists and drivers can increase perceived and actual safety.

Sources:
1. Metropolitan Transportation Commission, Association of Bay Area Governments, *Plan Bay Area, Regional Transportation Plan and Sustainable Communities Strategy*, July 2013
2. Bay Area Air Quality Management District, Proposed TFCA Regional Fund Policies and Evaluation Criteria for FYE 2017

TR10: Land Use Strategies

Brief Summary:
Local land use decisions can directly and indirectly impact air quality and greenhouse gas emissions, as well as people's exposure to toxic air contaminants (TACs). This measure supports land use patterns that reduce vehicle miles traveled (VMT) and associated emissions and exposure to toxic air contaminants, especially within infill locations and impacted communities.

Purpose:
The purpose of this control measure is to reduce emissions of the key ozone precursors, ROG and NOx, particulate matter, air toxics and greenhouse gases by promoting land use patterns, policies, and infrastructure investments that support higher density mixed-use, residential and employment development near transit. This measures also includes actions to reduce exposure to toxic air contaminants.

Travel Market Affected:
This measure affects all intraregional travel.

Regulatory Context and Background:
Promote Land Use that Reduces Vehicle Miles Traveled
Land use and zoning are powerful tools local governments can use to reduce vehicle use and emissions. Transportation, and particularly passenger vehicle use, is responsible for the majority of air pollution in the Bay Area. Motor vehicles contribute significantly to ozone precursor emissions (23 percent of ROG and 43 percent of NOx), peak PM2.5 concentrations (20 percent) and nearly 40 percent of GHGs. Vehicle use also contributes to 31 percent of toxic air contaminant emissions.

A significant body of research has demonstrated the relationship between land use and travel behavior. People who live in areas with higher densities, a mix of residential, retail and office uses, with well-designed pedestrian, bicycle and transit infrastructure take more trips by transit, bicycle, and walking which results in reduced driving. The National Research Council concludes that "the most reliable studies estimate that doubling residential density across a metropolitan area might lower household VMT by 5 to 12 percent, and perhaps by as much as 25 percent, if coupled with higher employment concentrations, significant public transit improvements, mixed uses, and other supportive demand management measures."

Additionally, key findings from MTC's Station Area Residents Survey (STARS) Report include the following:

- People who live within ½ mile of a rail/ferry station are four times as likely to use transit as people living farther than ½ mile from a rail/ferry station.
- Individuals living and working within ½ mile of a rail/ferry station use transit for 42 percent of their commute trips, whereas those who neither live nor work within ½ mile of a station use transit for only 4 percent of their commute trips.
- Households within ½ mile of rail/ferry stations generate about half of the vehicle miles

traveled compared to their suburban and rural counterparts.

- People who live within ½ mile of rail/ferry station walk about 50 percent of the time for all short trips (less than one mile), whereas residents who live greater than ½ mile away walk for only about 25 percent of short trips.

The significant contribution automobile use makes to air pollution and GHGs and the compelling land use and travel behavior connection prompted the state to require that regional planning agencies consider how land use and transportation investments may be better coordinated to reduce vehicle emissions, specifically GHGs. Senate Bill 375, signed into law in September 2008, required the Air Resources Board (ARB) to adopt regional GHG reduction targets for emissions associated with automobiles and light trucks. Metropolitan planning organizations were then required to develop a Sustainable Communities Strategy (SCS) in their long-range transportation plans to reach the GHG reduction targets. The SCS must demonstrate how the land use development pattern and the transportation network can work together to reduce GHG emissions. In addition, SB 375 requires that regions house all of their projected population, by income level, thereby integrating the Regional Housing Needs Allocation (RHNA) into the long-term regional plan for transportation investments.

The Regional Housing Needs Allocation is a state-mandated program to identify the total number of housing units (by affordability level) that each jurisdiction must plan for to meet state housing goals. And since the adoption of SB 375, RHNA also plays a key role in meeting regional GHG targets. The California Department of Housing and Community Development (HCD) identifies the total housing need for the San Francisco Bay Area for an eight-year period (current cycle is 2014 to 2022). ABAG and MTC must then develop a methodology to distribute this need to local governments. The methodology takes into account projected job and population growth, access to transit and existing development. The method also needs to ensure that allocation is consistent with the long-term development pattern in the SCS. Once a local government has received its final housing allocation, it must develop an updated plan to accommodate its portion of the region's housing need (via the Housing Element of the General Plan). Both the SCS and RHNA are, therefore, powerful regional planning tools to ensure that land use and transportation work together to reduce GHG emissions from vehicle trips.

The Bay Area's first Sustainable Communities Strategy – known as Plan Bay Area - was developed and adopted by ABAG and MTC in 2013. The plan accomplishes its GHG reduction goals established by ARB (7 percent per capita reduction by 2020 and 15 percent per capita reduction by 2035) through a strategy to meet 80 percent of the region's future housing needs in Priority Development Areas (PDAs). PDAs are neighborhoods within walking distance of frequent transit service, that offer a wide variety of housing options, and amenities such as grocery stores, community centers, and restaurants. For the transportation component of the plan, Plan Bay Area specifies how $292 billion in anticipated federal, state and local funds will be spent through 2040.

Local governments play a fundamental role in implementing the land use component of Plan Bay Area, as they are responsible for land use, zoning and planning for affordable housing within their communities. Plan Bay Area assists jurisdictions in implementing the SCS through funding of land use planning and transportation investments in infill locations near transit, i.e. in PDAs. The One Bay Area Grant (OBAG) program is the funding mechanism for Plan Bay Area. OBAG programs include approximately $800 million for projects over a four-year period (through FY2016). Funds are distributed to local governments that plan for and build affordable housing, as allocated through the RHNA process. Funds also support local transportation projects within Priority Development Areas.

The Bay Area Transit-Oriented Affordable Housing (TOAH) fund provides additional financing for the development of affordable housing and other community services near transit throughout the Bay Area. Through the fund, developers can access flexible, affordable capital to purchase or improve available property near transit stations for the development of affordable housing, retail space and other residential services, such as child care centers, fresh food outlets and health clinics. The TOAH fund was made possible through a $10 million investment from MTC.

The Air District also offers incentive programs to support investments in infill locations and PDAs. Incentive programs are largely funded through the Air District's Transportation Fund for Clean Air (TFCA). In 1991, the California State Legislature authorized the Air District to impose a $4 surcharge on motor vehicles registered within the San Francisco Bay Area to fund projects that reduce on-road motor vehicle emissions. Sixty percent of TFCA funds are awarded directly by the Air District to eligible projects and programs implemented directly by the Air District; through a grant program known as the Regional Fund Program. The remaining forty percent is forwarded to each Bay Area county through the County Program Manager program (see www.baaqmd.gov/tfca4pm for details).

Both the Regional Fund and the County Program Manager program support infill development. The Regional Fund includes up to $13.6 million annually in incentives for a variety of trip reduction programs; a portion of these funds have been reserved for trip reduction pilot projects within PDAs. Projects must reduce single-occupancy commute-hour vehicle trips by encouraging mode-shift to other forms of shared transportation. The County Program Manager fund is nearly $10 million annually; it includes funding for a variety of pedestrian, transit, and other trip reduction programs, including programs that support "smart growth" or infill development.

Additionally, the Air District helps inform local land use plans by incorporating smart growth model policies and guidance within its California Environmental Quality Act (CEQA) Guidelines. CEQA was adopted in 1970 and is intended to inform policy-makers and the public about potential environmental effects of a project; identify ways to reduce adverse impacts; offer alternatives to a project; and enhance public participation in the planning process. The Air District's CEQA Guidelines were developed to assist lead agencies in analyzing and minimizing air quality impacts associated with proposed land use decisions and development projects. The most recent guidelines include numerous sample mitigation measures and model local plan policies to implement infill or smart growth principles to reduce vehicle trips.

Promote Infill Development to Preserve Open Space and Agricultural Lands
Promoting development within PDAs may take development pressure off of the region's open space and agricultural lands. Open space and agricultural lands play a vital role not only as landscapes that can sequester carbon, but also generate far fewer GHG emissions than urban or suburban uses. Urban and suburban uses encourage greater vehicle miles traveled and contribute to greater air quality impacts relative to open space and agricultural lands.

Plan Bay Area identifies Priority Conservation Areas (PCAs), which are open spaces that provide agricultural, natural resource, scenic, recreational, and/or ecological values and ecosystem functions. These areas are identified through consensus by local jurisdictions and park/open space districts as lands in need of protection due to pressure from urban development or other factors. Plan Bay Area includes a target to direct all non-agricultural development within the existing urban footprint, which represents existing urban development and urban growth boundaries.

Local Agency Formation Commissions (LAFCOs), regional planning agencies responsible for approving boundary changes of cities and special districts, can also play a role in agricultural preservation by guiding development toward PDAs and away from open space and agricultural lands (See AG1: Agricultural Guidance and Leadership and NW1: Carbon Sequestration in Rangelands for more information).

Reduce Population Exposure to Toxic Air Contaminants
Communities are exposed to TACs as a result of emissions from numerous stationary and mobile sources of air pollution. Communities near large industrial sources, distribution centers, major freeways and seaports experience relatively higher pollution levels and corresponding health effects, compared to other parts of the region. To reduce exposure to local air pollution, the Air District regulates a variety of stationary sources through the New Source Review for Toxics permitting process for new and modified sources of toxic air contaminants. Stationary sources are also regulated by the Air District via source-specific regulations. The Air District also limits TACs through the administration of the Air Toxics "Hot Spots" Program. (See SS20: Air Toxics Risk Reduction from Existing Facilities and SS21: New Source Review for Toxics)

The Air District's CARE program, *Planning Healthy Places*, CEQA Guidelines and CEQA review process also address local exposure to toxic air contaminants, from both vehicle and non-vehicle sources. The Air District initiated the Community Air Risk Evaluation (CARE) program in 2004 to evaluate and reduce health risks associated with local exposures to air toxics in the Bay Area. The program examines air toxics emissions from stationary sources, area sources and on-road and off-road mobile sources with an emphasis on reducing population exposure to diesel exhaust. CARE combines technical analysis, outreach to impacted communities, and policy mechanisms to reduce emissions and health risks in those communities.

The Air District provides technical assistance and guidance to local governments specifically to address local air pollution exposure when planning for infill development through a guidance document, *Planning Healthy Places*. Infill locations are often near freeways, distribution centers, or large industrial sources. *Planning Healthy Places* promotes "healthy infill development" by encouraging local governments and developers to address and minimize potential local air pollution issues early in the land-use planning and development process. As part of this effort, the Air District provides information, recommendations, and technical tools to assist cities in incorporating air quality considerations into their planning processes.

Tools and assistance in *Planning Healthy Places* include:

- Web-based, interactive mapping tools to locate areas in the region that are estimated to have elevated levels of fine particulates and/or toxic air contaminants.
- Best practices that may be implemented by local governments and developers to reduce health risks from air pollution in areas that experience elevated levels of air pollutants, including best practices to reduce emissions. Best practices to reduce emissions include: retrofitting generators, limiting idling times or prohibiting idling, facilitating zero emission technology and alternative fuels, use of independent transportation refrigeration units on trucks, and use of transportation demand and traffic management strategies.

As stated above, the Air District's CEQA Guidelines were developed to assist lead agencies in analyzing and minimizing air quality impacts associated with land use development projects. In regards to local air pollution exposure, the Guidelines identify strategies on how local governments or project sponsors may avoid and mitigate population exposure to toxic air contaminants and criteria pollutants.

Implementation Actions:
The Air District will:

- Assist local governments with the implementation of Plan Bay Area:
  - Maintain land use plan guidance and best practices resources for local governments.
  - Continue to provide, and increase as appropriate, emission reduction incentive funding opportunities and vehicle trip reduction program funds (TFCA funds) for local government's with impacted communities and/or Priority Development Areas.
  - Assist local governments in securing incentive/grant funding for affordable housing projects or land use planning grants in transit rich areas, i.e. Priority Development Areas.
  - Work with local governments, regional agencies, and LAFCOs to discourage conversion of agricultural and natural lands, identified as PCAs in Plan Bay Area.
- Participate in the development of the land use scenario in the Sustainable Communities Strategy for 2040 Plan Bay Area to emphasize reduction of vehicle miles traveled and achievement of GHG emission reduction targets.
- Assist local governments with health protective infill development by:
  - Assisting local governments in accessing and utilizing on line maps via *Planning Healthy Places*.
  - Improving datasets for local-scale air pollution assessments, especially for permitted sources.
  - Assisting with the development of local plans to reduce exposure to air pollution.
  - Developing improved datasets on community health in impacted communities.
- Continue to assess health impacts to sensitive receptors living near highways and other

emission sources.

- Continue to focus enforcement action on emission sources in impacted communities and look for opportunities to partner with local jurisdictions.
- Continue to provide land use planning guidance and best practices to local governments.
- Update the CEQA Guidelines to reflect new data and current policy approaches.
- Conduct outreach to local jurisdictions, consultants, developers, and community members on revised CEQA Guidelines and provide technical assistance to lead agencies.
- Continue CEQA commenting by the Air District:
  - Review CEQA documents prepared for projects that could impact the Bay Area and recommend mitigation measures as appropriate.
  - Continue to provide on the Air District's CEQA website a listing of all CEQA comment letters.

MTC will:

- Fund the One Bay Area Grant Program Regional PDA Planning Program including: $10 million to the Transit Oriented Affordable Housing (TOAH) fund; $8 million to Regional PDA Planning and Technical Assistance; and $2 million to ABAG for its research and planning activities. ($20 million)
- Monitor and manage all awarded project contracts associated with the Regional PDA Planning, PDA Technical Assistance, and PDA Staffing Assistance grants.
- Continue to fund the TOAH revolving loan fund for affordable housing projects near transit in PDAs throughout the region. ($50 million)

Emission Reductions:

Pollutants*	2020	2030
ROG	103	43
NO_x	62	27
$PM_{2.5}$	11	8
PM_{10}	26	20
DPM	33	27
CO_{2e}	30,024	22,275

**criteria pollutants and diesel PM are reported in lbs/day; all toxics, except diesel PM are in grams/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:

The methodology for estimating emission reductions for this measure utilizes the concept of transportation efficiency by concentrating dense, mixed-use, and pedestrian-friendly urban "nodes" around public transportation. The overall approach for estimating infill vehicle-trip generation is based on adjusting baseline Institute of Transportation Engineers (ITE) vehicle-trip data[1].

[1] See: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_758.pdf
NCHRP Report 758; Trip Generation Rates for Transportation Impact Analyses of Infill Developments

The methodology has three steps:

1. Baseline ITE trip generation data are used to estimate the vehicular trip generation of the proposed infill development.
   a. Baseline/Suburban development assumed single family (9.57 trips per dwelling unit) residential trip rates and retail/shopping center (42.94 trips per dwelling unit) commercial trip rates
2. Infill vehicle trips ITE trip generation data are used in the evaluation of site traffic impacts.
   a. Infill development assumed multifamily (6.65 trips per dwelling unit) residential trip rates and general office building (11.01 trips per dwelling unit) commercial trip rates
3. Emission reductions result from the decrease in emissions associated with auto trips reduced by infill development compared to baseline/suburban development.

CO2 conversion/equivalency factors were used to estimate the emission reduction benefits for the criteria pollutants and mobile source air toxics.

Exposure Reduction:
As stated above, the Air District's CARE program, Planning Healthy Places, CEQA Guidelines and CEQA review process address local exposure to toxic air contaminants, from both vehicle and non-vehicle sources. The CARE program, specifically, evaluates health risks associated with local exposures to air toxics in the Bay Area. The program examines air toxics emissions from stationary sources, area sources and on-road and off-road mobile sources with an emphasis on reducing population exposure to diesel exhaust.

Emission Reduction Trade-offs:
None identified.

Cost:
Costs for MTC programs are listed above.

For Air District programs, specific costs are unknown. The Air District will provide technical support to cities and counties to reduce demands on local resources.

Co-benefits:

- Reduced travel costs.

- Community enhancements through revitalized downtowns, transit centers, and other major activity nodes.
- Closer integration of transportation and land use.
- Increased access to jobs, services, and stores.
- Improved public health by reduced driving and increased walking and biking.
- Enhanced collaboration with local governments, resulting in more wide spread and effective implementation of Air District programs.

Issues/Impediments:
Land use changes and new development occur slowly and are directly regulated by local jurisdictions, not regional agencies. In addition, higher density development can raise neighborhood concern over impacts on traffic, parking, localized air pollution, and other issues.

Sources:
1. State of California, Office of Planning and Research, *CEQA Guidelines and Greenhouse Gases*, http://opr.ca.gov/index.php?a=ceqa/index.html
2. California Air Pollution Control Officers (CAPCOA) CEQA and Climate Change White Paper, http://www.capcoa.org/CEQA/CAPCOA%20White%20Paper.pdf
3. Metropolitan Transportation Commission, Association of Bay Area Governments, Plan Bay Area, Regional Transportation Plan and Sustainable Communities Strategy, July 2013
4. California Air Pollution Control, *CAPCOA Model Policies for Greenhouse Gases in General Plans,* May 2009, http://www.capcoa.org/modelpolicies/CAPCOA%20Model%20Policies%20for%20Greenhouse%20Gases%20in%20General%20Plans%20-%20June%202009.pdf
5. California Air Resources Board, Air Quality and Land Use Handbook: A Community Health Perspective, April 2005, http://www.arb.ca.gov/ch/handbook.pdf
6. Metropolitan Transportation Commission, Characteristics of Rail and Ferry Station Area Residents in the San Francisco Bay Area: Evidence from the 2000 Bay Area Travel Survey, September 2006, http://www.mtc.ca.gov/planning/smart_growth/stars/
7. Cervero, Robert; Kickelman, Kara; National Research Council, *Travel Demand and the 3Ds: Density, Diversity, and Design*, September 1997

TR11: Value Pricing Strategies

Brief Summary:
This measure will pursue implementation of value pricing strategies such as tolling on trans-bay bridges and cordon pricing on roads, as well as auto pricing options, such as a VMT fee and pay-at-the-pump auto insurance.

Purpose:
The purpose of this measure is to reduce emissions of the key ozone precursors, ROG and NOx, particulate matter, air toxics and greenhouse gases by managing travel demand during congested conditions on Bay Area bridges, in San Francisco, and on other heavily congested freeways and roadways around the Bay Area.

Travel Market Affected:
The Value Pricing Strategies measure would affect intraregional travel, including commute travel, shopping, personal business, school trips, as well as social and recreational travel.

Regulatory Context and Background:
Congestion pricing involves charging drivers a fee to drive in congested areas. Revenue generated from fees are then used to fund transportation improvements — such as better transit service, signal coordination, and bicycle and pedestrian projects — that improve travel options and traffic flow. Congestion pricing is being advanced in San Francisco through a demonstration project as a part of the Treasure Island development project, and through ongoing planning for congestion pricing in downtown San Francisco.

In June 2011, the City of San Francisco approved development plans for Treasure Island, including 8,000 residential units, along with retail and commercial uses. The Treasure Island Transportation Implementation Plan, adopted as part of the development project's approval, calls for an integrated approach to managing traffic and improving mobility management, including a congestion fee to be assessed for residents traveling by private automobile on or off the island during peak hours. The congestion fee, in combination with parking charges and a pre-paid transit voucher for each household, will help fund a comprehensive suite of transportation services including new ferry service to San Francisco and enhanced East Bay bus services.

During rush hours, congestion in the greater downtown San Francisco area results in average bus transit and automobile speeds below 10 miles per hour. A study prepared by San Francisco County Transportation Authority found congestion pricing in downtown San Francisco to be a feasible and potentially effective way to manage and grow the transportation system while supporting new businesses and residents. San Francisco's mobility and pricing program could result in:

- 12 percent fewer peak-period vehicle trips and a 21 percent reduction in vehicle hours of delay
- 5 percent reduction in greenhouse gases citywide

- $60–80 million in annual net revenue for mobility improvements
- 20–25 percent transit speed improvement and 12 percent reduction in pedestrian incidents

In addition to congestion pricing in San Francisco, other pricing strategies could be considered region-wide to reduce VMT and congestion. Pricing strategies increase the marginal cost per mile driven, providing a greater incentive to reduce travel; resulting in fewer trips, shorter trips, greater use of alternative modes, and travel shifts to periods of lower congestion. The specific impacts depend on the alternatives available to travelers (i.e., mode, destination) and price sensitivity, which varies by income, personal and household characteristics, and specific aspects of the trip.

Pricing can take a number of forms, including:

- VMT fees (charging drivers per mile of travel)
- Increases in the existing gasoline tax or new fuel or carbon taxes that price travel according to fuel consumed or carbon emitted (providing an incentive to purchase more efficient vehicles as well as to reduce travel)
- Facility-specific tolls
- Congestion pricing (pricing roadway facilities when they are congested to reduce traffic on those facilities to an improved level of service)
- Cordon/area pricing (applying a fee for vehicles to enter or operate within a selected area, such as a central business district)
- Pay-As-You-Drive (PAYD) insurance (converting a significant portion of the essentially fixed cost of insurance to a marginal cost based on mileage).

VMT fees target reductions in vehicle miles of travel. Unlike road pricing measures where costs can be reduced by switching travel times, use of routes, or type of vehicle used, the only way for an individual to reduce costs under VMT fees is to drive less, thus reducing traffic and emissions. VMT fees do not, however, discourage peak-period driving (since every mile costs the same regardless of when it is driven) or encourage a shift to cleaner burning engines. They are not facility- or time-specific fees so they do not affect the entire vehicle fleet.

Past pricing studies have suggested that with higher travel costs region-wide, people and households tend to move to locations where accessibility to job opportunities is plentiful, so as to offset the impacts from an increase in travel costs. Correspondingly, employers will relocate to key locations to better align themselves with the newly emerging concentration of workers and households.

To assist in the implementation of the Sustainable Communities and Climate Protection Act of 2008 (SB 375), MTC is considering acquiring a federal Value Pricing Pilot Program grant from the Federal Highway Administration to examine road and auto pricing options, such as a VMT fee and pay-at-the-pump auto insurance.

Additionally, as mentioned in TR14: Cars and Light Trucks, MTC is considering proposing to use a feebate program to incentivize consumers to scrap older vehicles and purchase higher performing, cleaner vehicles. A feebate program uses a combination of fees and rebates to change consumer behavior. Consumers purchasing a vehicle that emits more CO_2 on a gram per mile basis than a defined standard are assessed a fee at the point of purchase. These fees are used to provide rebates to consumers that purchase vehicles that emit less CO_2 on a gram per mile basis than the defined standard.

Implementation Actions:

MTC will:

- Implement congestion pricing projects in San Francisco, as identified in Plan Bay Area ($150 million)
- Study ways to use pricing more effectively in funding of transportation by seeking a federal Value Pricing Pilot Program grant from the Federal Highway Administration to examine road and auto pricing options, such as a VMT fee.
- Explore options for developing a feebate program, as a funding mechanism for electric vehicle purchase incentives.

The Air District will:

- Support MTC in its grant application for a federal Value Pricing Pilot Program grant.
- Advocate for value pricing strategies that demonstrate their cost effectiveness in reducing vehicle emissions.

Emission Reductions:

Pollutants*	2020	2030
ROG	1,268	534
NO_x	762	335
$PM_{2.5}$	135	102
PM_{10}	322	243
DPM	409	336
TACs	0.17	0.13
CO_{2e}	370,601	274,947

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:

MTC's regional travel demand model (Version 0.3 of Travel Model One) was used to estimate the VMT impacts of this measure. The travel model assumes travel choices are determined by the perceived cost of operating an automobile, relative to the perceived cost of taking transit, paying a bridge toll, paying for parking, etc. As a simplification, the model assumes a uniform (across all travelers, across all travel conditions) perceived automobile operating cost. VMT fee could be implemented in a variety of ways and the method of implementation could impact the behavioral response, i.e. response to cost of automobile travel. For example, the VMT fee could be charged "at the pump", with the car communicating with the gasoline pump to determine the fee. Or, the fee could be collected annually/monthly/weekly as part of a vehicle registration process. The travel model assumes, implicitly, that paying the fee is similar to paying for gasoline and routine vehicle maintenance.

The California Air Resources Board emission model (EMFAC 2014) was used to calculate pollutant impacts. CO_2 conversion/equivalency factors were used to estimate the emission reduction benefits for the criteria pollutants.

Exposure Reduction:
Reducing high speed driving should help to reduce emissions of ROG, NOx, PM, and CO_2 and therefore exposure to air pollution throughout the Bay Area. Impacted communities near freeways and roads with significant auto and truck traffic will benefit.

Emission Reduction Trade-offs:
None identified.

Cost:
$150 million for implementation of congestion pricing projects in San Francisco, as identified in Plan Bay Area

Co-benefits:
- Generation of new funds for multi-modal transportation improvements
- Travel time savings
- Reduce congestion
- Community enhancements through the creation of more and higher quality transit options
- Shift demand from the peak travel period, thereby making non-peak public transit more sustainable and financially viable
- Give residents an incentive to live at higher densities in more central locations

Issues/Impediments:
Congestion pricing raises several equity issues, including income equity, geographic equity and modal equity. With income equity, low-income groups could be negatively affected by pricing strategies, as fees or other pricing strategies could place the burden of travel-behavior change disproportionally on low-income individuals. In geographic equity, some parts of the region could be made worse off than others, as traffic diversion from tolled routes could negatively impact neighborhoods or reduce performance on alternative toll-free route. Finally, with modal equity, public perceptions with regard to encouragement of multi-modal transportation can be an issue, as some individuals believe that it is not fair to offer the same travel-time savings to those who pay a toll as to those who “do the right thing” by carpooling or taking transit.

Sources:

1. Metropolitan Transportation Commission, Association of Bay Area Governments, *Plan Bay Area, Regional Transportation Plan and Sustainable Communities Strategy*, July 2013

2. San Francisco Transportation Authority, San Francisco Mobility, Access & Pricing Study, 2010
3. Rodier, Caroline J., University of California, Davis, A Review of the International Modeling Literature: Transit, Land Use, and Auto Pricing Strategies to Reduce Vehicle Miles Traveled and Greenhouse Gas Emissions, October 2009, http://eprints.cdlib.org/uc/item/2jh2m3ps
4. De Corla-Souza, Office of Innovative Program Delivery, Federal Highway Administration, U.S. Department of Transportation, Income-Based Equity Impacts of Congestion Pricing, December 2008, http://ops.fhwa.dot.gov/publications/fhwahop08040/fhwahop08040.pdf

TR12: Smart Driving

Brief Summary:
Smart Driving is a set of strategies and techniques that maximize fuel efficiency and reduce emissions by improving driving habits and vehicle maintenance. This measure would implement a smart driving pilot program that includes installing temporary in-vehicle devices that display vehicles gas mileage in real time, a social marketing campaign, vehicle maintenance tips, trip planning tools through 511.org and other public information/education initiatives.

Purpose:
The purpose of this measure is to reduce emissions of the key ozone precursors, ROG and NOx, particulate matter, air toxics and greenhouse gas emissions by educating drivers and improving vehicle maintenance.

Travel Market Affected:
This measure would affect intraregional travel, including commute travel, shopping, personal business, school trips, as well as social and recreational travel. This measure would primarily address freeway travel.

Regulatory Context and Background:
MTC has conducted an analysis on emissions created by vehicles traveling over 65 mph on freeways. The analysis demonstrated that by limiting passenger car travel to 65 mph, there is a potential to reduce VOC by 2,000 to 5,600 pounds per day and NOx by 1,800 to 3,800 pounds per day, if applied throughout the Bay Area. Approximately 60 percent of Bay Area driving (VMT) takes place on the freeway system and, based on Caltrans speed monitoring data, 34 percent of freeway driving occurs at speeds over 65 mph. Therefore, by addressing over-the-limit freeway driving, this measure could achieve significant emission reductions. A vehicle driven at 75 mph consumes approximately 40 percent more fuel and emits 35 percent more emissions than one driven at 60 mph.

There are a variety of techniques known as “smart driving”, “green driving”, or “eco-driving” that increase the fuel efficiency of auto travel, thereby reducing emissions and saving money; these include:

- Avoiding quick starts and aggressive driving
- Reducing highway speeds (55 mph is the most efficient speed for fuel consumption)
- Using overdrive and cruise control
- Avoiding driving in rush hour
- Using air conditioning sparingly
- Reducing idling
- Reducing drag by removing roof racks, tow-hook carriers, and other items that cause wind resistance
- Removing heavy unneeded items from cars
- Properly maintaining vehicles including optimal tire pressure

Smart driving also entails driver decisions such as vehicle selection and maintenance, route selection, vehicle load, and driver behavior, including vehicle speed.

The Metropolitan Washington Council of Governments (MWCOG) in Washington, D.C. completed an analysis of what it would take to meet their GHG goals. They found that the most cost effective and productive strategy that could be implemented at the regional or local level to reduce vehicle emissions was through smart driving strategies. For this reason, MWCOG joined in partnership with the Delaware, Maryland, New York, North Carolina, New Jersey, and Massachusetts Departments of Transportation, along with several other MPOs and Port Authorities to launch the I-95 eco-driving campaign, a public information campaign on the benefits of smart driving.

The largest smart driving study undertaken to date was by Fiat in 2010. The study analyzed the effects of their eco:Drive software with 5,700 drivers, over 428,000 journeys, 150 days and five countries. Over the course of the study, the average improvement in fuel economy was six percent. The top ten percent of participants improved their fuel efficiency by 16 percent. Based on the positive results of this study, Fiat has continued to expand their eco:Drive software to include in-vehicle displays and real time mobile apps. These improvements are mirrored in the technology that MTC is testing in their smart driving pilots (see below for more information). It is expected that with real-time feedback on driving habits, improvements in fuel efficiency could exceed the six percent seen in the initial study.

While there have been recent studies in the United States on smart driving, they have all been conducted with small sample sizes of twenty participants or less. In order to learn more about the potential of smart driving in the Bay Area, MTC is implementing the following smart driving pilots:

- In-vehicle devices, displaying real time miles per gallon (MPG) and/or feedback on efficient acceleration, deceleration, and maintaining a steady speed. These devices are mounted on the dashboard of the participants' vehicles; and
- MPG mobile apps, similar to the in-vehicle device pilot, but in a telephone application format. This pilot will be conducted in conjunction with ITS-UC Davis.

The in-vehicle display is connected to the vehicle's on-board diagnostic (OBD) port. The port receives information from the vehicles computer system in real-time to inform the display. The smart phone application calculates the driver's behavior based on the phone's GPS system. In both pilots, baseline driving habits over the course of at least one month will be collected. The devices will be in the participants' vehicles for a minimum of three months to see how quickly the smart driving habits are learned and if the behaviors persist over time.

Implementation Actions:

MTC will:

- Implement a smart driving social marketing campaign that will aim to teach drivers the basics of smart driving in-vehicle and maintenance behaviors in addition to trip linking and route planning. ($56 million)
- Offer several trip planning tools through 511.org. 511 provides real time and predicted future traffic information page which allows drivers to plan their trips to avoid congested routes.
- Implement a smart driving rebate program, linked to fuel efficiency meters. Under this program MTC will offer a $100 rebate to consumers who purchase an OBD-connected after-market device. This device would be very similar to the in-vehicle devices being tested through MTC's two pilots. The real time information on efficient driver behavior will quickly train drivers to alter their behavior in order to save money and gas, and reduce emissions. ($105 million)

The Air District will:

- Promote/implement a voluntary certification program with fleet operators that could be used as a marketing tool, utilizing Sustainable Earth Initiative's Green Fleets Toolkit
- Consider expanding Spare the Air Day messaging to include how complying with speed limits and other smart driving techniques can reduce smog forming pollution on Spare the Air Days, and reduce GHG's every day.

Emission Reductions:

Pollutants*	2020	2030
ROG	1,962	825
NO_x	1,178	518
$PM_{2.5}$	209	158
PM_{10}	497	376
DPM	633	519
TACs	0.20	0.02
CO_{2e}	573,189	425,247

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:

Different equations were used to calculate the various component of this control measure. Equations were developed specifically for the social marking elements. These equations incorporated driving behavior, such as acceleration and deceleration, maintenance, route planning and trip linking. The equations were used to calculate how driving behaviors impact VMT and therefore emission reductions. Emission reduction estimates were estimated via EMFAC 2014 trip end and exhaust emission rates. CO2 conversion/equivalency factors were used to estimate the emission reduction benefits for the criteria pollutants and mobile source air toxics (MSATs). Emission reductions estimated for criteria pollutants and toxics are nominal.

Exposure Reduction:
Reducing high speed driving should help to reduce emissions of ROG, NOx, PM, and CO_2 and therefore exposure to air pollution throughout the Bay Area.

Emission Reduction Trade-offs:
None identified.

Cost:
$161 million

Co-benefits:
- Reduced/less frequent servicing, maintenance and repair costs that result from reduced wear and tear of various vehicle components (i.e. tires, clutch, and engine).
- Economic savings from reduced costs associated with automobile crashes.
- Economic benefits from fuel savings to individual drivers and to the Bay Area economy as whole. For vehicles employing smart driving techniques, a range from 4.5 to 16.5 percent reductions in fuel consumption could be achieved.

Issues/Impediments:
Implementation of this control measure is dependent on available funding, collaboration between multiple agencies and the public's recognition of the consequences of high-speed driving and the positive effects of smart driving habits, e.g. maximizing fuel efficiency, fewer accidents.

Sources:

1. Metropolitan Transportation Commission, Association of Bay Area Governments, *Plan Bay Area, Regional Transportation Plan and Sustainable Communities Strategy*, July 2013
2. Fiat, 2009. Eco-Driving Uncovered: The benefits and challenges of eco-driving based on the first study using real journey data.
3. Kurani, K., Stillwater, T., and Jones, M., 2013. Ecodrive I-80: A Large Sample Fuel Economy Feedback Field Test: Final Report. Institute of Transportation Studies Report: ITS-RR-13-15. Available at http://www.fueleconomy.gov/feg/pdfs/EcoDrive%20I-80.pdf

TR13: Parking Policies

Brief Summary:
Parking policies and practices have a profound impact on vehicle travel and mode choice, as well as land use patterns and the quality of the built environment. Parking policies are also an important tool in implementing focused growth strategies. This control measure outlines how MTC and the Air District, in cooperation with regional agency partners, will 1) take actions at the regional level to implement parking policies that will benefit air quality, and 2) encourage and support local agency parking policies to reduce motor vehicle travel and promote focused growth.

Purpose:
This measure will reduce emissions of the key ozone precursors, ROG and NOx, particulate matter, air toxics and greenhouse gases by implementing parking policies that support in-fill and transit-oriented development and reduce vehicles miles traveled.

Travel Market Affected:
This measure would affect intraregional travel, including commute travel, shopping, personal business, school trips, as well as social and recreational travel.

Regulatory Context and Background:
Local governments have traditionally implemented parking policies that provide plentiful parking. Although “free” parking is often provided, there are both direct and indirect costs associated with all parking. Parking policies and zoning codes that promote an oversupply of parking contribute to reliance on the automobile and undermine infill and transit-oriented development.

Promoting parking policy reform will require political leadership in combination with technical assistance, resources, and incentives and disincentives. Parking policy reform and strategies could come in various forms, including:

- Eliminate or reduce minimum parking requirements;
- Limit the supply of off-street parking in transit-oriented areas;
- Encourage developers and property owners to unbundle the price of parking spaces from rents and purchase prices;
- Promote shared parking by different users;
- Implement market-rate pricing for off-street parking in high-use areas;
- Implement parking assessment districts that use revenue from street parking to fund pedestrian and streetscape improvements;
- Adopt design guidelines and policies to minimize surface area for parking;
- Implement car sharing and bike sharing programs in appropriate locations in exchange for reduced parking requirements, and provide as a benefit to renters;
- Encourage a coordinated parking policy approach among jurisdictions to minimize spillover to other jurisdictions and fears of unfair competition.

Cities and counties have direct authority over parking policies. However, regional agencies can assist local governments by providing technical resources, recommending best practices, and leading by example in adopting internal and external policies. MTC has provided such assistance through the following:

- "Parking Advanced Implementation Labs" offers professional assistance to local governments in adopting and implementing a specific parking strategy.
- Training: MTC provided training for local governments on the MTC publication *Reforming Parking Policies to Support Smart Growth*.
- Technical Assistance: MTC surveyed local jurisdictions' parking policies, interests and challenges, provided technical assistance for five specific locations, prepared an economic assessment of parking structures at transit stations, and conducted parking fundamentals workshops for local jurisdictions and other interested parties.
- Parking Workshops: In 2012-2013 MTC focused on technical analyses and communications methods, culminating in a series of parking workshops aimed at planning and transportation professionals. This effort included quick engaging videos summarizing key parking policy issues, best practices workshops, and additional technical reports.
- Transit Oriented Development - Technical Assistance Program (TOD-TAP): funds for planning efforts that include parking policy analysis in numerous communities. MTC developed guidance for the parking policy analysis section of the station area plans, and staff comments on the parking elements in the draft plans.
- Value Pricing Pilot Program for the Parking Pricing Regional Analysis Project: MTC was awarded a competitive grant from the Federal Highway Administration (FHWA) to establish a regional parking database, analyze a number of regional parking pricing policy options, and create and demonstrate local parking analysis tools. This specific effort was completed in 2015; however, this project has created a foundation for additional future development of the parking database, regional policy analyses and local strategies.
- *Parking Technology Roundtable.* In December 2014 MTC sponsored a round table discussion to share information, experiences and questions on how to best evaluate and implement parking technologies in support of local smart growth policies.
- MTC's Innovative Grants Program funds demonstration projects to test innovative strategies to promote changes in driving and travel behaviors.

Implementation Actions:

MTC will:

- Continue to provide technical assistance to local jurisdictions through the Transit Oriented Development Technical Assistance Program (TOD TAP) and offering best practices workshops.
- Consider parking projects as part of future Climate Program grant opportunities, such as the Transportation Demand Management program.
- Incorporate parking issues into the broader public outreach program for climate action.
- Continue support for State and Federal bills to reduce subsidies for parking.

- Conduct the VPP Parking Pricing Regional Analysis Project, which will create a foundation for additional future development of the parking database, regional policy analyses and local strategies.
- Fund the Climate Initiatives Innovative Grants Parking Policy project, including: goBerkeley, City of BerkeleyGrant ($2 million)

The Air District will:

- Highlight parking best practices, mitigation strategies, and/or guidance documents on the Air District's web site.
- Consider funding parking technology projects, including: real-time parking information, pay-by-phone parking, and parking hotlines.
- Encourage parking cash-out programs to employers and local governments.
- Encourage local agencies to adopt innovative parking strategies, including:
    - Eliminate or reduce minimum parking requirements;
    - Limit the supply of off-street parking in transit-oriented areas;
    - Encourage developers and property owners to unbundle the price of parking spaces from rents and purchase prices;
    - Promote shared parking by different users;
    - Implement market-rate pricing for off-street parking in high-use areas;
    - Implement parking assessment districts that use revenue from street parking to fund pedestrian and streetscape improvements;
    - Adopt design guidelines and policies to minimize surface area for parking;
    - Implement car sharing and bike sharing programs in appropriate locations in exchange for reduced parking requirements, and provide as a benefit to renters;
    - Encourage a coordinated parking policy approach among jurisdictions to minimize spillover to other jurisdictions and fears of unfair competition.
- Continue to provide comments, in regard to parking policies, on CEQA analysis of local plans and other projects to lead agencies.

Emission Reductions:

Pollutants*	2020	2030
ROG	1.41	0.59
NO_x	0.85	0.37
$PM_{2.5}$	0.15	0.11
PM_{10}	0.36	0.27
DPM	0.45	0.37
TACs	<0.01	<0.01
CO_{2e}	412	306

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:
According to the City of Berkeley, average daily traffic on the streets in the three pilot areas is 105,500. Commonly used figures are that 30% of traffic consists of drivers looking for a parking space and that the average cruising distance to find a curb space is 0.5 miles (this is based in part on research by UCLA Professor Donald Shoup). This translates to 15,825 daily VMT from "search driving" in the pilot areas. Also according to the City, the number of blocks in high parking demand areas that have on-street parking occupancy greater than 85 percent has decreased by 12 percent. This increase in parking availability is assumed to yield a corresponding 12 percent decrease in search driving. This results in a reduction of 1,899 VMT daily, or 693,135 VMT annually.

It is assumed that under demand-responsive parking management, it is easier to find parking but that the same number of trips continues to be made—in other words, there is no reduction in vehicle trips.

The above figures for reduced vehicle trips and VMT are translated into reduced GHG emissions using starting- and running-exhaust emission factors from EMFAC2011, the 2011 version of the computer model for estimating emissions from on-road vehicles in California. EMFAC 2011 emission factors were updated to reflect the current version of the EMFAC model, EMFAC2014 and the emission factors applied were for light-duty autos operating in Alameda County. Starting-exhaust emission factors are applied to the reduced trips while running-exhaust factors are applied to the reduced VMT. Emissions are given in metric tons of carbon dioxide-equivalent (CO_2e), a measure of the aggregate global-warming potential of various air pollutants. CO_2 conversion/equivalency factors were used to estimate the emission reduction benefits for the criteria pollutants and mobile source air toxics (MSATs).

Exposure Reduction:
This measure will reduce region-wide population exposure to air pollutants based on the estimated reduction in emissions.

Emission Reduction Trade-offs:
None identified.

Cost:
Approximately $2.6 million for grants.

Co-benefits:
- Improved housing affordability.
- Conservation of energy.
- Improved water quality / reduced storm water run-off.
- Promotion of more efficient use of land.
- Increased transit ridership, walking, and cycling.
- Enhanced community design and quality of life.
- Cost savings to those providing parking cash-out program.

- Reduced vehicle cruising and associated congestion and emissions.
- Reduced health risks from vehicle emissions and enhanced walkability.
- Potential to use any revenue generated by parking fees to fund improvements to transit and other alternative modes of travel.

Issues/Impediments:
Local government parking reform can be impeded by limited resources and technical expertise, especially in small municipalities. Parking policies are a highly political issue on the local level. Local governments may be reluctant to adopt parking reforms due to lack of political support, business concern that their city will be at a disadvantage with competitors in neighboring cities without similar parking reforms. Since parking costs are often hidden in rents and purchases, residents may not understand the basis or need for parking reform.

Local governments develop local parking policies based upon local needs and priorities. Willingness to implement policies consistent with regional parking policies will vary among these entities.

Sources:

1. Donald Shoup. *The High Cost of Free Parking.* Washington D.C.: APA Planners Press, 2005.
2. Metropolitan Transportation Commission, Association of Bay Area Governments, *Plan Bay Area, Regional Transportation Plan and Sustainable Communities Strategy,* July 2013
3. Metropolitan Transportation Commission, Reforming Parking Policies to Support Smart Growth; Toolbox/Handbook: Parking Best Practices & Strategies for Supporting Transit Oriented Development in the San Francisco Bay Area, June 2007 http://mtc.ca.gov/sites/default/files/Toolbox-Handbook.pdf

TR14: Cars & Light Trucks

Brief Summary:
This control measures summarizes actions by the Air District, MTC, local businesses, city and county governments, and state and federal agencies to expand the use of Zero Emission Vehicles (ZEVs) and Plug-in Electric Vehicles (PEV), comprising both battery electric and plug-in hybrid passenger vehicles and light-duty trucks within the Bay Area.

Purpose:
This measure will reduce key ozone precursors of ROG and NOx, particulate matter, air toxics, and greenhouse gases by providing incentives for the purchase of electric and plug-in hybrid vehicles and light-duty trucks.

Travel Market Affected:
This measure would affect inter- and intraregional travel, including commute travel, shopping, personal business, school trips, as well as social and recreational travel.

Regulatory Context and Background:
In September 1990, ARB adopted the Low-Emission Vehicle Regulation to reduce pollution from passenger cars and light-duty trucks. This regulation required large auto manufacturers to bring to market vehicles with zero emissions beginning with 1998 model-year vehicles. The regulation is implemented through the Zero Emission Vehicle (ZEV) program, which originally required, starting with 1998 model year vehicles, that 10 percent of new vehicle sales by large auto manufacturers have zero emissions. ARB subsequently modified the program to allow up to 60 percent of the zero emission requirements to be met with vehicles having extremely low emissions and other specific attributes. Vehicles meeting these standards are referred to as "partial zero emission vehicles" (PZEV) and "advanced technology partial zero emission vehicles" (AT-PZEV). Additional amendments were also made to reflect the pace of ZEV development, the emergence of new ZEV and near-ZEV technologies, and the need to clarify the language of the regulation.

In January 2012, , ARB approved the Advanced Clean Cars (ACC) program. The ACC program incorporated three elements that combine the control of smog-causing (criteria pollutant) emissions and GHG into a single coordinated package of requirements for model years 2015 through 2025. These three elements included the Low-Emission Vehicle III (LEV III) regulations, the Zero-Emission Vehicle (ZEV) regulations, and the Clean Fuels Outlet regulations. Additionally, hydrogen fueling infrastructure was provided with a dedicated funding source by the California Legislature through passage of Assembly Bill 8 (AB 8 - 2013).

ARB's *Mobile Source Strategy*
For the State Implementation Plans for the South Coast and San Joaquin Valley Air Basins, ARB is proposing a comprehensive strategy to reduce criteria, toxic and greenhouse gas emissions from mobile sources. For passenger vehicles, the strategy calls for increasing the penetration of plug-in hybrid electric vehicles (PHEV) and zero-emission vehicles (ZEV) such as battery-

electric (BEV) and hydrogen fuel cell electric vehicles (FCEV). Additionally, renewable energy will comprise at least 50 percent of the electricity and hydrogen supply supporting these electric vehicles. A large portion of the liquid fuels for combustion engine vehicles will also need to be sourced from renewable feedstock.

To implement the Mobile Source Strategy, ARB staff will propose modifications to the Advanced Clean Cars to increase the number of new ZEVs and PHEVs sold in California. The revised regulation may include lowering fleet emissions further beyond the super-ultra-low-emission vehicle (SULEV) standard for the entire light-duty fleet through at least the 2030 model year, and look at ways to improve the Smog Check and On-Board Diagnostics programs to ensure continued reductions in emissions. Additionally, new standards may be considered to further increase the sales of ZEVs and PHEVs in 2026 (and later years) beyond the levels required to ensure future emission reduction, climate, and petroleum targets are met.

MTC's Climate Initiatives Program and Plan Bay Area
In response to the passage of climate change legislation AB32 and SB375, in December 2009, MTC adopted a Climate Initiatives Program, a key component of MTC's GHG emissions reduction strategy, which anticipates a 16 percent per capita reduction in GHG emissions from light duty vehicles by 2040. The program makes short-term investments that reduce transportation-related emissions by reducing vehicle miles traveled, and encouraging new technologies. Through the program, MTC partnered with the Air District in sponsoring the #BetterDrive campaign to provide local residents opportunities to test drive electric vehicles.

Bay Area Plug-In Electric Vehicle (PEV) Readiness Plan
To further accelerate the purchase and lease of zero-emission and plug-in hybrid vehicles in the Bay Area, in 2013 the Air District, in partnership with MTC and ABAG, developed the *Bay Area Plug-In Electric Vehicle (PEV) Readiness Plan*. This plan is guiding the actions of the Air District, MTC and ABAG, as well as other regional public and private partners, in developing financial incentives for the purchase and lease of PEVs, locating charging locations at worksites and public areas, and developing local planning and building code best practices to ensure PEVs are well integrated into the region. The plan also includes a siting analysis, which seeks to guide and coordinate future PEV charging infrastructure-siting efforts based on anticipated or projected demand for PEVs.

PEV Incentives
State and local incentives, combined with a $7,500 federal tax credit, have spurred the increase in PEV sales. The Bay Area is the strongest market of PEVs in the nation, as well as having the most charging stations available per capita. According to the Center for Sustainable Energy, Bay Area residents, private fleets and government agencies received 38% of the rebates available from CARB between 2010 and 2016 for qualifying PEVs. The Air District contributed to the strong market for PEVs by allocation $14 million in incentives during FY 2015/16, primarily for battery electric vehicles.

Another one of the main drivers for PEV sales has been the High Occupancy Vehicle (HOV) lane access. The DMV issues Clean Air Vehicle decals to vehicles that meet specified emissions standards, which allow a vehicle to be operated in an HOV lane by a single occupant. White Clean Air Vehicle decals are currently available to an unlimited number of qualifying battery electric, hydrogen fuel cell, and compressed natural gas (CNG) vehicles. The current expiration date for the white stickers is January 1, 2019. Green Clean Air Vehicle decals were issued to the first 85,000 applicants that purchased or leased cars meeting California's advanced technology, partial zero emission vehicle (AT PZEV) requirement. The expiration date for the green decals is also January 1, 2019.

Vehicle Buy Back Program

The Air District's Vehicle Buy Back Program (VBB) is a voluntary program that takes older, high polluting vehicles off the road. The VBB program pays $1,000 for an operating and registered 1994 and older vehicle. Vehicle dismantlers contracted by the Air District scrap the vehicles. The program is funded through the Air District's Carl Moyer, Mobile Source Incentive Fund and Transportation Fund for Clean Air (TFCA) programs.

The state administers a Voluntary Accelerated Vehicle Retirement (VAVR) program which targets vehicles that fail the biennial Smog Check. This program provides money to vehicle owners to retire older, more polluting vehicles. The purpose of this program is to reduce emissions by accelerating the turnover of the existing fleet to newer, cleaner vehicles. This program is a component of California's State Implementation Plan, which outlines the State's strategy for meeting health-based ambient air quality standards. The State's program provides $1,000 per vehicle ($1,500 for low-income vehicle owners) for old vehicles that fail the most recent biennial Smog Check Test.

To accelerate the removal of old, highly polluting cars from the San Joaquin Valley and South Coast Air Basins, ARB in 2015 ran a successful small enhancement to the VAVR program. The "Plus-Up" enhancement provide additional cash to low-income residents participating in the VAVR program if they purchased of a newer, cleaner car. The "Plus-Up" program is expanding in 2017; $40 million has been allocated to programs in the San Joaquin and South Coast Air Basins, with an additional $20 million to other parts of California.

Clean Vehicles Feebate Program

A feebate program uses a combination of fees and rebates to change consumer behavior. Consumers purchasing a vehicle that emits more CO_2 on a gram per mile basis than a defined standard are assessed a fee at the point of purchase. These fees are used to provide rebates to consumers that purchase vehicles that emit less CO_2 on a gram per mile basis than the defined standard.

Feebates have been used with some success in other countries, including Denmark, France, the Netherlands, and Norway. In the early 1990s, ARB studied a fee-bate program for California, and again in 2009, in response to a legislative initiative (AB 493, 2007). The Air District will, in cooperation with MTC and ARB, continue to seek legislative authority to implement a feebate program in the Bay Area. Funding to implement a Bay Area-wide feebate is included in the draft investment strategy for *Plan Bay Area 2040*.

Implementation Actions:
The Air District and/or MTC will:

- Consistent with the goals of the *Bay Area PEV Readiness Plan*, both the Air District and MTC will commit regional clean air funds toward qualifying vehicle purchases and infrastructure development subsidies.
- Partner with private, local, state and federal programs to promote the purchase and lease of battery-electric and plug-in hybrid electric vehicles.
- Partner with private, local, state and federal programs to install and expand public charging infrastructure and to promote existing charging infrastructure. Advocate for increased government incentives and research programs with local businesses, non-profits and governments.
- Develop model ordinances and/or direct local governments to existing ordinances (such as in Sonoma, Santa Clara, and Contra Costa County) concerning installation of vehicle charging in new homes.
- Support the use of renewable electricity in both ZEVs and PHEVs, with additional support for low carbon, renewable fuels in the onboard internal combustion engines in PHEVs.
- Support research programs advancing technology for plug-in hybrid, battery electric and hydrogen-fueled vehicles.
- Promote the DMV's Clean Air Vehicle decal program to encourage purchase of ZEVs and PHEVs
- Obtain legislative authority for a regional fee-bate initiative. Work with ARB and MTC to implement the program.
- In 2017, apply for funding to run a "Plus-Up" program in the Bay Area as part of the State's VAVR program. This funding will be used to assist low-income residents to retire older vehicles that fail Smog Check and purchase a newer, cleaner vehicle.
- In 2020, implement a regional "Plus-Up" program as part of the Vehicle Buy Back; this regional effort will assist vehicle owners in replacing older vehicles that still pass Smog Check with new a new zero emission or plug-in hybrid electric vehicle.
- Work with MTC to ensure ZEVs and PHEVs have access to the region's HOV lanes and the Express Lane Networks beyond 2019.

Emission Reductions:

Pollutants*	2020	2030
ROG	84	64
NO_x	84	64
$PM_{2.5}$	16	14
PM_{10}	17	15
DPM	-	-
TACs	-	-
CO_{2e}	4,566	3,963

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:
Emission reductions for this measure have been calculated for the years 2017 through 2030, and are based upon ongoing incentive programs for new vehicles and the Vehicle Buy-back Program. For new vehicle purchases, the annual VMT is assumed to be 15,000 miles.

Emission reductions were calculated by assuming that each ZEV and PHEV will be purchased in lieu of an average brand new gasoline powered vehicle. For zero emission vehicles, the emission reductions are calculated as the difference between new vehicle emissions and zero emissions in the years 2017 through 2030. For these estimates, we assume that during the fourteen year period, older vehicles are retired and replaced like-for-like with new vehicles, and the new vehicles remain in operation during the entire period; that is a vehicle purchased in 2017 would still be in operation in 2030. Because new standards haven't yet been adopted for MY 2026-2030, we assume that new gasoline and PHEV vehicles meet the existing SULEV20 standard.

For plug-in hybrid vehicles, it is assumed that the vehicles will be certified by ARB as Super Ultra Low Emission Vehicles and will operate in electric mode for 50 percent of the annual VMT, or 7,500 miles. For PHEV's, we have assumed that 75 percent of the electricity used by the vehicles will come from grid-electricity, while the remaining 25 percent of the electricity comes from burning gasoline in the vehicle engine.

Exposure Reduction:
Reduction in the use of gasoline will also reduce public exposure to air toxics, particularly in communities near heavily traveled roads and freeways.

Emission Reduction Trade-offs:
This measure will not increase emissions of any pollutant from motor vehicles; however, to the extent that it helps to increase the number of ZEVs and PHEVs in use within the Bay Area, it may increase emissions of criteria pollutants and greenhouse gases from power plants that generate the required electricity.

Cost:
Cost for this measure assumes that the Air District and MTC will provide up to $5 million per year from 2017 through 2021 and that the Air District will provide up to 2.5 million from 2022 through 2030 for subsidies towards the purchase of qualifying vehicles and infrastructure. Additional benefits from incentives will occur if the region receives funding from state and federal incentive programs, tax refunds and rebates, and private sources.

Co-benefits:
The expanded use of newer, cleaner electric powered cars will reduce water pollution and decrease reliance on crude oil for transportation fuel. Benefits of "green" job creation are dependent on commitments to manufacture compliant vehicles within the Bay Area.

Issues/Impediments:
- Funding for vehicle subsidies
- Limited availability of ZEV and Plug-in Hybrid vehicles
- Vehicle price and ongoing maintenance costs
- Advances in battery technology

Sources:
1. BAAQMD, *Grant Application, U.S. Department of Energy (DOE), National Energy Technology Laboratory, Funding Opportunity: Clean Cities FY09 Petroleum Reduction Technologies Projects for the Transportation Sector, Area Interest #4; Funding Opportunity Number DE-PS26-09NT01236-04; CFDA Number 81.086.* June 2009
2. BAAQMD, et al., *Bay Area Plug-in Vehicle Readiness Plan*, December 2013. Available online at http://www.bayareapevready.org/.
3. BAAQMD, Presentation to the California Energy Commission's "Integrated Energy Policy Report Workshop," June 5, 2014
4. Bunch, David S. and David L. Greene (2010) Potential Design, Implementation, and Benefits of a Feebate Program for New Passenger Vehicles in California: Interim Statement of Research Findings. Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-10-13
5. CARB, *Initial Statement of Reasons for Rulemaking: Proposed 2014 Amendments to the Zero Emission Vehicle Regulation*, September 2, 2014
6. CARB, *Staff Report: Initial Statement Of Reasons For Proposed Rulemaking, Public Hearing To Consider The "Lev Iii" Amendments To The California Greenhouse Gas And Criteria Pollutant Exhaust And Evaporative Emission Standards And Test Procedures And To The On-Board Diagnostic System Requirements For Passenger Cars, Light-Duty Trucks, And Medium-Duty Vehicles, And To The Evaporative Emission Requirements For Heavy-Duty Vehicles,* December 7, 2011.
7. MTC, *Draft 2017 Transportation Improvement Program (TIP) For the Nine-County San Francisco Bay Area,* June 24, 2016
8. United States Department of Energy, Office of Energy Efficiency and Renewable Energy, Alternative Fuels Data Center, "Hybrid and Plug-in Electric Vehicle Emissions Data Sources

and Assumptions." Retrieved on 7/1/2015 from http://www.afdc.energy.gov/vehicles/electric_emissions_sources.html
9. CARB, *Revised Proposed 2016 State Strategy for the State Implementation Plan*, March 7, 2017.
10. Center for Sustainable Energy, *Experience Electric: #TheBetterRide, Campaign Report*, August 2016
11. Center for Sustainable Energy, *California Air Resources Board Clean Vehicle Rebate Project, Rebate Statistics*. Date last updated on March 01, 2017. Retreived March 08, 2017 from https://cleanvehiclerebate.org/rebate-statistics.
12. Szabelan, Sarah Jo, *Charging Ahead: How the Bay Area is leading the Country on Electric Vehicles*, SPUR, February 09, 2017. Retreived March 08, 2017 from http://www.spur.org.

TR15: Public Outreach

Brief Summary:
The Public Outreach control measure includes activities to encourage Bay Area residents to make choices that benefit air quality. This measure includes various public outreach campaigns to educate the public about the health effects of air pollution and the air quality benefits of reducing motor-vehicle trips and choosing transportation modes that reduce motor vehicle emissions. The measure includes outreach and education regarding electric vehicles, smart driving, carpooling, vanpooling, taking public transit, biking, walking, and telecommuting.

Purpose:
The purpose of this measure is to reduce emissions of the key ozone precursors, ROG and NOx, particulate matter, air toxics and greenhouse gas (GHG) emissions.

Travel Market Affected:
This measure would affect intraregional travel, including commute travel; shopping, personal business, school trips, social and recreational travel. In addition, this measure may help to reduce emissions from the use of lawn and garden equipment and recreational watercraft.

Regulatory Context and Background:
Electric Vehicle Strategy
The Air District and MTC view PEVs as a promising technology for reducing tailpipe emissions, thus helping the region achieve local, state, and federal criteria pollutant and GHG emission reduction targets. In December 2013, the Air District, in partnership with MTC and ABAG, completed a *Bay Area Plug-in Electric Vehicle Readiness Plan* (www.baaqmd.gov/EVready). The plan outlines a series of strategies and best practices that can be taken by regional agencies and other PEV stakeholders to remove potential barriers and accelerate deployment of PEVs.

An EV Promotional Campaign is one of the strategies outlined in the Readiness Plan and a well-coordinated regional PEV marketing campaign that specifically targets Bay Area consumers is needed in order to successfully capture the attention and acceptance of the broader general public. This campaign was implemented in 2013-2016 by MTC and the Air District.

Campaign development began in October 2012 and included research into which activities would be the most successful to increase EV adoption. Research indicated that allowing interested individuals to test drive EVs in an environment free of sales pressure would be the best strategy. An initial one-year ride-and-drive campaign was then launched in Spring 2014, marketed as Experience Electric. Through the Experience Electric campaign, MTC offered twenty-one free, interactive Ride-and-Drive events at venues around the Bay Area. The ride-and-drives allowed drivers to test-drive EVs and share their experience via social media.

To evaluate the campaign, MTC implemented a pre-drive, post-drive and follow-up surveys (several months after the ride and drive) to event participants. Overall, the events yielded positive effects on perceptions of EVs, perceived barriers to EV purchase, and intent to purchase an EV immediately following the events in the post-drive survey. Because of these results, the Air District provided additional funds for six ride-and-drive events in winter 2015 and spring 2016.

In addition to the campaign, the Air District provides funding for outreach and activities including implementing the training described in the PEV Plan for local government agencies and the public, conducting workshops and participating in workgroups and other opportunities to support PEV deployment and sharing best practices.

Spare the Air

The STA Every Day Program is the backbone of the Air District's efforts to encourage the public to take direct action to reduce emissions and improve air quality. Since motor vehicles are the leading source of ozone forming emissions in the Bay Area, efforts to reduce vehicle travel, particularly on days with Spare the Air Alerts, can help avoid exceedance of federal and state standards. STA Every Day includes the following components:

- Outreach Program
    - STA Alert notifications via media channels, alert notification sign up lists, and the employer program.
    - Advertising campaign through print, billboards, TV ads and website ads.
    - Media outreach through news programs and community based outreach channels, such newsletters.
    - Outreach at community events, such as county fairs.
    - Coordination with MTC/511.
- Employer Program
    - Employer coordinators inform their workforce of impending Spare the Air days, educate employees about the ways individuals can improve air quality, and motivate them to take action.
- Community Resource Teams
    - Local civic groups, agencies, businesses and environmental organizations meet regularly and work collaboratively to implement projects that promote cleaner air. Team members, with Air District support, are responsible for developing and carrying out local projects.
- Winter Spare the Air
    - The Winter Spare the Air program notifies residents when particulate matter levels are anticipated to be unhealthy. On these high pollution days, the Air District issues a Winter Spare the Air Alert which prohibits wood burning throughout the Bay Area.
- Youth Programs
    - Protect Your Climate Curriculum: 16 lessons for 4th and 5th grade students that focus on air pollution, energy, waste reduction and transportation.
    - Clean Air Challenge Curriculum: a science-based curriculum which includes experiments that help students understand air pollution and climate change.
    - Cool the Earth: a greenhouse gas reduction program for K-8th grade students and their parents.

- As the World Warms: a classroom supplement including news stories and puzzles on climate change for elementary aged students.
- eCO2 Commute Challenge Project Manual: a tool to help high school students become a part of the solution to climate change by taking action in their schools to reduce greenhouse gas emissions from student commutes by promoting walking, biking, riding the bus and carpooling.

In addition, Spare the Air Youth is a regional program, implemented by MTC and the Air District, that aims to educate, inspire and empower youth and families in the San Francisco Bay Area to walk, bicycle, carpool and take transit. Spare the Air Youth seeks to find effective ways to reduce GHG and other emissions related to transportation, while also providing a regional resource for students, parents, teachers and program providers.

Non-Commute Trip Reductions Campaign

Non-commuting travel generally includes vehicle trips associated with schools, hospitals, medical centers, banks, stores, post offices, entertainment, recreation, etc. Reducing non-commute trips may contribute to the overall goal of reducing vehicle miles traveled (VMT) and therefore air pollution in the Bay Area.

Non-commute trip reduction strategies have been successfully implemented in the Bay Area and other regions of the nation. For example, the City of Walnut Creek and Emeryville offer free shuttles to and from shopping districts. In the Denver area, retail shopping centers are also operating shuttles that are realizing high ridership. Shuttles may be funded privately or through public-private partnerships. In the instance of shopping centers, retail benefits from shared underwriting of the shuttle costs; these costs return benefits for both shoppers and employees, especially in high shopping seasons where parking is limited.

Non-commute trips may also be the focus of residentially-based education and marketing campaigns. A particularly strategic time to approach people about travel behavior changes is when they change either their place of work or residence. The Sacramento Area Council of Governments (SACOG) is working with outreach partners throughout the region to expand on commute campaigns with information on non-commute trip reduction strategies. Outreach partners will be supported with collateral materials to share with real estate agents, rental and lease agents, and new home welcome services.

Outreach could also include presentations to interest groups, including but not limited to, realtor associations, business organizations, chambers of commerce and service clubs. Information could also be developed for new home buyers, seniors in assisted living facilities, recreation and park districts, school districts, senior centers, neighborhood associations, and advocacy groups for alternative modes, including bicycling and walking.

The Spare the Air Everyday Campaign has a non-commute emphasis as well. In addition to reducing commute trips, the campaign speaks to reduce driving and other activities that generate air pollution, not only during weekdays, but on all days of the week. Spare the Air

Everyday asks residents to reduce pollution by making clean air choices every day. This can include walking and biking more often, taking transit, telecommuting or carpooling, driving less, reducing energy consumption at home, and making many other daily choices that improve air quality.

Implementation Actions:
The Air District will:
- Implement the Spare the Air Every Day Campaign including Spare the Air alerts, employer program, and community resource teams
- Implement outreach and education efforts in partnership with MTC, including the Spare the Air Youth Program

MTC will:
- Implement the Spare the Air Youth Program with the Air District
- Encourage alternative modes of travel for non-commute trips, including walking, bicycling, transit and carpooling via the development of outreach programs to targeted travel sector groups
- Explore ways to expand public awareness of availability and benefits of transit, bicycling, walking, or carpooling/vanpooling for non-commute trips

Emission Reductions:
N/A

Emission Reduction Methodology:
N/A

Exposure Reduction:
N/A

Emission Reduction Trade-offs:
None identified.

Cost:
Spare the Air Program: $6 million/year
EV Outreach: approximately $500,000/year
Non-Commute Trips Campaign: N/A

Co-benefits:
This measure raises public awareness about the causes of and solutions to air pollution. People who choose to change their travel or other behaviors in response to a voluntary request for a STA Alert may reduce vehicle use or change other polluting activity on a regular basis, as advocated in the STA Every Day and the Spare the Air Youth programs. Additionally, increased travel by bike and walk modes may increase individuals' physical health and quality of life.

Issues/Impediments:
Implementation of this measure requires that funding is available for these programs. In addition, because the Spare the Air program is voluntary in nature, its effectiveness depends on the cooperation of the general public.

Sources:

1. Purvis, Charles L., *Incorporating Work Trip Accessibility in Non-Work Trip Generation Models in the San Francisco Bay Area*, January 1996 http://www.mtc.ca.gov/maps_and_data/datamart/research/paper96.htm

TR16: Indirect Source Review

Brief Summary:
An indirect source review (ISR) rule would reduce construction and operating emissions associated with new or modified land uses in the Bay Area. The Indirect Source Review measure is intended to address potential increases in air pollutant emissions related to economic and population growth in the region. Indirect sources are development projects that generate or attract motor vehicle trips, thus “indirectly” cause air pollution from vehicles and area sources. Area source emissions include fireplaces, home heating furnaces, hot water heaters, and landscape maintenance equipment.

Purpose:
This measure will reduce emissions of key ozone precursors, ROG and NOx, particulate matter, toxic air contaminants and greenhouse gases by reducing construction and operational emissions associated with new or modified land uses.

Travel Market Affected/Source Category:
On-road and off-road mobile emission sources are the main source categories targeted by this measure. However, space heating, landscape maintenance and wood burning emission source categories could also be included.

Regulatory Context and Background:
The California Clean Air Act (CCAA) explicitly grants air districts authority to adopt and implement regulations to reduce or mitigate emissions from indirect and area wide sources of air pollution. This may be done by air districts through the use of measures which reduce the number and length of vehicle trips (Health and Safety Code §40716(a)(1)). Based on CCAA enabling legislation, it is the intent of the legislature “that districts shall endeavor to achieve and maintain state ambient air quality standards…by the earliest practicable date. In developing attainment plans and regulations to achieve this objective, districts shall consider the full spectrum of emissions sources and focus particular attention on reducing the emissions from transportation and area wide emission sources (H&SC §40910).” The CCAA also states that this ISR authority does not limit or supersede local land use authority of cities and counties.[1]

Varying degrees and forms of ISR rules have been implemented in air districts throughout California, including Colusa County, Great Basin Unified, Imperial County, Mendocino County, San Joaquin, and Shasta County. Some of these rules are strictly cost recovery mechanisms for air districts to recoup the costs associated with CEQA review while others encourage new development to implement on-site emission reduction strategies or require applicants to pay an off-site mitigation fee.

[1] Other relevant ISR sections in the CCAA include: 40717(g), 40918(a)(4), and 42311(g).

In 2005, the San Joaquin Valley Air Pollution Control District (San Joaquin Valley APCD) adopted Rule 9510 as an ISR rule. The rule applies to residential, commercial, industrial, office and recreational development projects above a certain size (e.g., 50 residential units or 2,000 square feet of commercial space). Development projects must reduce their construction and operational emissions to be below two tons per year of NOx and PM10 through onsite mitigation or pay an off-site mitigation fee. The fee formula is structured to encourage on-site mitigation measures. San Joaquin Valley APCD uses the fees to fund off-site mitigation projects that reduce NOx and PM10 emissions. To date, San Joaquin Valley APCD has mostly funded off-site projects that include retrofitting or replacing engines in on-road and off-road vehicles and agriculture equipment.

Imperial County APCD adopted Rule 310, Operational Development Fee, in 2007. It assesses a per square foot fee on all new commercial development and a per unit fee on residential development above four units. Project proponents have the option to either provide on and off site mitigation, pay the mitigation fee, or do a combination of both. Fees collected are used to fund mitigation projects that reduce ozone precursors and PM10.

On November 2, 2010, Proposition 26 passed by over 52 percent of California voters. Proposition 26 amended the California Constitution by redefining "tax" to include any "levy, charge, or exaction of any kind" and requiring any new fees (or taxes) that meet this definition be approved by a 2/3 vote from each house of the State Legislature for statewide fees or by 2/3 voter approval for local fees. It should also be noted that there are seven exemptions to Proposition 26 requirements. Therefore, any ISR developed by the Air District that would include fees would have to be consistent with Proposition 26 requirements.

Implementation Actions:
The Air District will:

- Consider developing a rule that sets air quality performance standards for new and modified development.
- Reconvene a broad-based stakeholder workgroup to discuss Indirect Source Rule concepts.

Emission Reductions:

Pollutants*	2020	2030
ROG	0.30	Na
NO_x	0.24	Na
$PM_{2.5}$	0.11	Na
PM_{10}	0.47	Na
CO_{2e}	333	Na

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:
The emissions reduction methodology for this measure is based on a methodology developed and reported by the San Joaquin Valley APCD Indirect Source Review (ISR) program. The San

Joaquin Valley APCD rule requires the payment of mitigation fees for projects that will result in 2 tons of NOx or 2 tons of PM emissions per year or more. Air District staff looked at the number of development projects and plans listed in the Air District CEQA database (estimated for the year 2020) that may be subject to the ISR program. The emission reductions above estimate the results if 15 percent of emissions from new construction are mitigated through off-site mitigations.

Exposure Reduction:
This measure will reduce region-wide population exposure to air pollutants based on the estimated reduction in emissions. This measure will also reduce localized population exposure to air pollution.

Emission Reduction Trade-offs:
None identified.

Cost:
Specific costs will be determined during rule-making.

Co-benefits:
- Improved project design and planning.
- Public health benefits from reduced emissions, improved pedestrian access, and use of green building elements.

Issues/Impediments:
Regional rules or regulations that impact local land use decisions and/or development can be politically challenging to develop or implement.

Sources:

1. Memo to Mobile Source Committee, September 11, 2007: *2005 Ozone Strategy Further Study Measure 18: Indirect Source Mitigation Program*
2. SCAQMD ISR: http://www.aqmd.gov/home/regulations/rules/proposed-rules/pr2301
3. SJVAPCD ISR Web site http://www.valleyair.org/ISR/ISRHome.htm
4. Imperial Valley Rule 310 Operational Development Fee
5. 2008 Annual Report on the District's Indirect Source Review Program, SJVUAPCD http://www.valleyair.org/Board_meetings/GB/agenda_minutes/Agenda/2008/June/Item%2013/GVB%20Agenda%20Item%2013.pdf
6. Socioeconomic analysis SJVAPCD http://www.valleyair.org/ISR/Documents/RULE_9510_AppendixF.pdf

TR17: Planes - Cleaner Aircraft Engines and Renewable Jet Fuel

Brief Summary:
This measure consists of the efforts of the Federal Aviation Administration's (FAA) Continuous Lower Energy, Emissions and Noise (CLEEN) Program. The goals of the CLEEN Program include the development of new commercial aircraft engines by 2023-25 that would emit 60 to 75 percent fewer NOx emissions than current aircraft engines, as well as demonstrate the feasibility of jet fuel derived from crops and other renewable resources.

Purpose:
This measure will reduce emissions of a key ozone precursor, NOx, through the development and use of cleaner aircraft engines, and reduce GHGs through improvements in engine efficiencies and increased use of jet fuel derived from renewable sources.

Travel Market Affected:
This measure will affect airline travel into and out of the Bay Area.

Regulatory Context and Background:
Commercial aircraft engines operating from the three major airports in the Bay Area – San Francisco International, Oakland International and San Jose International – contribute 3.2 percent to the region's NOx inventory, while small aircraft, military planes, and ground support equipment contribute an additional 1.2 percent. All aircraft operations contribute 1.6 percent of the region's ROG emissions, and less than 1 percent of the region's PM2.5 emissions.

Aircraft emission standards have been in place for about 30 years and essentially apply to all commercial aircraft. Over the years, emission standards have been set for different aspects of aircraft engines:
- in 1974 for engine smoke (revised several times since) and fuel venting
- in 1984 for hydrocarbon emissions
- in 1997 for NOx and carbon monoxide emissions
- in 2005 for NOx emissions

The U.S. Environmental Protection Agency (US EPA) works with the FAA and the United Nations International Civil Aviation Organization (ICAO) in the development of international aircraft emission standards. The FAA is responsible for enforcing the aircraft emission standards set by US EPA. ICAO was established by the United Nations to ensure safety, equality, and consistency among international air transport services. One of ICAO's objectives is to lead international bodies in the development of standards and procedures for aircraft engines. The US EPA's current rules on aircraft emissions are equivalent to the ICAO standards.

To further reduce emissions from commercial jet engines, the FAA established the Continuous Lower Energy, Emissions and Noise (CLEEN) program in partnership with commercial airlines, jet engine manufacturers and airplane manufacturers. The CLEEN program (and some companion, subsidiary programs, such as the "Farm to Fly" program and the Airline

Sustainability Center [ASCENT]), is an effort to accelerate development and commercial deployment of environmentally promising aircraft technologies and sustainable alternative fuels. The aircraft technologies focus on reduction in aircraft noise, emissions, and fuel burn, while the renewable fuel programs focus on development of direct replacement of petroleum derived jet fuel.

In February 2016, the International Civil Aviation Organization finalized performance standards for new aircraft that will require improved fuel efficiency and reductions in CO_2 emissions. The new standards will apply to all new commercial and business aircraft delivered after January 1, 2028. The standards require an average of 4 percent reduction in fuel consumption, with actual reductions ranging from 0 to 11 percent, depending on the size of the aircraft. The EPA is currently developing a federal regulation that will apply these standards to all domestic aircraft.

Implementation Actions:
The Air District will:

- Support efforts, via letters of support on legislative action or other activities, to increase the use of cleaner burning jet fuel and low-NOx engines in commercial jets arriving and departing the Bay Area.

Emission Reductions:
Emission reduction estimates for this measure are not available. The Air District will be encouraging airlines and the FAA to deploy cleaner planes, but there is too much uncertainty to reasonably estimate benefits over the next thirteen years.

Exposure Reduction:
This measure may reduce region-wide population exposure to air pollutants.

Emission Reduction Trade-offs:
None identified.

Cost:
Unknown

Co-benefits:
More efficient engines and use of cleaner fuels will reduce GHG emissions.

Issues/Impediments:
Commercial aircraft emissions are regulated by US EPA and international treaties, which can take years to develop and implement any lower emission standards. Local air districts are preempted from adopting regulations controlling emissions from these sources.

Sources:

1. Federal Aviation Administration, Continuous Lower Emissions, Energy, and Noise (CLEEN) Program website; accessed February 9, 2015;

https://www.faa.gov/about/office_org/headquarters_offices/apl/research/aircraft_technology/cleen/

2. Federal Aviation Administration, website for Annual Meeting of the CLEEN Consortium, November 2014, accessed February 9, 2015. https://www.faa.gov/about/office_org/headquarters_offices/apl/research/aircraft_technology/cleen/2014_consortium/
3. Environmental Protection Agency, Office of Transportation and Air Quality, Regulatory Announcement, November 2005, http://www.epa.gov/oms/regs/nonroad/aviation/420f05015.pdf
4. Environmental Protection Agency, "Finding That Greenhouse Gas Emissions From Aircraft Cause or Contribute to Air Pollution That May Reasonably Be Anticipated To Endanger Public Health and Welfare," Federal Register Volume 81, Number 157, August 15, 2016
5. International Civil Aviation Organization, *On Board a Sustainable Future: Environmental Report*, 2016

TR18: Goods Movement

Brief Summary:
The measure includes regional programs to reduce emissions associated with goods movement, including funding for goods movement related infrastructure, planning work to update the Regional Goods Movement Plan and participation in the regional Goods Movement Collaborative. Goods movement is a critical component of the Bay Area's economic and transportation system, and a significant source of air pollutant emissions. Exposure to diesel particulate matter from goods movement disproportionately impacts the health of residents near ports, rail yards, distribution centers, and roads with high truck volumes. Investing in the Bay Area's trade corridors will address existing air quality and public health issues as well as help the region to prepare for continued growth in this economic sector. This measure focuses primarily on regional planning and infrastructure, while Control Measures TR19, 20, 21, & 22 focus on reducing emissions from trucks and other equipment used to move goods.

Purpose:
This measure will reduce emissions of the key ozone precursors, ROG and NOx, particulate matter, toxic air contaminants and greenhouse gases associated with goods movement.

Travel Market Affected:
This measure would affect goods movement activity within the region.

Regulatory Context and Background:
Goods movement is a critical component of the Bay Area's economic and transportation system. Whether it is delivering construction materials or consumer goods to the growing population, or exporting electronics and food throughout the world, a robust goods movement system is essential for both business and residents to function and thrive in the Bay Area.

Exposure to diesel particulate matter from goods movement operations greatly impacts the health of community residents near ports, rail yards, distribution centers, and roads with high truck volumes. Analysis by the Air District has found that emissions of diesel particulate matter (PM) account for 80 percent of the risk from toxic air contaminants (TACs) in the Bay Area. Twenty-two percent of the total California population living in close proximity to goods movement corridors is located in the Bay Area.

Nearly a third of the region's employment is in goods movement related industries, such as manufacturing, freight transportation, and the warehouse and distribution businesses. Goods movement is a critical source of job diversity in the region, providing job opportunities for people with lower levels of education and providing opportunities for training and career advancement.

The region is home to five maritime ports, including the Port of Oakland, which is the fifth busiest container port in the nation, as well as the gateway to two small river ports in Sacramento and Stockton. The Port of Oakland plays a particularly important role in supporting the state's agricultural sector, providing the primary means of exporting produce from the Central Valley to the Pacific Rim. The other four marine ports (Port of Redwood City, Port of Benicia, Port of Richmond and Port of San Francisco) are primarily niche ports serving bulk products, including petroleum products, construction material and scrap metal. In addition, both Oakland International Airport and San Francisco International Airport play key roles in air cargo trade.

In November 2006, California voters approved Proposition 1B, a $19.9 billion transportation infrastructure bond. Proposition 1B included a $2 billion Trade Corridors Improvement Fund (TCIF) to improve goods movement infrastructure statewide. In 2008 the state augmented the TCIF fund to nearly $2.5 billion and programmed just over $3 billion for high-priority goods movement projects. Nearly $585 million of this total will fund seven key Bay Area goods movement projects, including I-580 Truck Climbing Lane, I-880 Reconstruction at 29th and 23rd Avenues, the Outer Harbor Intermodal Terminal, and the Richmond Rail Connector.

Proposition 1B also included $1 billion for a Goods Movement Emissions Reduction program. The Air District is responsible for developing various programs for the bond, including a diesel truck replacement program. (See TR19: Medium and Heavy Duty Trucks)

In addition, ARB's 2007 Goods Movement Action Plan seeks to meet five specific goals for addressing the air pollution associated with goods movement, including reducing "total statewide international and domestic goods movement emissions to the greatest extent possible and at least back to 2001 levels by year 2010."

On July 16, 2015, Governor Brown issued an Executive Order directing state agencies to coordinate on the development of "… an integrated action plan that establishes clear targets to improve freight efficiency, transition to zero-emission technologies, and increase the competitiveness of California's freight system." The final plan was released on July 29, 2016. The plan and additional information on the State's sustainable freight efforts is available at More information is available at http://www.casustainablefreight.org/.

ARB's *2016 Mobile Source Strategy* and their *Revised Proposed 2016 State Strategy for the State Implementation Plans* includes several new regulatory proposals to further reduce emissions from the goods movement sector. These new proposals include lower NOx standards for new truck engines, a "last-mile" regulation requiring the use of near-zero and zero emission delivery trucks, expansion of the current shore power regulation to cover bulk carriers and oil tankers, and a call for the federal EPA to adopt Tier 5 emission standards for new locomotives, with more stringent emissions requirements for remanufacturered locomotive engines.

Regional Goods Movement Planning

The Alameda County Transportation Commission (ACTC) is leading a Bay Area *Goods Movement Collaborative* which brings together partners, community members and stakeholders from across the region and the country. The intent is to create an organized structure to understand goods movement needs in the Bay Area and to identify, prioritize and advocate for short- and long-term strategies to address these needs within a Countywide Goods Movement Plan.

The ACTC has also partnered with MTC to jointly develop not only a Countywide Goods Movement Plan, but the Regional Goods Movement Plan – which will outline a long-range strategy for how to move goods efficiently, reliably, and sustainably within, to, from and through the county and the entire region. The joint long-range plan development will ensure consistency between both plans and enable outreach to a wider range of stakeholders to provide a comprehensive understanding of the goods movement system in Alameda County and the Bay Area.

In addition, MTC has developed a Freight Emissions Reduction Action Plan (Action Plan) as part of Plan Bay Area 2040. The Action Plan recommends specific programs, projects and policies for the goods movement system, including all modes of transportation. The strategies focus on potential application of near-zero and zero-emission technologies, and assess the benefits from operational and technology-based efforts to reduce truck trips and travel time. MTC will work closely with the Air District as well as local and state stakeholders in the implementation of the Action Plan.

Implementation Actions:
MTC will:

- Fund the I-880 Improvements at 23rd and 29th Avenues via Proposition 1B Trade Corridors Improvement Fund.
- Fund the 7th Street overpass realignment at the Port of Oakland.
- Fund the Outer Harbor Intermodal Terminals project via Proposition 1B Trade Corridors Improvement Fund.
- Continue participation in the Goods Movement Collaborative, led by the Alameda County Transportation Commission.
- Implement the *Freight Emissions Reduction Action Plan*.

The Air District will:

- Continue participation in the implementation of the *Regional Goods Movement Plan*. The regional work is being closely integrated with the Alameda County Transportation Commission's countywide goods movement planning effort, as well as the ongoing state and federal freight planning and policy activity to ensure consistency among all plans.
- Continue participation in the Goods Movement Collaborative, led by the Alameda County Transportation Commission.
- Work with MTC on the implementation of a *Freight Emissions Reduction Action Plan*.
- Work with ARB and Caltrans on the implementation of the *Sustainable Freight Action Plan*, as well as participate in the development of the proposed freight-related regulations included in the *2016 Mobile Source Strategy and the Revised Proposed 2016 State Strategy for the State Implementation Plans*. The initial regulatory effort will focus on converting the fleet of Class 3-6 urban delivery and vocational trucks to near-zero and zero emission

operations through introduction of low-NOx engines, hybrid drive systems and battery electric and/or fuel cell propulsion.

Emission Reductions:
This measure will reduce some of the emissions emitted by goods movement sources, as cleaner engines are deployed and improved infrastructure reduces delays. The emission reduction benefits from Air District actions are included in Control Measures TR19, 20, 21 & 22.

Exposure Reduction:
This measure will reduce local population exposure to diesel particulate matter in various parts of the region. Impacted communities near freeways and roads with significant auto and truck traffic will benefit.

Emission Reduction Trade-offs:
Infrastructure improvements that provide congestion relief or new capacity for trucks and trains may increase local exposure to diesel particulate matter.

Costs:
Cost to industries have not been estimated; planning activities are difficult to quantify in terms of financial impacts to trucking industry.

Co-benefits:
- Economic benefits from faster, more efficient goods movement

Issues/Impediments:
- In designing and implementing goods movement efficiency measures, care should be taken to avoid creating induced demand for goods movement that could increase emissions.
- High costs to reduce emissions from aging goods movement equipment and infrastructure may be burdensome for the private sector. For example, large diesel trucks, some of which stay on the road for many years and are replaced at a slow rate, often operate on very small profit margins.
- Funding availability may constrain the implementation of goods movement emission reduction programs.
- Technological issues may be a limiting factor in retrofitting and replacing on- and off-road mobile sources due to technical capabilities, availability and rate of deployment.
- Under existing guidelines, incentive funding can only be made available for projects that reduce emissions that are surplus and not required by existing regulation. As CARB regulations that require owners of diesel engines to replace or retrofit these engines are phased in over the next several years, the number of engines that are eligible for incentive funding will decrease. Therefore, it may be difficult to achieve the same amount of emission reductions through the existing incentive programs.

- The uncertain state of the economy may limit the number of diesel equipment owners willing to enter into contracts to receive incentive funding because it commits them to monitoring and use requirements that have financial implications.

TR19: Medium- and Heavy-Duty Trucks

Brief Summary:
The Air District will directly provide, and encourage other organizations to provide, incentives for the purchase of 1) new trucks with engines that exceed ARB's 2010 NOx emission standards for heavy-duty engines, 2) new hybrid trucks, and 3) new zero-emission trucks. The Air District will work with truck owners, industry, ARB, the California Energy Commission, and others to demonstrate additional battery-electric and hydrogen fuel cell zero emission trucks.

Purpose:
This measure will reduce key ozone precursors ROG and NOx by replacing older, higher emission trucks and engines. In addition, the measure will also reduce diesel particulate matter, toxic air contaminants and greenhouse gases.

Source Category/Travel Market Affected:
Medium- and Heavy Duty On-Road Trucks, including all trucks weighing more than 10,000 pounds in Gross Vehicle Weight (Classes 3-8).

Regulatory Context and Background:
Emissions from medium- and heavy-duty trucks account for nearly 24 percent of NOx emissions in the Bay Area; they are also a significant source of diesel particulate matter, a known carcinogen. Beginning with the model year (MY) 2010 standards adopted by both ARB and the US EPA, truck emissions for both particulate matter and NOx will be substantially lower than earlier model year trucks.

However, because medium- and heavy-duty trucks are kept in service for many years and fleet turnover is slow, it can take a long time to see the air quality benefits of the new emission standards. To accelerate the replacement or retrofit of old trucks, ARB adopted a regulation that requires diesel trucks and buses that operate in California to be upgraded to reduce emissions. Newer heavier trucks and buses must meet PM filter requirements beginning January 1,2012. Lighter and older heavier trucks must be replaced starting January 1, 2015. By January1, 2023, nearly all trucks and buses will need to have 2010 model year engines or equivalent.

In March 2017, ARB released its *Revised Proposed State Strategy for the State Implementation Plan* for meeting federal ambient air quality standards in the South Coast and San Joaquin air districts, as well as achieving California's climate change and petroleum reduction goals. For trucks, ARB staff are proposing tighter NOx emission standards, support for EPA's greenhouse gas/fuel economy regulation, a new "Last Mile" regulation that would require use of near-zero and zero emission trucks for local deliveries, and a new fuel requirement that will require 50 percent of diesel fuel sold in California be derived from renewable sources.

While ARB is proposing to adopt lower NOx limits on new trucks, most heavy-duty trucks operating in California originate their trips from outside of the State. To see the maximum benefits from cleaner trucks, the federal EPA will need to adopt a similar national standard. Towards that end, the Air District in June, 2016, joined a petition submitted to EPA by the South Coast Air District calling for the adoption of ultra-low NOx emission standard of 0.02 g/bhp-hr for MY2022 engines – 90% lower than the 2010 new engine emission standard currently in place. In December, 2016, EPA indicated that they would begin development of the new standard, with a goal of promulgating the new standard by 2018.

In addition, MTC has developed a *Freight Emissions Reduction Action Plan* (Action Plan) as part of *Plan Bay Area 2040*. The Action Plan recommends specific programs, projects and policies for the goods movement system, including all modes of transportation. The strategies focus on potential application of near-zero and zero-emission technologies, and assess the benefits from operational and technology-based efforts to reduce truck trips and travel time. MTC will work closely with the Air District as well as local and state stakeholders in the implementation of the Action Plan.

Zero-Emission Drayage Truck Demonstration Project
In 2012, Governor Brown signed into law three bills – AB 1532 (Pérez), SB 535 (De León), and SB 1018 (Budget and Fiscal Review Committee) – that established the Low Carbon Transportation Greenhouse Gas Emission Reduction Fund (GGRF). This fund receives Cap-and-Trade auction proceeds and provides the framework for how the auction proceeds will be administered in furtherance of the purposes of AB 32, including supporting long-term, transformative efforts to improve public health and develop a clean energy economy.

A portion of the GGRF funds (up to $25 million statewide) will be directed at projects that reduce greenhouse gases, criteria pollutants, and toxic air contaminant emissions in disadvantaged communities. Projects funded under this solicitation are to demonstrate full zero-emission drayage trucks, and drayage trucks that offer zero-emission miles (near zero-emission) by employing on-board range extending internal combustion engines or other technologies. In May 2016, the South Coast Air Quality Management District, in collaboration with the Bay Area air district and other partners, were awarded $23.6 million to demonstrate various zero and near-zero emission technologies on trucks primarily serving the ports of Oakland, Los Angeles, and Long Beach.

Implementation Actions:
In the Bay Area, the Air District will work with local/regional trucking companies to deploy near-zero and zero emission trucks in local service, with emphasis on trucks operating within West Oakland and other CARE areas. The Air District will:

- Directly provide, and/or work with other entities to provide, incentives to accelerate the replacement of heavy-duty on-road diesel engines in advance of requirements of the ARB in-use heavy-duty truck regulation.
- Either directly provide, and/or work with partner agencies and companies to provide, funding to demonstrate the technology of hybrid drive trains for medium-and heavy-duty trucks, to demonstrate the technology of battery electric trucks, and to support further development of hydrogen fuel cell trucks.

- As technologies become commercially available, the Air District will work directly with partner agencies and companies to offer financial incentives to accelerate deployment of near-zero and zero emission trucks.

Emission Reductions:

Pollutants*	2020	2030
ROG	53	44
NO_x	2,278	362
$PM_{2.5}$	4	10
PM_{10}	4	11
DPM	4	10
CO_{2e}	58,234	138,306

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:
Because of the complexity of the incentive programs for heavy-duty trucks, the emissions reductions are based on the replacement of 2,500 medium- and heavy-duty (> 10,000 lbs) trucks with new zero emission trucks, at an average rate of approximately 180 trucks per year. The trucks are assumed to average 40,000 miles per year. Baseline emission factors for criteria pollutants are taken from ARB's Appendix D, Carl Moyer Program, 6/29/15. Emission factors for CO_2 are from EMFAC 2014. We assume that between 2017 and 2022, the replaced trucks were built before 2010, while between 2023 and 2030, the replaced trucks are MY 2010 or newer. Potential emissions reduction benefit from short-term truck demonstrations have not been included in the emissions estimates due to the uncertain nature of the cost and implementation timelines.

Exposure Reduction:
This measure will accelerate the realization of the health benefits of an adopted ARB regulation by reducing exposure to diesel PM and by reducing NOx emissions that contribute to regional ozone formation. Impacted communities near freeways and roads with significant truck traffic will benefit.

Emission Reduction Trade-offs:
None identified.

Cost:
The cost to implement this measure will be determined primarily by the level of financial incentive that will be offered to fleet owners to encourage early compliance with the ARB truck regulations, or for the purchased of advanced technologies such as hybrid drive systems and zero emission battery or fuel cell trucks. Incentive funding from the Air District and partner agencies fluctuates from year-to-year and depends upon annual budget allocations, so per truck incentive amounts will be determined during the development of the program. Existing incentive programs managed by the Air District currently provide up to $50,000 per truck.

Co-benefits:
To the extent this measure is successful in replacing diesel trucks with either hybrid drive systems and/or zero emission electric technologies, there will be a reduction in petroleum usage in the Bay Area.

Issues/Impediments:
This control measures sets forth enhancements for an existing program and should not give rise to any new obstacles, as long as funding for the incentives is secured.

Sources:

1. BAAQMD, Carl Moyer Incentive Program, http://www.baaqmd.gov/Divisions/Strategic-Incentives/Funding-Sources/Carl-Moyer-Program.aspx
2. California Air Resources Board, *2011 Carl Moyer Guidelines (as amended)*, December 28, 2016. http://www.arb.ca.gov/msprog/moyer/moyer.htm
3. California Air Resources Board, *Appendix D: Tables for Emission Reduction and Cost-Effectiveness Calculations*, June 29, 2015. http://www.arb.ca.gov/msprog/moyer/guidelines/2011gl/2011cmp_appd_06_29_15.pdf
4. California Air Resources Board, *Mobile Source Strategy*, May 16, 2016.
5. Environmental Protection Agency and Department of Transportation – National Highway Traffic Safety Administration, "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles – Phase 2: Final Rule," Prepublication Version, August 16, 2016. https://www3.epa.gov/otaq/climate/documents/2016-08-ghg-hd-final-rule-phase2-preamble.pdf
6. South Coast Air Quality Management district et al. "Petition to EPA for Rulemaking to Adopt Ultra-Low NOx Exhaust Emissions Standards for On-Road Heavy-duty Trucks and Engines." June 3, 2016. Accessed March 13, 2017 at https://www.epa.gov/aboutepa/petitions-officeair-and-radiation.
7. CARB, *Revised Proposed 2016 State Strategy for the State Implementation Plans*, March 7, 2017.

TR20: Ships - Ocean-Going Marine Vessels

Brief Summary:
This measure proposes implementation of a Green Ship Program (Program) based on a strategy in place at the Ports of Los Angeles and Long Beach. Financial incentives for cleaner Tier 2 and Tier 3 ocean-going vessels to call at the ports serve as the basis of the Program. The Program was initiated as part of the San Pedro Bay Ports Clean Air Action Plan. This measure also recognizes the need to monitor progress under such programs and augment them as necessary to ensure sufficient results.

Purpose:
This measure will reduce emissions of the key ozone precursors, ROG and NOx, through the development and use of cleaner engines in ocean-going marine vessels. In addition, emissions of particulate matter, toxic air contaminants, carbon monoxide and greenhouse gases would be reduced.

Travel Market Affected:
This measure would affect cargo shipping into and out of Bay Area ports.

Regulatory Context and Background:
Large ships such as container ships, tankers, bulk carriers, and cruise ships are significant contributors of ozone precursors (VOC and NOx), carbon monoxide (CO), and particulate matter (PM), within commercial ports and along coastal areas. There are two types of diesel engines used on large ships: main propulsion and auxiliary engines. The main propulsion engines on many large ships are "Category 3" (or C3) marine diesel engines, which can stand over three stories tall and run the length of two school buses. Auxiliary engines on large ships typically range in size from small portable generators to locomotive-size engines. Marine diesel engines were first regulated by the U.S Environmental Protection Agency in 2004.

In a rule published on April 30, 2010, EPA adopted standards that apply to C3 engines installed on U.S. vessels and to marine diesel fuels produced and distributed in the United States. The rule added two new tiers of engine standards for C3 engines: Tier 2 standards that took effect in 2011, and applies to all newly constructed marine engines and Tier 3 standards, which took effect in 2016, and will also apply to newly constructed marine engines. Older Category 3 vessels are not required to adopt new engine standards. It also includes a regulatory program to implement Annex VI to the International Convention for the Prevention of Pollution from Ships (a treaty called "MARPOL") in the United States, including engine and fuel sulfur limits, and extends the Emission Control Area (ECA) for engine and fuel requirements to U.S. internal waters.

The ports of Los Angeles and Long Beach have created incentive programs to attract clean ships to their ports. The Port of Long Beach's Green Ship Incentive Program financially rewards qualifying vessel operators for deploying "green" ships (vessels with new marine engines that meet Tier 2 and Tier 3 standards) to the Port of Long Beach. The Port of Los Angeles's

Environmental Ship Index program offers incentives based on engine emissions certification, participation in clean air demonstration projects and the voluntary vessel speed reduction zone off the California coast and approaches to San Pedro Bay.

Vessels with main engines meeting 2011 Tier 2 standards established by EPA and the International Maritime Organization (IMO) will be eligible for an incentive of $2,500 per ship call. For even cleaner vessels meeting the 2016 Tier 3 standards, the incentive will increase to $6,000 per ship call.

Tier 2 engines reduce NOx emissions by 15 percent, and Tier 3 engines reduce NOx emissions by 80 percent.

Shore Power

Shore power is the provision of electrical power to a ship at berth while its main and auxiliary engines are shut down. Shore power was first commercially implemented in 2001 by Princess Cruises in Alaska. China Shipping, in 2004, was the first container carrier in California to use shore power at the Port of Los Angeles. Since 2004, the California ports have installed shore power connections at all container and most cruise ship terminals.

In December 2007, ARB approved the "Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in a California Port" Regulation, commonly referred to as the At-Berth Regulation. The At-Berth Regulation is intended to reduce emissions from diesel auxiliary engines, which emit diesel particulate matter and oxides of nitrogen (NOx) on container ships, passenger ships, and refrigerated-cargo ships while berthing at a California Port. The At-Berth Regulation effects the Ports of Los Angeles, Long Beach, Oakland, San Diego, San Francisco, and Hueneme.

The At-Berth Regulation requires vessel fleet operators visiting to either: 1) turn off auxiliary engines and connect the vessel to some other source of power, most likely grid-based shore power; or 2) use alternative control technique(s) that achieve equivalent emission reductions. Vessels are defined, for the most part, to include cruise ships (which berth in SF) and container ships, which most often berth at the Port of Oakland. As of January 1, 2017, covered shipping lines must have 70% or more of their ship visits in compliance with the regulations. Compliance increases to 80% of ship visits in 2020.

The Air District provides financial support, on a case-by-case basis, for the development of shore-power projects that reduce emissions from ships while at berth. Funds are provided through the Carl Moyer Memorial Air Quality Standards Attainment Program (Carl Moyer Program) which provides grant funding for cleaner-than-required engines and equipment. The Air District administer these grants and selects which projects to fund. Eligible projects include cleaner on-road, off-road, marine, locomotive, lawn & garden, light duty passenger vehicles being scrapped and agricultural equipment. For shore power projects, only applicants that can demonstrate that the project is not required by the ARB Shore Power Regulation are eligible.

Implementation Actions:

The Air District will:

- Work with the Ports of Oakland, San Francisco, Richmond, Benicia & Redwood City to develop an incentive program to attract clean ships, and to explore the feasibility and potential benefits from a vessel speed reduction program.
- Continue to provide financial support on a case-by-case basis for the development of shore-power projects that reduce emissions from ships while at berth.

Emission Reductions:

Pollutants*	2020	2030
NO_x	75	38

**criteria pollutants and TACs are reported in lbs/day*

Emission Reduction Methodology:

For the purposes of estimating emission reductions from a Green Ports program, Air District staff assumed that by 2020, the incentives would be sufficient to attract 100 Tier 2 compliant and 50 Tier 3 compliant vessels to Bay Area ports. Vessels are assumed to be container ships that remain in the Bay for 24 hours, proceed directly to and from the assigned berth for a total transit time of 2 hours, operate on fuel compliant with ARB's low-sulfur fuel rule, and are connected to shore power while at berth. Each vessel is assumed to have a main engine rated at 43,000 kilowatts and each vessel is assumed to produce the current average emissions. Using these assumptions, the emissions were calculated by determining the difference in emissions between current emissions and the estimated emissions if 100 ships were replaced with Tier 2 compliant vessels and 50 ships were replaced with Tier 3 compliant vessels.

Exposure Reduction:

This measure will reduce region-wide population exposure to air pollutants based on the estimated reduction in emissions.

Emission Reduction Trade-offs:

None identified.

Cost:

Based on the assumptions used to estimate emission reductions for this measure, costs in 2020 will be $5.5 million for incentives, while costs in 2030 will be $2 million

Co-benefits:

More fuel efficient engines with lower NOx may also reduce GHG emissions attributable to local shipping activity.

Issues/Impediments:

The most significant challenge to implementing this measure will be the willingness of both the local ports and ship operators to fund and participate in a Bay Area Green Ports program.

Sources:

1. US EPA, Ocean Vessels and Large Ships: EPA Actions website, accessed September 22, 2014; http://www.epa.gov/otaq/oceanvessels.htm https://www.faa.gov/about/office_org/headquarters_offices/apl/research/aircraft_technology/cleen/
2. Wyenn, Morgan: *LA and Long Beach Ports adopt Clean Ship Programs in Hopes to Reduce Air Pollution*, May 9, 2012; http://switchboard.nrdc.org/blogs/mwyenn/la_and_long_beach_ports_adopt.html
3. The Port of Long Beach, *The Port of Long Beach Green Ship Incentive Program* brochure; http://www.polb.com/civica/filebank/blobdload.asp?BlobID=9768
4. The Port of Los Angeles and the Port of Long Beach, *San Pedro Bay Ports Clean Air Action Plan*, October 2010, http://www.cleanairactionplan.org/reports/documents.asp
5. The Port of Los Angeles and the Port of Long Beach, *2017 San Pedro Bay Ports Clean Air Action Plan: Draft Discussion Document,* November 2016.
6. California Air Resources Board, *Mobile Source Strategy*, May 16, 2016.
7. CARB, *Revised Proposed 2016 State Strategy for the State Implementation Plan*, March 7, 2017.

TR21: Boats: Cleaner Commercial Harbor Craft

Brief Summary:
This measure supports control technologies that could be deployed on commercial harbor craft to reduce emissions beyond what is required by the statewide Harbor Craft Regulation. Possible technologies include wind assist, hybrid systems, use of alternative fuels, retrofit of existing older marine engines with selective catalytic converters, and diesel particulate filters.

Purpose:
This measure will reduce emissions of the key ozone precursors, ROG and NOx, through the development and use of cleaner commercial harbor craft engines. In addition, the measure will reduce emissions of particulate matter, toxic air contaminants and greenhouse gases.

Travel Market Affected:
This measure would affect emissions from travel done via commercial harbor craft, including ferries, excursion vessels, tugboats, towboats, and commercial and charter fishing boats in the Bay Area.

Regulatory Context and Background:
There are several types of harbor craft used in California and in the Bay Area, including crew and supply boats, charter fishing vessels, commercial fishing vessels, ferry/excursion vessels, pilot vessels, towboats or push boats, tug boats, and work boats. Approximately eighty percent of commercial harbor craft engines operating in California are unregulated diesel engines, accounting for approximately 6,600 pounds per day of diesel particulate matter and 146,000 pounds per day of NOx.

On September 2, 2008, the California Air Resources Board adopted an Air Toxics Control Measures imposing emission limits for new and in-use commercial harbor craft operated within California waters and twenty-four nautical miles of the California coastline. For new harbor craft, each propulsion and auxiliary diesel engine on the vessel is required to be certified to the most stringent federal new marine engine emission standards for that engine's power rating and displacement in effect at the time of sale, lease, rent, or acquisition. The commercial harbor craft regulation imposes additional requirements for larger new ferries (with the capacity to transport seventy-five or more passengers), either by using best available control technology (“BACT”), or by using a federal Tier 4 certified propulsion engine.

For in-use harbor craft, new or in-use diesel engines may not be sold, offered for sale, leased, rented, or acquired unless the diesel propulsion or auxiliary engines are certified to at least the federal Tier 2 or Tier 3 marine emission standards for new engines of the same power rating and displacement. In-use emission requirements are imposed on Tier 0 and Tier 1 marine engines in ferries, excursion vessels, tugboats, towboats, push boats, and multipurpose harbor craft. Those harbor craft are required to meet emission limits equal to or cleaner than the Tier 2 or Tier 3 standards in effect at the time the engine is brought into compliance.

California's commercial harbor craft regulation also impose requirements related to monitoring, reporting and recordkeeping of compliance on owners and operators of new and in-use harbor craft. Subject to ARB approval, harbor craft owners and operators may opt to meet requirements by implementing alternative emission control strategies.

The Air District offers funding to reduce emissions from commercial marine vessels subject to ARB's commercial harbor craft regulation. Funds are available for engine replacement, engine remanufacture, engine retrofit, and shore-power projects that reduce emissions from a ship at berth (as long as the shore-power project is not required by the ARB shore power regulation).

Implementation Actions:
The Air District will:

- Focus on assisting fleets to achieve early compliance with the ARB harbor craft air toxic control measure and supporting research efforts to develop and deploy more efficient engines and cleaner, renewable fuels for harbor craft.
- Coordinate with ARB, the CEC, local port authorities and vessel owners to support field demonstrations of advanced technology for marine and off-road engines and hybrid drive trains. Targeted technology should be those that reduce both criteria pollutants and greenhouse gases at the same time by focusing on fuel economy and renewable fuels.

Emission Reductions:

Pollutants*	2020	2030
ROG	2	< 0.1
NO_x	59	29
$PM_{2.5}$	2	2
PM_{10}	2	2
DPM	2	2
CO_{2e}	1,543	1,313

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:
To estimate emission reductions for this measure, Air District staff assumed that between 2017 and 2020 the typical project will consist of the replacement of pre-1988 off-road engines rated at 350 brake horse power-hour with new Tier 3 compliant engines, and that between 2021 and 2030 the typical project will replace Tier 1 compliant engines with Tier 3 compliant engines. Each engine is assumed to operate 1,000 hours with an average load factor of 43 percent. Emission reductions are based on the replacement of ten engines per year between 2017 and 2030 at an average grant of $100,000. Due to advances in engine design, new Tier 3 engines are approximately 15 percent more fuel efficient than pre-1988 engines, resulting in reductions of CO_2.

Exposure Reduction:
This measure will reduce region-wide population exposure to air pollutants based on the estimated reduction in emissions.

Emission Reduction Trade-offs:
None identified.

Cost:
The cost to implement this measure will be determined primarily by the level of financial incentives that will be offered for early compliance with the harbor craft regulation and for the new advanced technology demonstration projects.

Co-benefits:
New engines for marine vessels are incorporating better control of lubricating oils and unburned fuel droplets from crankcases, resulting in less oil leaking into vessels, thereby reducing harmful water pollution, as well as expensive disposal procedures by vessel owners. The development of more energy efficient engines and drive-trains, as well as local development of renewable diesel should both result in energy savings and the creation of "green" jobs.

Issues/Impediments:
- Funding for demonstrations of advanced engine designs and hybrid drive trains.
- Interest from fleets in early compliance with ARB's harbor craft air toxic control measure.

Sources:

1. Federal Register Volume 76, Number 125 (Wednesday, June 29, 2011), Notices, Pages 38153-38155, from the Federal Register Online via the Government Printing Office [www.gpo.gov], FR Doc No: 2011-16398, http://www.gpo.gov/fdsys/pkg/FR-2011-06-29/html/2011-16398.htm
2. California Air Resources Board, Commercial Harbor Craft: What Owners/Operators Need to Know; revised January 15, 2014; http://www.arb.ca.gov/ports/marinevess/harborcraft/documents/chcpamphlet01162014.pdf
3. Federal Register, *California State Nonroad Engine Pollution Control Standards; Commercial Harbor Craft Regulations; Notice of Decision*, December 13, 2011; https://www.federalregister.gov/articles/2011/12/13/2011-31916/california-state-nonroad-engine-pollution-control-standards-commercial-harbor-craft-regulations#footnote-7
4. State of California, Air Resources Board, *Carl Moyer Program*. http://www.arb.ca.gov/msprog/moyer/moyer.htm

TR22: Construction, Freight and Farming Equipment

Brief Summary:
The Air District will work to reduce emissions from off-road equipment used in the construction, freight handling and farming industries by pursuing the following strategies: 1) offering financial incentives between 2017 and 2030 to retrofit engines with diesel particulate filters or upgrade to equipment with electric or Tier IV off-road engines; 2) work with ARB, the California Energy Commission and others to develop more fuel-efficient off-road engines and drive-trains; and 3) work with local communities, contractors, freight handlers, farmers and developers to encourage the use of renewable electricity and renewable fuels, such as biodiesel from local crops and waste fats and oils, in applicable equipment.

Purpose:
This measure will reduce key ozone precursors, ROG and NOx, through the installation of abatement devices on existing diesel equipment and offering financial incentives to replace older diesel equipment. This measure will also reduce toxic air contaminants, such as diesel particulate matter (PM), and greenhouse gases.

Source Category/Travel Market Affected:
Construction, Freight Handling, and Farm Equipment

Regulatory Context and Background:
Construction, freight and farming equipment contribute approximately 15 percent of the regional inventory of NOx emissions, and 5 percent of PM2.5 emissions. Construction equipment is also a contributor to local exposure of diesel PM. Criteria pollutant emissions from the engines in construction, freight and farming equipment, which are primarily diesel, are subject to control under regulations adopted by both ARB and U.S. EPA.

ARB's control of criteria pollutant emissions from off-road engines used in construction, freight and farming equipment was authorized by the California Clean Air Act as codified in the Health and Safety Code sections 43013 and 43018. In 1992, ARB approved initial regulations to control exhaust emissions from heavy-duty off-road compression ignition (CI) engines 175 horsepower (130 kilowatts) and above. These initial standards are referred to as Tier I standards. In 1994, ARB approved the State Implementation Plan (SIP) for ozone, which included measures calling for new state and national emission standards for off-road CI engines beginning in 2005.

U.S. EPA promulgated new emission standards for off-road engines in 1998, with ARB adopting parallel standards in 2000. The standards are phased in through two additional stages which are referred to as Tiers 2 and 3. In 2004, Tier 4 emission standards were adopted and were phased in for new engines between 2011 and 2014. The coordinated efforts of ARB, U.S. EPA, and engine manufacturers to introduce lower-emission off-road CI engines nationwide will result in substantial air quality benefits in California and the rest of the country.

However, recognizing that construction, freight and farming equipment are long-lived, with existing engines remaining in service for many years, in 2007 ARB adopted an off-road equipment regulation to accelerate reductions of NOx and diesel PM from existing off-road engines. Beginning in 2012 and through 2023, the off-road regulation requires operators of older equipment to either install abatement devices, upgrade to Tier 3 and eventually Tier 4 engines, or to retire older equipment. However, equipment used in agricultural operations at least 50 percent of the time are exempt from the performance requirements of the ARB off-road regulations.

ARB's initial AB 32 Scoping Plan, adopted in 2008, identified strategies for reducing CO2 from a variety of sources in California, including construction, freight and farming equipment. ARB's strategies include reducing the carbon content of diesel fuel; promoting alternative fuels and renewable diesel fuels; and investigating ways of increasing fuel economy.

In 2012, Governor Brown signed into law three bills – AB 1532 (Pérez), SB 535 (De León), and SB 1018 (Budget and Fiscal Review Committee) – that established the Low Carbon Transportation Greenhouse Gas Emission Reduction Fund (GGRF). This fund receives Cap-and-Trade auction proceeds and provides the framework for how the auction proceeds will be administered in furtherance of the purposes of AB 32, including supporting long-term, transformative efforts to improve public health and develop a clean energy economy. On June 23, 2015 ARB announced the availability of $47.3 million in Advanced Technology freight demonstration projects as part of their funding plan to distribute GGRF funds. These funds are open to public agencies and nonprofits. The demonstration of advanced freight technologies is an important step in reaching the state's and the Air District's air quality and GHG reduction goals, and reducing exposure to air toxics and PM in impacted communities.

In May 2016, ARB released its 2016 *Mobile Source Strategy*. For construction and other off-road equipment, ARB staff are proposing increased use of fuel derived from renewable sources, measures to improve worksite efficiencies, deployment of zero emission technologies into targeted categories, programs to encourage application of on-road engine advances to off-road equipment, and increased incentives for early deployment of clean technologies.

Implementation Actions:
This measure will primarily focus on assisting fleets to achieve early compliance with the ARB in-use off-road regulation and supporting research efforts to develop and deploy more efficient engines and cleaner, renewable fuels for construction and farming equipment.

The Air District will:

- Between 2017 and 2030 provide incentives for the early deployment of electric, Tier 3 and 4 off-road engines used in construction, freight and farming equipment. Based on the recent four years of incentives, the Air District will likely provide incentives for the replacement of 82 off-road equipment engines annually through 2020. The actual number of replacements will depend on the amount of funding available and the number of engine owners taking advantage of the incentives.

- Between 2017 and 2025, coordinate with ARB and the CEC, as well as construction firms, farmers and others, to support field demonstrations of advanced technology for off-road engines and hybrid drive trains. Targeted technology should be those that reduce both criteria pollutants and greenhouse gases at the same time by focusing on fuel economy and renewable fuels.
- Beyond 2025, provide support for the purchase of commercially available off-road equipment that runs on both renewable electricity and diesel, with an emphasis placed on fuels that can be developed and produced locally.

Emission Reductions:

Pollutants*	2020	2030
ROG	12	0.9
NO_x	111	59
$PM_{2.5}$	4	1
PM_{10}	4	1
DPM	4	1
CO_{2e}	2,575	1,931

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:
To estimate emission reductions for this measure, Air District staff assumed that the typical projects between 2017 and 2020 will consist of the replacement of uncontrolled “Tier 0” off-road engines rated at 175 brake horse power-hour with new Tier 4 compliant engines; and between 2021 and 2030 the typical project will consist of the replacement of Tier 2 compliant engines with Tier 4 compliant engines. Each engine is assumed to operate 500 hours annually with an average load factor of 35 percent. Due to advances in engine design, load sensing, and idle-limit controls, new engines are approximately 25 percent more fuel efficient than Tier 1 engines, resulting in reductions of CO_2. Emission reductions are based on the replacement of 82 engines per year at an average grant of $12,195.

Exposure Reduction:
Efforts to reduce diesel PM will reduce exposure of residents and workers in the vicinity of construction sites and farms. Additionally, reduction of NOx emissions will help reduce regional ozone levels/exposure, while reductions in both NOx and diesel PM emissions will contribute to reductions in the directly emitted PM and formation of secondary PM, reducing overall population exposure to fine particulate matter.

Emission Reduction Trade-offs:
The use of diesel PM filters and other abatement devices on Tier 4 compliant engines generally reduces fuel economy by approximately 3 percent however advances in engine design and load sensing generally improve the fuel efficiency of new engines. Additionally, installation of abatement devices on equipment utilizing hybrid drive systems will not result in any fuel penalties.

Cost:
Available funding from the Air District varies from year to year as approved by the Board of Directors. Between 2010 and 2014, funding ranged from $2.8 and $11.3 million. The average incentive offered to a fleet operator to purchase a Tier 4 engine or to participate in a demonstration of near-zero or zero emission equipment varies, as the number of grant applicants vary each year.

Co-benefits:
New engines for construction, freight and farming equipment are incorporating better control of lubricating oils and unburned fuel droplets from crankcases, resulting in less oil leaking on the ground, thereby reducing harmful water pollution. The development of more energy efficient engines and drive-trains, as well as local development of renewable diesel should both result in energy savings and the creation of "green" jobs. In addition, this measure will reduce black carbon, which is short lived greenhouse gas.

Issues/Impediments:
- Limited funding for demonstrations of advanced engine designs and hybrid drive trains.
- Interest from fleets in early compliance with ARB's off-road in-use engine air toxic control measure.

Sources:

1. BAAQMD, *Base Year 2008 Emissions Inventory: Summary Report*, May 2011
2. BAAQMD, *Base Year 2008 Emissions Inventory: Source Categories*, May 2011
3. BAAQMD, Source Inventory of Bay Area Greenhouse Emissions, December 2008
4. State of California, Air Resources Board, *Staff Report: Initial Statement of Reasons for Proposed Rulemaking: Proposed Regulation for In-Use Off-Road Diesel Vehicles*, April 2007.
5. State of California, Code of Regulations, Title 13, Section 2449 et seq., 2009
6. State of California, Air Resources Board, Carl Moyer Program: http://www.arb.ca.gov/msprog/moyer/moyer.htm
7. California Air Resources Board, *Mobile Source Strategy*, May 16, 2016.

TR23: Lawn Care Equipment

Brief Summary:
Use of gasoline lawn mowers and leaf blowers contribute to air pollution, primarily through the release of volatile organic compounds (VOC) and particulate matter (PM). While progressively more stringent emission standards have reduced pollution from lawnmowers and leaf blowers, sufficient numbers of older two-stroke and four-stroke engines remain in use in the Bay Area. The Air District has pursued removal of these older engines through voluntary exchange programs that target commercial all lawn and garden equipment, including mowers and backpack-style leaf blowers. The Air District will continue this program, as well as seek funding to develop an internet-based exchange program for residential lawn care equipment.

Purpose:
Reduce VOC and PM emissions through the continuation of the Air District's Commercial Lawn and Garden Equipment Replacement program and through the development of an ongoing residential lawn mower exchange program.

Source Category:
Lawn, Garden and Utility Equipment: Gasoline Lawn Mowers and Leaf Blowers

Regulatory Context and Background:
Lawn, garden and utility equipment includes of a wide variety of small engines used in lawn mowers, leaf blowers, chainsaws, trimmers, shredders, stump grinders, commercial turf equipment and other types of equipment that collectively account for less than 6 percent of the total VOC inventory in the Bay Area. This equipment primarily uses gasoline engines, although there is some diesel and propane powered equipment. Electric powered equipment has begun to gain market share, particularly with lawnmowers, chainsaws, leaf blowers and other small equipment used by homeowners.

The small gasoline engines on lawn and garden equipment were first regulated in 1995 by ARB, with the newest, most stringent regulations becoming effective with the MY 2008 equipment. There are over 1.71 million lawnmowers and leaf blowers in the Bay Area, of which approximately 310,000 are two stroke engines. Two stroke engines generate significantly more air pollution, especially particulate matter, compared to four stroke engines. The Air District conducted lawn mower exchange programs between 1999 and 2006 by offering cash incentives to consumers to purchase electric or mechanical equipment. Residents exchanged slightly more than 7,800 two- and four-stroke lawnmowers for new electrical and mechanical mowers. Estimated emission reductions from the program were 10,600 pounds per year of ROG, NOx and PM, at an annualized cost-effectiveness of approximately $3.90 per pound.

In the *2016 Mobile Source Strategy*, ARB staff have proposed three actions to further reduce emissions from small engines: enhanced enforcement, tighter emissions standards, and incentives to increase the use of electric equipment. Because there have been high failure rates have been observed in evaporative emissions testing of small engines, ARB staff is currently increasing enforcement of current standards with manufacturers. ARB staff is finalizing amendments to existing regulations to tighten exhaust and evaporative emission standards for small off-road engines beginning in 2018; the proposed amendments may include incentives for manufacturers to produce zero-emission equipment. ARB staff also plans to propose a combination of manufacturing and purchasing incentives to replace at least 25 percent of the existing small engines with zero emission equipment, while the remaining engines will would meet exhaust and evaporative emission standards that by 2030 would be approximately 90 percent tighter than today's standards. Because the regulatory amendments and other proposed actions are not yet adopted, any likely benefits are not included in the emissions estimates below.

The Air District will focus its efforts through its grant programs by encouraging the purchase of zero emission electrical and mechanical equipment. In November 2014, $470,000 became available for a *Commercial Lawn and Garden Equipment Replacement* effort in Alameda and Contra Costa Counties. These funds were used to replace commercial lawn mowers, leaf blowers, sweepers, chainsaws, line trimmers, and hedge trimmers with zero-emission equipment.

The Air District hopes to secure funds to expand the Commercial Lawn and Garden Equipment Replacement program into all Bay Area counties, and develop a residential program in the near future.

Implementation Actions:
The Air District will:
- Seek additional funding to expand the Commercial Lawn and Garden Equipment Replacement Program into all nine Bay Area counties.
- Establish a Residential Lawn and Garden Equipment Replacement Program.
- Explore options to expand the program to cover shredders, stump grinders, and commercial turf equipment. Expansion of the program will depend on the availability of cleaner replacement equipment, costs, and a reliable source of incentive funding.

Emission Reductions:

Pollutants*	2020	2030
ROG	1,134	2,835
NO_x	32	315
$PM_{2.5}$	63	630
CO_{2e}	8,742	21,854

**criteria pollutants and TACs are reported in lbs/day; CO_{2e} is reported in metric tons/year*

Emission Reduction Methodology:
For the purposes of estimating cumulative reductions achieved by 2020 and 2030, it is assumed that the incentive program will expend $500,000 per year to encourage the purchase of 2,000 new, zero emission electric or mechanical instead of new gasoline powered pieces of

equipment. The emission reduction estimates in the table above represent the amount of avoided emissions because 8,000 zero emission pieces will be in use in the year 2020 and 20,000 in the year 2030 due to the provision of the Air District's incentive funding. (It is assumed for these calculations that the equipment purchased between 2017 and 2020 will be retired by 2030.) Emission reductions are based on the average new gasoline equipment have small engines rated at 7 hp, consume an average of 0.3 gallons of gasoline per day and operate 1.4 hours on a typical day, and met ARB emission standards for engines manufactured beginning in 2008.

Exposure Reduction:
Gasoline engines emit high levels of hydrocarbons, many species of which are listed as air toxics. Purchasing electric or mechanical zero- emission equipment will result in reductions in toxic emissions.

Emission Reduction Trade-offs:
This measure will reduce emissions of NOx, ROG, CO, PM and CO2, but because it potentially replaces gasoline powered equipment with electric powered equivalent, it will contribute to an incremental increase in electricity production, which may cause slight increases in emissions from power plants.

Cost:
The average incentive amount provided as part of the Commercial Lawn and Garden Equipment program in Alameda and Contra Costa Counties was $940. Because the proposed program will include equipment used for both commercial and residential application, the expected average incentive amount would be $250.

Co-benefits:
Use of push lawn mowers, electric or battery lawn mowers and leaf blowers will result in reductions in water pollution and fossil fuel use. There will also be consumer savings. New leaf-blowers also operate at lower decibel levels, reducing noise impacts.

Issues/Impediments:
The main obstacle is the need to secure funding to implement this measure. While funding is potentially available through the CARB-administered Carl Moyer Program, limitations on the amount available statewide and types of qualifying equipment will mean other sources of funding will be crucial for the success of this control measure.

Sources:
1. Bay Area Air Quality Management District, *Bay Area Emissions Inventory Summary Report: Criteria Air Pollutants*, Base Year 2011, May 2014
2. Bay Area Air Quality Management District, *Staff Report: Acceptance of Funds from the National Fish and Wildlife Foundation for a Commercial Lawn and Garden Equipment Replacement Program*, November 26, 2014

3. Data on total lawn mowers and leaf blowers obtained from California Air Resources Board, Offroad2007 model
4. California Air Resources Board, *California Exhaust Emission Standards and Test Procedures for 2005 and Later Small Off-Road Engines*, July 26, 2004 (www.arb.ca.gov/regact/sore03/sore03.htm; accessed on November 18, 2016.)
5. California Air Resources Board, *Mobile Source Strategy*, May 2016
6. California Air Resources Board, Proposed 15-Day Changes to the Small Off Road Emissions Standards, February 24, 2017 (https://www.arb.ca.gov/msprog/offroad/sore/appadraft15day02242017.docx; accessed on March 2017).

EN1: Decarbonize Electricity Generation

Brief Summary:
This measure would focus on lowering carbon emissions by switching the fuel sources used in electricity generation. The measure would promote and expedite a transition away from fossil fuels used in electricity generation (i.e., natural gas) to a greater reliance on renewable energy sources (e.g., wind, solar). In addition, this measure would promote an increase in cogeneration, which results in useful heat in addition to electricity generation from a single fuel source.

Purpose:
The purpose of this control measure is to reduce emissions of criteria pollutants, toxic air contaminants and greenhouse gases (GHGs) in the generation of electricity.

Source Category:
This measure affects electricity-generating power plants in the Bay Area.

Regulatory Context & Background:
Power plants generate electricity via a variety of fuel sources – fossil fuels (most commonly coal or natural gas), renewables (e.g., solar and wind) or other sources (e.g., nuclear). In addition, cogeneration, also referred to as combined heat and power (CHP), is the simultaneous generation of useful heat and electricity from a single fuel source. As such, CHP systems result in more "use" from a fuel source than non-CHP systems and thus increase the total efficiency of the fuel source.

As shown in Table 1, as of April 2016, nearly 85 percent of the electricity generation capacity in the Bay Area is from fossil-fueled power plants, all from natural-gas plants (CEC 2016).[1] Renewable-fuel sources account for the remaining capacity (over 15 percent), with the majority of this capacity coming from wind power (nearly 13 percent). While renewable plants contribute a modest portion of the energy-generation capacity in the Bay Area, plants fueled by renewable sources account for the majority of physical electricity-generating facilities in the Bay Area (nearly 72 percent). Lastly, while nearly 64 percent of natural-gas plants in the Bay Area are CHP facilities (28 of 44), the electricity-generation capacity of these CHP plants represents less than 16 percent of the total capacity of these plants (1,011 MW of 6,351 MW).

[1] There are also ten peaker plants in the Bay Area, only used for power generation when there is high demand. These plants, all fueled by natural gas, have a total capacity of just over 775 MW.

Table 1. Electricity Generation Capacity in the Bay Area by Fuel Source

Fuel Source	Capacity[1] *MW (%)*	Plants	
		# (%)	CHP facilities (MW/#)
Fossil Fuels			
Natural gas	*6,351 (84.8%)*	*44 (28.4%)*	*1,011/28*
Fossil Fuels Sub-total	**6,351 (84.8%)**	**44 (28.4%)**	**1,011/28**
Renewables			
Wind	*954 (12.7%)*	*25 (16.1%)*	*-/-*
Solar	*109 (1.5%)*	*68 (43.9%)*	*-/-*
Digester or Landfill Gas	*65 (0.9%)*	*13 (8.4%)*	*13/3*
Hydroelectric	*15 (0.2%)*	*5 (3.2%)*	*-/-*
Renewables Sub-total	**1,143 (15.2%)**	**111 (71.6%)**	**13/3**
TOTALS			
	7,494	**155**	**1,024 /31**

1. Capacity totals to more than 100 percent due to rounding.

As the regional agency responsible for protecting air quality in the Bay Area, the Air District has the authority to adopt regulations and rules to limit air emissions from stationary sources. As such, power plants must request and be granted an authority to construct and a permit to operate from the Air District that outlines the operating conditions of and emission limits at each facility. Among the permit requirements required by the Air District is the condition that combustion equipment – such as gas turbines and heat recovery boilers – use the Best Available Control Technology (BACT) to minimize emissions. In addition, projects may be subject to emission offset requirements, Prevention of Significant Deterioration (PSD) analysis requirements, and health risk screening analysis (HRSA) requirements.

Electricity is delivered to residential and commercial customers in the Bay Area via a mix of investor-owned utilities (IOU), publically-owned utilities (POU) and community choice energy (CCE) providers. The dominant electricity provider in the Bay Area is the IOU Pacific Gas and Electric (PG&E). Two examples of POUs are the municipal electric utilities Alameda Municipal Power, which provides electricity to residents and businesses in the city of Alameda, and Silicon Valley Power, which provides electricity to residents and large corporations such as Yahoo in the city of Santa Clara. CCEs are growing in popularity. A CCE is a system that allows cities and counties to aggregate the buying power of individual customers within a defined jurisdiction in order to secure alternative energy supply contracts on a community-wide basis. As of mid-2016, the three operational CCEs in the Bay Area are Marin Clean Energy (MCE), serving Marin County, unincorporated Napa County and the cities of Benicia, El Cerrito, Richmond and San Pablo; Sonoma Clean Power (SCP), serving a number of cities in and unincorporated areas of Sonoma County; and CleanPowerSF, serving San Francisco City and County.

California, with its abundant natural resources, has a long history of supporting the development and utilization of renewable energy. For example, following deregulation of the electric utilities in California in 1998, the California Energy Commission (CEC) was placed in charge of a new Renewable Energy Program to help increase total renewable-electricity production statewide. Among the various elements of the program, market-based incentives were provided for new and existing utility-scale facilities powered by renewable energy. In 2002, California established its Renewables Portfolio Standard (RPS) Program. This program, jointly implemented by the California Public Utilities Commission (CPUC) and the CEC, is one of the most ambitious renewable energy standards in the country. The RPS program required that all electricity retailers in California (including IOUs, POUs, and CCEs) increase procurement from eligible renewable energy resources to 20 percent by the end of 2013, then to further increase renewable procurement to 25 percent by the end of 2016, and 33 percent of total procurement by 2020. Passage of Senate Bill (SB) 350 in September 2015 increased and extended the required procurement from renewable sources to 50 percent by 2030.

Electricity providers in the Bay Area are on track to meet, and in some cases have already exceeded, these RPS goals. For example, PG&E served 29.5 percent of its retail electricity sales with renewable power in 2015, placing it ahead of the 2016 requirement, and has stated that it is well ahead of schedule in meeting the 2020 goal (PG&E 2016a). In addition, PG&E's Solar Choice Program allows customers to purchase 50 to 100 percent of their electricity needs from solar projects created for this program in PG&E's service territory (PG&E 2016b). The CCEs in the Bay Area have exceeded these goals, providing customers electricity generated with 33 percent (SCP), 35 percent (CleanPowerSF) and 50 percent (MCE), or offering for a premium 100 percent renewable energy (all three Bay Area CCEs). Similarly, Silicon Valley Power and Alameda Municipal Power offer customers the option to buy electricity generated by 100 percent renewable sources.

In addition, there are numerous efforts at the State level to promote the development of CHP. For example, ARB's Initial Scoping Plan (2008) outlines a target of 4,000 MW of additional CHP capacity, and an associated reduction of 6.7 MMT CO_2e, by 2020. Similarly, AB 1613, the *Waste Heat and Carbon Emissions Reduction Act*, created a feed-in tariff to incentivize the development of small CHP (no larger than 20 MW). In addition, in 2010, Governor Brown called for an additional 6,500 MW of new CHP capacity by 2030 in his Clean Energy Jobs Plan.

Implementation Actions:

The Air District will:

- Engage with PG&E, municipal electric utilities and CCEs to maximize the amount of renewable energy contributing to the production of electricity within the Bay Area as well as of electricity imported into the region.
- Work with CCE networks (such as LEAN Energy) to explore options for supporting the formation of new CCEs, such as providing start-up funding or credit guarantees.
- Support the development of bioenergy to displace electricity generated from fossil fuels for applications where renewable electricity is unsuitable. Track and participate in the state's Bioenergy Interagency Working Group. Engage with stakeholders including dairy farms,

forest managers, water treatment facilities, food processors, public works agencies and waste management to increase use of biomass in electricity production. The Air District's role may be to facilitate pilot testing of new technologies and applications, expedite Air District permitting of biofuel facilities, provide technical analysis, etc.

- Expedite Air District permitting for new, large-scale renewable energy generation and high-efficiency CHP facilities.as well as fir biofuel facilities where necessary.
- Explore developing grant and/or incentive programs to facilitate, promote and pilot test new renewable energy-based electricity technologies and applications, such as energy storage technology.

Emission Reductions:
Emission reduction estimates are not available.

Emission Reduction Methodology:
N/A

Exposure Reduction:
The decarbonizing of fuel sources used to generate electricity in the Bay Area would result in fewer GHG and criteria pollutant emissions. In addition, as generation of electricity shifts away from fossil-fueled power plants to plants fueled by renewable sources (either because plants are converted or production at these plants is lowered), communities located near fossil-fueled power plants would be exposed to lower levels of criteria pollutants and toxic air contaminants. Moreover, increased efficiencies with CHP would reduce fuel consumption which in turn lowers GHG and criteria pollutant emissions.

Emission Reduction Trade-Offs:
None anticipated.

Cost:
To shift electricity generation at power plants in the Bay Area away from fossil fuels to renewable sources, existing plants would need to be modified and/or new (renewable) plants would need to be constructed. This effort would require considerable upfront capital investment. At the same time, renewable power plants (particularly solar and wind) have considerably lower operational costs than traditional fossil-fuel plants – in part because the "fuel" used is essentially free – such that this initial investment would be returned on a shorter term.

Co-Benefits:
In addition to the emission reduction benefits of decarbonizing electricity generation, a greater reliance on renewable fuel sources has these additional benefits:

- There is an essentially endless supply of many of these resources (e.g., wind and solar), some are generated as byproducts of other industries (i.e., biomass) and others are replenished over time (i.e., hydro).

- Once fully developed, these facilities are much more cost-effective as the fuel source is far cheaper than coal and/or natural gas.
- Power generation from these sources (esp. wind and solar) are isolated from fluctuations in economic markets and are not affected by international political instability.
- There are economic benefits associated with manufacturing and maintaining renewable power plants, keeping businesses and jobs in California.

Additional benefits from CHP include:
- Reduced electricity losses from transmission and distribution along power lines due to electricity and heat being generated on-site.
- Increased reliability for critical facilities, such as hospitals, data centers, prisons, and wastewater treatment plants.

Issues/Impediments:
Fossil-fuel power plants typically generate greater quantities of electricity than renewable plants (e.g., solar and wind farms need substantial amounts of land), so there is the challenge of generating enough electricity to meet demand via renewable sources. In addition, renewable energy sources have issues with the reliability, predictability and consistency of the supply since renewable energy often relies on the weather for its source of power. For example, hydro generators need rain to fill dams to supply flowing water, wind turbines need wind to turn the blades, and solar collectors need clear skies and sunshine to collect heat and make electricity. When these resources are unavailable, so is the capacity to make energy from them. Similarly, the intermittent nature of many renewables renders them non-dispatchable and thus ineffective at responding to changing demand, especially meeting peak demand. As such, developing systems to cost-effectively store this energy for later use is key to improving the viability of renewable energy. Lastly, there are issues with grid reliability and integration associated with the intermittent nature of power generated by way of renewable resources (especially wind and solar).

Sources:

1. California Air Resource Board, *Climate Change Scoping Plan – a framework for change*, December 2008.
2. California Energy Commission, *California Electricity Data, Facts, & Statistics*, California Power Plant Database (Excel File), created on April 12, 2016, website accessed at http://energyalmanac.ca.gov/electricity/ on July 13, 2016.
3. CEC, *California Electricity Producers*, http://energyalmanac.ca.gov/electricity/overview.html.
4. CEC, *California Renewable Energy Overview and Programs*, http://www.energy.ca.gov/renewables/.
5. CEC, *Combined Heat and Power*, http://www.energy.ca.gov/chp/.
6. California Public Utilities Commission, California Renewables Portfolio Standard (RPS), http://www.cpuc.ca.gov/PUC/energy/Renewables/.

7. PG&E, 2016a, *PG&E Achieves Major Renewable Energy Milestone*, http://www.pgecurrents.com/2016/02/25/pge-achieves-major-renewable-energy-milestone/, posted February 25, 2016.
8. PG&E, 2016b, *PG&E's Solar Choice Program*, http://www.pge.com/en/myhome/saveenergymoney/solar/choice/index.page.

EN2: Decrease Energy Use

Brief Summary:
This measure focuses on decreasing energy use in the Bay Area by (1) increasing consumer awareness about energy efficiency through education and outreach and (2) tracking electricity use.

Purpose:
The purpose of this control measure is to decrease the amount of energy consumed in the Bay Area through increased efficiency and conservation. With decreased energy use, less electricity generation is required, and thus there would be a reduction in the emissions of greenhouse gases (GHGs), criteria pollutants and toxic air contaminants (TACs).

Source Category:
This measure affects electricity-generating power plants.

Regulatory Context & Background:
Table 1 indicates the electricity usage in the nine-county Bay Area for the last ten years broken down by non-residential and residential users (CEC 2016). After a sharp increase in electricity usage from non-residential users in 2007 and 2008, non-residential usage fell in 2009 and has gradually climbed since to just under 40 million megawatt hours (MWh) annually in 2014. Residential electricity usage has followed a slightly different pattern, with a one-year peak in 2006 followed by lower usage that gradually increased through 2009, and then slowly declined in the last five years, capped by a sharper drop to under 16 million MWh annually in 2014. Overall, since climbing until a peak in 2008, total electricity usage in the nine-county Bay Area has averaged just over 55 million MWh annually. In addition, over this ten-year period, the split between annual non-residential and residential usage has remained quite constant, with non-residential users accounting for approximately 71 percent of electricity consumption annually and residential users some 29 percent.

Table 1. Electricity Consumption in the nine-county Bay Area (in million MWh)

	2005	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***
Non-Residential	37.4	37.9	40.1	40.4	38.8	38.7	39.3	38.9	39.3	39.7
Residential	15.9	16.5	16.0	16.2	16.3	16.2	16.3	16.2	16.1	15.7
Total	**53.3**	**54.4**	**56.1**	**56.6**	**55.1**	**54.9**	**55.6**	**55.1**	**55.4**	**55.4**

Projections of electricity consumption over the next decade indicate that demand for electricity will increase over this time period as a result of economic and demographic growth (Kavalec 2015).[1] Specifically, in the Bay Area, electricity consumption is expected to increase 0.98 percent annually under a low-energy demand scenario to as much as 1.66 percent annually

[1] This study also considered the effect of other factors – such as electricity rates and the effects of efficiency programs and on-site electricity production - on electricity demand.

under a high-energy demand scenario each year between 2013 and 2025.[2] Statewide, the majority of this annual increased demand would be attributed mostly to growing demand in the residential sector (1.44 to 2.29 percent), more moderate demand growth in the commercial sector (0.97 to 1.79 percent) and limited demand growth (or even decrease) in the industrial sector (-0.42 to 0.44 percent). It is reasonable to expect that demand will continue to increase beyond 2025 along with expected increases in both the population and job numbers in the Bay Area, as shown in Table 2 (ABAG 2013).

Table 2. Total Population and Jobs in the Bay Area: 2005 through 2040.

	2005	*2010*	*2015*	*2020*	*2025*	*2030*	*2035*	*2040*
Population	7,096,500	7,150,739	7,461,400	7,786,800	8,134,000	8,496,800	8,889,000	9,299,100
Jobs	3,449,740	3,385,300	3,669,990	3,987,150	4,089,320	4,196,580	4,346,820	4,505,230

Sources: Numbers from ABAG 2013.

It is important to note that demand for electricity would also grow as a result of increased electrification across sectors (i.e., switching from fossil fuels to electricity as a fuel source), a key component of the Air District's regional GHG-reduction efforts. For example, control measure BL2: Decarbonize Buildings calls for replacing furnaces, water heaters and other appliances in buildings currently powered by fossil fuels with low- and zero-carbon alternatives, including electric-powered options. Similarly, control measure TR14: Cars & Light Trucks promotes the replacement of fossil-fueled vehicles with electric vehicles. While these efforts to increase electrification would result in an overall decrease in GHG emissions, they would also put upward pressure on electricity demand.

At the same time that electricity consumption is expected to increase in the future, emissions of GHGs from electricity generation are actually expected to decrease over this time period.[3] This decline in emissions is largely the result of implemented policies that serve to lower GHG emissions from this sector by increasing reliance on renewable sources to generate electricity, such as the Renewable Portfolio Standard.

This control measure serves to strengthen another important factor in lowering GHG emissions from this sector - reducing energy use. Much of this effort to date has taken the form of energy-efficiency programs, which originated during the energy crisis of the 1970s with the emergence of the concept of "energy conservation" as a means for customers to cope with soaring energy prices (ACEEE 2015). Since that time, despite a decline in energy-efficiency programs with utility deregulation in the 1990s, these programs have expanded and are widely regarded as an integral and highly valuable element of utility investments and operations that provide significant energy and economic benefits to both the utility and ratepayers, while also

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[2] This forecast is for the Pacific Gas and Electric Company (PG&E) planning area, which extends beyond the Bay Area into more northern, southern and eastern portions of the state. PG&E is the principal electricity provider in the Bay Area.

[3] GHG emissions from the energy sector include emissions from electricity generated and used within the Bay Area, and electricity generated outside the Bay Area that is imported into and used within the region (BAAQMD 2015).

generating jobs and reducing emissions of air pollutants. California's investment in energy-efficiency programs has resulted in per capita energy use in California remaining essentially flat since the 1970s, while per capita consumption in the rest of the United States has increased by about 33 percent (CPUC 2015).

Energy-efficiency programs in California either focus on achieving in-the-moment demand reductions, or on longer-horizon energy consumption reductions. For example, Flex Alerts, issued by the California Independent Systems Operator (ISO), are urgent, voluntary calls to conserve electricity and shift demand by using major appliances after 6 pm. This program decreases not only energy consumption but also the reliance on peaker plants, which generate electricity only when there is high demand and generally emit more criteria pollutants and GHGs than facilities that run consistently. These "demand response" approaches are critical for reducing energy use during peak demand times or events. Longer-horizon programs include Energy Upgrade California, a state initiative to help Californians make investments to save energy and conserve natural resources, help reduce demand on the electricity grid, and make informed energy management choices at home and at work. Regionally, the Bay Area Regional Energy Network (BayREN), a collaboration of the nine Bay Area counties led by the Association of Bay Area Governments, implements a series of initiatives that deliver energy savings such as providing technical assistance to consumers and contractors to retrofit housing units, offering energy-saving rebates for the housing sector, and offering multiple financing options to assist diverse consumers in undertaking energy projects. Locally, cities and counties across the Bay Area have adopted a wide range of policies, including measures in their climate action plans, aimed at increasing energy efficiency such as facilitating energy audits of buildings and promoting energy-efficiency retrofits of existing homes and commercial buildings.

As noted in ARB's 2008 Climate Change Scoping Plan, one of the challenges to fully implementing energy-efficiency programs and actions is lack of access by the public, residents and business to information about these programs, their benefits, and how to participate in them. Therefore, while California has a long history of success in implementing regulations and programs to encourage energy efficiency, additional efforts are needed to overcome the information barriers to provide the benefits of increased efficiency to more Californians and, in doing so, help meet California's GHG emission goals. This control measure serves to overcome these challenges.

Implementation Actions:
The Air District will:

- Provide education and outreach about energy-efficiency programs and financing available to local governments, residents, and businesses in the Bay Area.
- Increase consumer awareness about energy-efficiency benefits by incorporating this message into existing outreach programs such as Spare the Air, outreach to Bay Area schools, community engagement campaigns, etc.
- Work with partners such as PG&E, municipal utilities and community choice energy providers to develop messaging to decrease electricity demand during peak times.

- Explore promoting emerging technologies that support automated demand response and energy storage technologies.
- Distribute information on state and local energy-efficiency programs to permitted sources.
- Work with local governments to adopt additional energy-efficiency policies and programs, including within climate action plans and other local plans, and to identify resources for tracking building stock information (e.g., square footage, age of buildings) to inform future policy-making.

Emission Reductions:
Due to the uncertain nature of the implementation actions, emission reductions cannot be quantified.

Emission Reduction Methodology:
N/A

Exposure Reduction:
Reducing energy use would reduce the need to generate electricity in or import electricity into the Bay Area. As electricity generation drops, communities located near fossil-fueled power plants would be exposed to lower levels of criteria pollutants and TACs.

Emission Reduction Trade-Offs:
This control measure is designed purely to reduce energy consumption, so there would be no direct emission trade-offs. There may be indirect emissions associated with the production and delivery of some energy-efficient technologies.

Cost:
N/A

Co-Benefits:
In addition to a reduction in emissions of GHGs, criteria pollutants and TACs, there are a number of co-benefits associated with reducing demand for electricity:
- Improved air quality near power plants (due to reduced production);
- Increased reliability of power supply and cost; and
- Financial savings through reduced energy usage.

Issues/Impediments:
No significant issues or impediments are anticipated due to the voluntary nature of this control measure.

Sources:

1. American Council for an Energy-Efficient Economy, *Energy Efficiency Programs*, http://aceee.org/portal/programs, accessed on September 28, 2015.
2. Association of Bay Area Governments, *ABAG Projections 2009: Regional Projections*, http://www.abag.ca.gov/planning/currentfcst/regional.html.

3. Association of Bay Area Governments, *Plan Bay Area Projections 2013*, http://www.abag.ca.gov/planning/housing/projections13.html.
4. BAAQMD, 2015, *Bay Area Emissions Inventory Summary Report: Greenhouse Gases Base Year 2011*.
5. Bay Area Regional Energy Network, https://www.bayren.org/.
6. California Air Resources Board, 2008, *Climate Change Scoping Plan – a framework for change*.
7. California Energy Commission, *Energy Consumption Data Management System – Electricity Consumption by County*, http://www.ecdms.energy.ca.gov/elecbycounty.aspx, accessed on January 13, 2016.
8. California Public Utilities Commission, *Energy Efficiency*, http://www.cpuc.ca.gov/PUC/energy/energy+efficiency/, accessed on September 28, 2015.
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BL1: Green Buildings

Brief Summary:
This control measure would increase energy efficiency and the use of onsite renewable energy—as well as decarbonize existing end uses—for all types of existing and future buildings. The measure includes policy assistance, incentives, diffusion of public information, and targeted engagement and facilitation of partnerships in order to increase energy efficiency and onsite renewable energy in the buildings sector.

Purpose:
This measure will reduce greenhouse gas (GHG) emissions, criteria pollutants and toxic air contaminants (TACs) associated with the operation of buildings.

Source Category:
Building energy use, including electricity and natural gas use.

Regulatory Context and Background:
The majority of the residential building stock was constructed prior to 1978, when the first statewide building energy-efficiency standards, Title 24, Part 6 of the California Building Code, were implemented. The California Energy Commission periodically updates these standards, however, the standards and their updates focus on new construction and alterations, leaving a large part of the building stock unaffected by these statewide requirements. There are approximately 2.8 million housing units in the Bay Area (ABAG/MTC 2013) and 70 percent of them were built prior to 1980 (U.S. BOC 2012). In order to meet this challenge, Governor Brown is making energy efficiency in existing buildings a pillar of the State's plan to reduce GHG emissions. Senate Bill 350, passed by the Legislature in September 2015, calls for a doubling of energy efficiency in existing buildings throughout the state.

According to state law, only the California Building Standards Commission can establish building standards, with energy-efficiency standards developed by the California Energy Commission. Air Districts do not have the legal authority to adopt or enforce building standards. However, cities and counties may adopt local ordinances that exceed state energy-efficiency standards under certain conditions. Many local jurisdictions in the Bay Area have adopted ordinances that require higher energy-efficiency standards than those under Title 24. These municipal ordinances largely focus on reducing energy use in new construction rather than mandating changes to existing buildings when a change in ownership or the structure itself would provide an opportunity to upgrade the properties. Some local jurisdictions have enacted voluntary efforts to improve energy efficiency and increase the rates of adoption for onsite renewable energy (e.g., solar photovoltaic systems). These programs have also helped offset participating buildings' demand for energy from nonrenewable sources to some degree. Some buildings have even been able to generate an energy surplus that utility companies have purchased based on rates set by state law. Local ordinances and programs that address energy efficiency in new construction are important, but existing buildings also need to be addressed in order to meet California's energy efficiency goal and the Air District's regional GHG reduction target.

Various financing options, including rebates and tax incentives, have led to wider adoption of energy-saving improvements and renewable-energy technology. On-bill financing of energy improvements has helped some California utility customers make improvements that immediately reduce their energy bill, which allows them to realize significant long-term energy savings and enjoy cost savings once they finish paying for their improvements in the near- to mid-term. Programs that provide public funding for private energy improvements, such as the Low-Income Weatherization Program (LIWP) or Bay Area Regional Energy Network (BayREN), help realize energy savings for many households and property owners who would otherwise be unable to afford it. BayREN is a collaboration of the nine counties, Association of Bay Area Governments, and the California Public Utilities Commission designed to implement scalable regional initiatives that deliver effective energy savings. BayREN programs include initiatives such as providing technical assistance to consumers and contractors to retrofit housing units, offering energy-saving rebates for the housing sector, and working with local agencies to enhance energy code compliance. To date, over 2,200 single-family homeowners in the Bay Area have participated in BayREN's Home Upgrade Initiative and completed their projects. More than 1,400 more have participated in its Assessment Incentive Initiative. To date, 15,896 multi-family units have completed the BayREN multi-family program that offers free technical assistance and rebates for energy-efficiency upgrades.

Another energy financing option is Property Assessed Clean Energy (PACE) programs. PACE programs are financing approaches that help residential and commercial property owners fund energy-efficiency upgrades, and on-site renewable-energy systems. Thousands of homeowners have used PACE to secure 100 percent upfront financing for building performance upgrades that are repaid over time through a voluntary special assessment on their property tax bill. All Bay Area counties are now participating in at least one of the PACE financing programs for single-family housing, which means that all homeowners in the Bay Area can apply for financing for energy improvements. Almost all Bay Area jurisdictions also have a multi-family and commercial PACE program available.

State laws and regulations, utility company policies and the choices made by utility consumers have helped to improve energy efficiency and the percentage of renewable energy in the region's energy mix. For example, in addition to increasing energy efficiency of existing buildings, Senate Bill 350 calls for a 50 percent renewable content in the statewide electricity mix by 2050. Rebate programs by utility companies combined with state and federal tax breaks have incentivized many utility customers to make energy-efficiency upgrades or replacements. This means that less electricity will be used to operate residential, commercial, institutional and industrial buildings in the future. Decarbonizing buildings by moving away from natural-gas appliances in favor of electric-powered end uses and stimulating the use of onsite renewable energy will help the region contribute to meeting the state's goal while reducing emissions of GHGs, TACs and criteria pollutants.

Implementation Actions:
The Air District will implement the following approaches to reduce building-related emissions.

Policy Assistance to Local Jurisdictions

- Develop or identify and promote best practices and model ordinances such as:
    - requiring energy assessments, building benchmarking and/or upgrades at time of sale;
    - requiring or incentivizing best practices such as: cool roofs and pavement; solar roofs; geothermal or electric heat pumps and solar water heating; streamlining, coordination and reduction of permit fees for energy efficiency/low carbon strategies; or use of green concrete and other low-energy building materials; and
    - implementing innovative development strategies, such as transferable development credits that limit the overall amount of conditioned space in an area.
- Engage local jurisdictions and the California Energy Commission to identify barriers to effective local implementation of Title 24 building energy code, and develop solutions to improved implementation/enforcement.
- Provide information and/or guidance on developing funding mechanisms (such as carbon fees) that generate revenue to reinvest in local climate protection programs.

Incentives

- Implement a $4.5 million grant program to, in part, facilitate implementation of green building efforts at the local level.
- Develop tools and incentives to facilitate PACE financing.
- Work with ABAG's BayREN program to make additional funding and other financial incentives available for energy-related projects in the buildings sector.
- Develop or identify and promote financing options for property owners and utility customers to implement energy-related projects (e.g., public agencies purchasing solar systems in bulk to secure discounts, working with state officials and county tax assessors to develop tax incentives).

Targeted Engagement and Partnerships

- Partner with KyotoUSA to identify energy-related improvements and opportunities for onsite renewable energy systems in school districts, and investigate funding strategies to implement upgrades.
- Explore opportunities to advocate at the state level to allow air districts to promulgate rules that establish green building standards that apply at a regional level.
- Engage with partners (e.g., BayREN) to target reducing emissions from specific types of buildings or certain geographic areas (e.g., neighborhoods with older homes that are most in need of upgrading).

Emission Reductions:

Pollutants*	2020	2030
ROG	7	30
NO_x	78	367
$PM_{2.5}$	12	53
SO_2	2	9
CO_{2e}	37,149	141,767

**criteria pollutants are reported in lbs/day; CO_{2e} is reported in metric tons/year (100-yr GWP)*

Emission Reduction Methodology:

Only actions that support energy efficiency were quantified in this control measure. Actions that support implementation of renewable energy programs and projects are considered supportive measures of control measure BL2: Decarbonize Buildings and are quantified under that control measure. Average participation rates for existing buildings are derived from local climate action plans, and then multiplied by the number of existing residential buildings. The same was done for new housing stock derived from ABAG's 2013 Projections for the years 2016 to 2030. Energy-use data in the residential sector, including average energy consumption by end use, were determined from a number of sources including the California Energy Commission (CEC), the United States Department of Energy (USDOE), (Residential Energy Consumption Survey (RECS) and the American Housing Survey/American Community Survey (AHS/ACS) (U.S. Census) reports. These figures were then multiplied by the most recent CO_2e emission factors from Pacific Gas and Electric (PG&E), assuming that California would meet its 2030 renewable portfolio standard of 50 percent.

Commercial participation rates were determined in a similar approach as the residential sector and were multiplied by the amount of commercial space available in the Bay Area. New regional commercial building stock was determined based on the anticipated number of new jobs multiplied by the current amount of square feet used by employees today. Commercial sector energy use data, including average energy consumption by end use in existing buildings and energy savings, were determined based on a number of sources including CEC, USDOE, and CBECS (U.S. Census) reports.

Saving energy will also reduce various criteria pollutants including NOx, ROG, $PM_{2.5}$ (all PM from domestic natural gas production is considered to be < 1 micron), CO and SO_2. Emission reductions were estimated for grid-sourced electricity from Bay Area power plants that was replaced by renewable energy (e.g., solar photovoltaics) using 2014 emission factors from PG&E.[1] Emission reductions associated with natural gas were also estimated using PG&E emission factors for 2014.

[1] Electricity imported from outside the region was not included in total electricity used to calculate criteria pollutant emission reductions because these emissions have no impact on regional air quality in the Bay Area.

Given that the majority of the implementation actions in this control measure are voluntary, emission reduction estimates for both 2020 and 2030 were revised down by 50 percent in order to conservatively estimate the impact of this control measure.

Exposure Reduction:
This measure could help to reduce exposure in impacted communities that are located near power plants, particularly "peaker plants," due to reduced production at these plants as a result of the reduction in electricity demand. In addition, decarbonizing area sources like furnaces, water heaters and woodstoves that rely on combustion will reduce the prevalence of particulate matter and TACs both in residential units and nearby.

Emission Reduction Trade-offs:
This control measure is designed to reduce energy consumption, so there would be no direct emission trade-offs. There might be an increase of indirect emissions associated with the production and delivery of some energy-efficient technologies.

Cost:
The cost of implementing the action items will be borne by public agencies, companies and individual households. Public agencies could also incur direct costs from directly financing programs aimed at improving energy efficiency or encouraging renewable energy projects. For example, Renewable Funding, one of the largest financing companies for PACE programs, estimates that every $10,000 provided by the Air District or other public entity to cover transaction costs would leverage approximately $250,000 in PACE financing for building owners. Local jurisdictions could forgo revenue by lowering certain fees or taxes intended to stimulate projects. Households would also incur upfront costs by investing in projects that boost energy efficiency or implement renewable energy for their homes, while accruing net savings over the long-term.

Co-benefits:
Increasing energy efficiency and onsite renewable-energy generation will result in a number of co-benefits, including:

- Improved air quality near power plants (due to reduced production)
- Increased reliability of power supply and cost
- Reduced capital costs for utilities by avoiding upgrades and expansions
- Energy savings, including savings by reducing distribution losses between power plants and the end user
- Financial savings for utility customers through reduced energy usage
- Green job creation (local manufacturers/suppliers/contractors for installing technologies)
- Increased property values
- More transparency and certainty in real estate market by allowing a prospective property owner to know the energy performance of a structure

Issues/Impediments:
Significant impediments to the voluntary approaches described in this measure are not anticipated. At the local level, jurisdictions may face resistance for some of the ordinances due to concerns about the cost of implementation. Significant impediments to implementation of the incentive-based components to this control measure are not anticipated apart from the availability of adequate financial resources.

Sources:

1. Association of Bay Area Governments (ABAG) and the Metropolitan Transportation Commission (MTC). 2013. *Plan Bay Area: Strategy for a Sustainable Region*. http://planbayarea.org/plan-bay-area/final-plan-bay-area.html.
2. BAAQMD. 2006. *Preparation of Emissions Inventories of Toxic Air Contaminants for the Bay Area*.
3. Bay Area Air Quality Management District. September 2010. *Bay Area 2010 Clean Air Plan.* http://www.baaqmd.gov/Divisions/Planning-and-Research/Plans/Clean-Air-Plans.aspx.
4. California Energy Commission (CEC). 2013. *California Energy Demand 2014-2025: Final Forecast.* Publication Number: CEC-200-2013-004-SF-V1.
5. California Energy Commission (CEC). 2013. *2013 Integrated Energy Policy Report*. Publication Number: CEC-100-2013-001-CMF.
6. California Energy Commission (CEC). 2015. *Existing Buildings Energy Efficiency Action Plan*. http://www.energy.ca.gov/ab758/documents/.
7. U.S. Bureau of the Census (BOC). 2012. 2008 – 2012 American Community Survey 5-Year Estimates, Table B25034; generated by Douglas Kolozsvari; using American FactFinder; http://factfinder2.census.gov; (27 January 2015).

BL2: Decarbonize Buildings

Brief Summary:
This control measure would reduce greenhouse gas (GHG) emissions, criteria pollutants and toxic air contaminants (TACs) by limiting the installation of space- and water-heating systems and appliances powered by fossil fuels. This measure will be implemented by developing model policies for local governments that support low- and zero-carbon technologies as well as potentially developing a rule limiting the sale of natural-gas furnaces and water heaters.

Purpose:
This measure will reduce GHGs, criteria pollutants and TACs associated with the burning of fossil fuels by limiting the sale and installation of natural gas furnaces, water heaters and appliances, and by encouraging the use of low- and zero-carbon technology alternatives throughout buildings in collaboration with local governments.

Source Category:
Area sources – fossil-fuel-powered furnaces, water heaters and appliances.

Regulatory Context and Background:
Residential and commercial building occupants often rely on natural gas to power furnaces, water heaters, stoves, and clothes dryers, making building-related combustion a significant contributor to GHG emissions and other air pollutants in the Bay Area. In 2010, there were almost 2.8 million housing units in the Bay Area and by 2040 the number of housing units is expected to exceed 3.4 million. Currently, the majority of residents in single-family homes and multi-unit residences use natural gas for space and water heating, and many households use natural gas for other end uses such as cooking and clothes drying. As a result, residential end uses are responsible for about two-thirds of regional GHG emissions directly emitted from buildings. The burning of fossil fuels in both residential and commercial buildings was responsible for approximately 12 percent of regional GHG emissions in 2015. In 2011, residential combustion was responsible for roughly 25 percent of total Bay Area fine particulate matter ($PM_{2.5}$) emissions. Residential combustion also generates a significant amount of nitrogen oxides (NOx) and carbon monoxide (CO) emissions. Fossil-fuel combustion in buildings also produces TACs including polycyclic aromatic hydrocarbons (PAHs) and formaldehyde, both of which have been identified as carcinogens.

Direct emissions from buildings can be eliminated by switching to renewable-energy technologies, or greatly reduced by switching to electricity, in order to heat space and water as well as to cook food and dry clothes. For example, ground-source heat pumps (GSHP) or air-source heat pumps (ASHPs) can replace natural-gas-powered central furnaces and wood-burning heating systems. The GSHP technology uses a heat-exchanging fluid flowing through a series of underground lines to heat and cool buildings. Since GSHP systems cool or heat a building using only the electricity needed to circulate the heat-exchanging fluid, they are highly energy efficient. ASHP technology works in a similar fashion using the ambient air, but tends to be less efficient than geothermal systems. Direct emissions associated with clothes drying could also be reduced with an increased prevalence of air-drying clothes.

Reducing emissions from water heating is also possible through the use of solar and electric water heaters. Solar water heater systems use the energy of the sun to directly heat water before the water is sent to a storage tank. This storage tank can be a traditional water heater or the system can be combined with electric tankless water heaters to ensure an adequate supply of hot water. A residential or commercial building that uses a GSHP or ASHP for space heating can use the excess heat captured with a de-superheater to heat the building's water.

Certain natural-gas appliances can also be supplanted by electric-powered alternatives. Induction stoves use electricity to generate a magnetic field that creates heat in the bottom of the cookware made with ferromagnetic material. This process results in less energy loss and faster cooking times. Induction also offers users greater control over cooking temperatures and therefore does not sacrifice the performance offered by gas stoves. In the case of drying clothes, gas dryers have long been touted as being more energy efficient than conventional electric dryers. However, gas dryers still use more energy than high-efficiency electric dryers. In addition, electric heat-pump dryers are the most efficient type of clothes dryer on the market. Using electricity for these end uses still results in some GHG emissions, as natural gas constitutes part of the energy fuel mix supplying the electricity used in the Bay Area. However, as the electricity mix continues to be less carbon-intensive, the GHG benefit of switching from natural gas to electricity end uses will increase.

Implementation Actions:

The Air District will:

- Explore potential Air District rule-making options regarding fossil-fuel-based space and water heating systems for both residential and commercial use.
- Develop or identify and promote model policies and best practices for local governments to restrict the use of fossil fuel-based furnaces, water heaters and natural-gas appliances in buildings and the promotion of air-drying clothes.
- Explore incentives for property owners to replace their furnace, water heater or natural-gas powered appliances with zero-carbon alternatives.
- Provide resources that inform building owners and tenants of the technical considerations, economic advantages and environmental benefits on low- and zero-carbon technologies such as renewable-energy systems (e.g., ground source heat pumps, solar water heaters) and electrical appliances (e.g., induction stoves, ENERGY STAR clothes dryers).
- Update the Air District's CEQA Guidelines to recommend that all commercial and multifamily developments install low-GHG technology, such as ground source heat pumps, solar thermal and solar hot water heaters, as a mitigation measure when project emissions are anticipated to have a significant impact on air quality or GHGs.
- Work with local jurisdictions to include low- and zero-carbon technologies in green building ordinances for all developments where it is technically feasible.
- Advocate for state regulation updates to encourage the development and installation of low/zero-carbon technologies.
- Support the development of financial incentives, such as low interest loan programs or tax

incentives that facilitate the installation of zero-carbon technologies.

Emission Reductions:

Pollutants*	2020	2030
ROG	14	54
NO_x	157	635
$PM_{2.5}$	25	98
SO_2	9	34
CO_{2e}	90,858	313,586

**criteria pollutants are reported in lbs/day; CO_{2e} is reported in metric tons/year (100-yr GWP)*

Emission Reduction Methodology:

Emission reductions are assumed to come from switching from natural gas or utility-provided electricity to renewable energy. There are four primary fuel-switching technologies that were quantified as part of this measure: solar photovoltaics, solar water heating, ground-source heat pumps, and air-source heat pumps. Participation rates for existing buildings are drawn from local climate action plans, and various reports on these technologies, and were then multiplied by the number of existing residential buildings for their respective target years. Segmentation for new housing stock was derived from ABAG's 2013 Projections for the years 2016 to 2030. Assumptions on energy savings came from a number of sources including CEC, USDOE, RECS and AHS/ACS (U.S. Census) reports.

Commercial participation rates were determined in a similar approach as the residential sector. Commercial sector energy use data, were determined based on a number of sources including CEC, USDOE, and CBECS (U.S. Census) reports. New regional commercial building stock was determined based on the anticipated number of new jobs multiplied by the current amount of square feet used by employees today. These figures were then multiplied by GHG emission factors from PG&E, assuming that California would meet its 2030 renewable portfolio standard of 50 percent.

With the replacement of natural-gas furnaces and water heating systems, various criteria pollutants will be reduced, including NOx, ROG, $PM_{2.5}$ (all PM from domestic natural gas production is < 1 micron), CO and SO_2. Emission reductions were estimated for grid-sourced electricity from Bay Area power plants that was replaced by renewable energy (e.g., solar photovoltaics) using 2014 emission factors from PG&E.[1] Emission reductions associated with natural gas were also estimated using PG&E emission factors for 2014.

Given that the majority of the implementation actions are voluntary, emission reduction estimates for both 2020 and 2030 were revised down by 50 percent in order to conservatively estimate the impact of this control measure.

[1] Electricity imported from outside the region was not included in the total electricity used to calculate criteria pollutant emission reductions because these emissions have no impact on regional air quality in the Bay Area. Criteria pollutant emission factors were from the year 2014.

Exposure Reduction:
This measure will reduce region-wide population exposure to criteria pollutants as building users switch from natural gas to low- and zero-carbon systems and appliances. It will also potentially improve indoor air quality by reducing exposure to TACs within buildings.

Emission Reduction Trade-offs:
This control measure is designed to reduce energy generated from fossil fuels. There might be an increase of indirect emissions associated with the production and delivery of some energy-efficient technologies. While the demand for electricity could rise with a switch from natural gas to some technologies (e.g., heat pumps), the carbon content of electricity will continue to diminish (due to the statewide Renewables Portfolio Standard and EN1: Decarbonize Electricity Generation), resulting in lower net emissions.

Cost:
Cost estimates for the various actions identified for this measure will be estimated during program implementation.

Co-benefits:
Ground- and air-source heat pumps are the most efficient types of heating systems currently available. These systems can also cool residential units and negate the need for dedicated air conditioning systems. This reduces the demand for peak power used to cool residential units in warm seasons, which could offset the need for "peaker" power plants and prevent rolling blackouts. Likewise, solar water heaters reduce the need to use electricity and natural gas to heat water.

Over the life of low- and zero-carbon systems and appliances, utility customers will realize significant cost savings. These savings exceed the marginal capital cost of these systems – thereby providing a long-term net economic benefit.

Eliminating sources of combustion from residential units can also reduce the incidents of carbon monoxide poisoning and fire-related injuries and deaths due to equipment failures, accidents and natural disasters.

Issues/Impediments:
Low- and zero-carbon technologies can require a greater upfront capital investment. However, they result in reduced operating costs over the lifetime of the investment. GSHPs are expected to have a long lifespan of 50 years or more, which lowers replacement costs. Some site-specific constraints could exist for certain types of low-carbon systems. GSHPs may not be feasible due to site-specific geological conditions. ASHPs generate more noise than other heating systems and have an exterior unit (similar to certain air conditioning units) that could dissuade some potential users due to aesthetics. In the case of solar water heating, a building's surroundings (e.g., tree cover) could affect solar exposure and the performance of a system. The cultural attachment to gas stoves and the cost of purchasing new cookware could affect the adoption of induction stoves.

Sources:

1. Association of Bay Area Governments (ABAG) and the Metropolitan Transportation Commission (MTC). 2013. *Plan Bay Area: Strategy for a Sustainable Region*. http://planbayarea.org/plan-bay-area/final-plan-bay-area.html.
2. BAAQMD. 2006. *Preparation of Emissions Inventories of Toxic Air Contaminants for the Bay Area*.
3. California Energy Commission (CEC). 2014. *Geothermal Heat Pump and Ground Loop Technologies*. Building Standards Office, Efficiency Division.
4. KEMA Inc. 2010. *2009 California Residential Appliance Study*. California Energy Commission. CEC-200-2010-004-ES.
5. Mullen, Nassim A., Jina Li and Brett C. Singer. 2012. *Impact of Natural Gas Appliances on Pollutant Levels in California Homes*. Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory.

BL3: Market Solutions

Brief Summary:
This control measure will facilitate market-based solutions to reduce greenhouse gas (GHGs), criteria pollutants and toxic air contaminants (TACs) emissions from existing residential, commercial, institutional and industrial buildings. The Air District aims to create a supportive environment for inventors, entrepreneurs, and private companies as they develop innovative solutions for building-related energy and the scaling of those interventions.

Purpose:
This measure will reduce GHGs, criteria pollutants and TACs associated with the operation of buildings.

Source Category:
Building energy use, including electricity and natural-gas use.

Regulatory Context and Background:
Existing buildings pose a significant challenge and opportunity to reducing emissions in the buildings sector. More than half of California's residential buildings and more than 40 percent of commercial buildings were built prior to California's adoption of its first energy standards in 1978 as part of the state's Title 24 building code. The Bay Area is the oldest urban area of California so it is not surprising that almost 70 percent of the Bay Area housing stock was built prior to 1980. Many of these buildings would require significant upgrades to bring their energy performance up to today's standards. Senate Bill 350, passed by the Legislature in September 2015, calls for a doubling of energy efficiency in existing buildings, yet state building energy-efficiency requirements only apply to existing structures if they undergo a major renovation or addition. Innovative market-based solutions that encourage owners and tenants to voluntarily improve the energy performance of the existing building stock could play an important role in the effort to achieve GHG reductions in the buildings sector.

Individual inventors, entrepreneurs and private companies have proven their ability to bring key energy-related innovations to market. Innovative solutions have developed in response to government regulations, or in response to market forces such as high energy prices. Regardless of the motivation, the role of the market is important in the development of new energy-saving solutions, the adaptation of existing technologies to the building sector, and the marketing or scaling up of a proven energy-related solution.

The state and the federal governments have played key roles in supporting market-based solutions for the building sector. Research grants, competitions and project funding have been provided for the development and commercialization of building-related technology that produces or saves energy. Each year, the Department of Energy's Energy Efficiency and Renewable Energy Office allocates hundreds of millions of dollars to building-related initiatives, programs and projects, including funding for private sector innovation. It also helps facilitate partnerships and business between private-sector actors. The California Energy Commission has provided millions of dollars more annually to enable the market to provide new or expanded solutions to energy-related challenges. Some public agencies also offer "calls for innovation" that seek the private sector's help in solving challenging energy-related problems that may currently be overlooked by the market or require incentives to develop potential solutions.

Implementation Action:
The Air District will consider issuing a call for innovation to support market-based approaches that bring new, viable solutions to significantly reducing GHG emissions associated with existing buildings.

Emission Reductions:
Emission reductions may be estimated during specific program implementation.

Emission Reduction Methodology:
N/A

Exposure Reduction:
This control measure could reduce exposure of building occupants to certain TACs and criteria pollutants by encouraging the adoption of green technologies that emit fewer pollutants and release fewer GHGs.

Emission Reduction Trade-offs:
Certain technologies may have emission reduction trade-offs. For example, a product that helps seal a house could reduce GHGs from heating and cooling the structure, but also contribute to increased indoor air pollutants. Potential trade-offs will need to be evaluated on a project- or program-basis.

Cost:
The primary cost of implementing this measure is the financial award associated with the call for innovation. The size of this award, or awards, will be determined.

Co-benefits:
This control measure has the potential to increase energy efficiency and onsite renewable energy generation, which will result in a number of co-benefits including:

- Improved air quality near power plants (due to reduced electricity demand/production)
- Reduced capital costs for utilities by avoiding upgrades and expansions
- Financial savings for utility customers through reduced energy usage
- Green job creation (local manufacturers, suppliers, contractors for installing technologies, other support services, etc.)
- Increased property values

Issues/Impediments:
No significant issues or impediments are identified at this time.

Sources:

1. U.S. Bureau of the Census (BOC). 2012. 2008 – 2012 American Community Survey 5-Year Estimates, Table B25034; generated by Douglas Kolozsvari; using American FactFinder; http://factfinder2.census.gov.
2. Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy. http://energy.gov/eere/buildings/emerging-technologies.

BL4: Urban Heat Island Mitigation

Brief Summary:
This control measure aims to reduce the "urban heat island" (UHI) phenomenon by increasing the application of "cool roofing" and "cool paving" technologies, as well as increasing the prevalence of urban forests and vegetation, through voluntary approaches and educational outreach.

Purpose:
The purpose of this control measure is to reduce greenhouse gas (GHG) emissions and the formation of ground-level ozone by mitigating the urban heat island phenomenon. Reducing UHI effects can reduce localized ozone levels, as well as emissions of particulate matter (PM), air toxics and greenhouse gases related to energy consumption associated with air conditioning. In addition, reducing UHI effects can help to offset impacts of temperature increases related to global warming.

Source Category Affected:
Electricity generation for buildings and evaporative emissions from automobiles.

Regulatory Context and Background:
As urban areas develop, natural, permeable surfaces and vegetation are replaced by impermeable structures and paved surfaces. This development transforms the area into a drier micro-environment, which absorbs, rather than reflects, the heat of the sun. Thus, UHIs are created, which can be up to 10°F hotter than natural background temperatures. Factors that contribute to UHI formation include the following:

- many man-made surfaces composed of dark materials that absorb and store the sun's heat;
- buildings, industrial processes, and motor vehicles that produce heat;
- loss of trees and vegetation due to urbanization causing a reduction in cooling from evapo-transpiration; and
- urban structures that form canyons that reduce ventilation and trap heat.

Elevated temperatures caused by UHIs can accelerate the formation of ground-level ozone, or smog, and can contribute to adverse health impacts, such as respiratory and heat-related ailments. Higher temperatures can also result in increased electricity use to cool buildings. Mitigation methods include judiciously increasing the reflectivity of built surfaces, such as roads, parking lots and rooftops, increasing tree-cover and other vegetation (for shading and the cooling effect of increased evapo-transpiration), and increasing ventilation.

Cool Paving
On average, about 12 percent of an urban city's land area is devoted to parking lots. This number can be even higher in suburban communities. The hottest pavements tend to be impermeable and dark in color, with solar reflectance values (albedo) under 25 percent. These pavements can heat to 150°F or more on hot days. Utilizing cool paving techniques, such as using coatings or paving mixes that increase the road surface's reflectiveness, can reduce this

temperature by 30°F or more. Many parking lots are resurfaced every 5-10 years. The amount of parking lot construction and re-surfacing that occurs in the Bay Area provides a significant opportunity to increase albedo (reflectivity) while providing ancillary benefits such as an extended life of the paved surface and storm water benefits associated with use of permeable pavement.

Cool Roofs

Most existing flat roofs have an albedo of 10 to 20 percent. These roofs absorb much of the remaining solar radiation and heat up the buildings they cover. Cool roofing technologies, such as lighter or more reflective paint, coatings, membranes, shingles or tiles, can increase a roof's albedo, on average, to about 50-60 percent. A 2000 study by Lawrence Berkeley National Laboratory revealed a 13-18 percent reduction in air conditioning-related electricity use in residential and commercial buildings in San Jose due to the application of cool roof strategies. While cool roofing reduces the need for air conditioning during periods of heat, it can have an opposite impact during periods of cold by reflecting solar radiation away from the buildings, potentially requiring an increase in heating during winter months. In most locations, the balance of these two effects results in a net reduction in energy use. However, in some locations, there may not be an energy-reduction benefit from the application of cool roof technologies. Implementation of cool roof technologies should take into account local climate conditions across the Bay Area and potentially include mitigation strategies (e.g., attic insulation) to reduce the amount of energy needed to heat these structures on cooler days.

Urban Forests

Planting trees through a comprehensive urban forestry program can mitigate urban heat islands by reducing the amount of the sun's energy absorbed and stored by pavements and roofs, and through transpiration – the process by which plants convert moisture to water vapor and cool the air. Choosing the right trees is critical in fostering urban forests that can benefit both air quality and the global climate. Deciduous trees that provide shade in the hotter summer months but lose their leaves in the cooler winter period can have a greater positive impact on energy use than evergreen trees. In addition, some trees emit high levels of volatile organic compounds (VOCs) whereas other trees emit few VOCs. Some tree species also require more water than others to establish, which could increase energy use for irrigation. While this control measure focuses on tree planting on parking lots, urban tree planting is addressed more broadly in control measure NW2: Urban Tree Planting.

The California Energy Commission oversees the regular updating of the State's Building Energy Efficiency Standards for Residential and Nonresidential Buildings. These Standards apply to new construction and alterations/remodels of existing buildings, and were most recently updated in 2013. The 2013 update included, in its prescriptive approach, standards for cool roofs. Standards for cool paving were not included. Under state law, local governments (cities and counties) can adopt local energy-efficiency requirements that are more stringent than the State standards. Since air districts have no direct authority to adopt building codes, this Air District's approach under this control measure is to work with local governments to adopt their own local ordinances and policies that complement the requirements set by the State.

Implementation Actions:

The Air District will:

- Develop and promote adoption of a model ordinance for "cool parking" that promotes the use of cool surface treatments for new parking facilities as well existing parking lots undergoing re-surfacing. This could include a combination of cool pavement and use of shade trees.
- Develop and promote adoption of model building code requirements for new construction or re-roofing/roofing upgrading for commercial and residential multi-family housing to accelerate implementation of and expand the number of roofs impacted by the State's Building Energy Efficiency Standards.
- Include cool roof, cool paving and parking lot tree shading as recommended mitigation measures in CEQA comments and guidance.
- Collaborate with expert partners such as LBNL to investigate the spatial and temporal variation in current and projected Bay Area temperatures and ozone levels, as well as the air-quality and other health benefits that could accrue from various urban cooling measures. Include Bay Area-specific heat vulnerability assessments in the analysis.
- Collaborate with expert partners such as LBNL to perform outreach to cities and counties to make them aware of cool roofing and cool paving techniques, having white roofs on their vehicle fleets, and of new tools available.
- Develop a geographically targeted public awareness campaign for urban cooling measures.
- Support adoption of more rigorous State energy standards for cool roofs by helping the California Energy Commission incorporate quantified air-quality benefits in cost-benefit analyses.
- See NW2 for proposed actions related to urban tree planting.

Emission Reductions:

Pollutants*	2020	2030
ROG	2	3
NO_x	16	31
$PM_{2.5}$	3	6
SO_2	1	3
CO_{2e}	12,831	14,512

**criteria pollutants are reported in lbs/day; CO_{2e} is reported in metric tons/year (100 yr GWP)*

Emission Reduction Methodology:

Emission reductions for this measure primarily focus on electricity demand for cooling buildings. The Air District's GHG inventory estimates indirect emissions for electricity use for both commercial and residential buildings to be 4.3MMT CO2e and 3.9 MMT CO2e per year in 2015, respectively. Title 24 energy-efficiency standards require some large commercial and residential buildings to install cool roofs. It was assumed that roughly 50 percent of new and existing commercial buildings and 30 percent of residential buildings would have a cool roof by 2030. Air conditioning accounts for roughly 15 percent of commercial electricity use and about

7 percent of residential use. It was assumed that cool roofs in the Bay Area would reduce air conditioning related electricity use by an average of 20 percent.

Due to the reduction of electricity used for cooling buildings, emissions of criteria pollutants are also expected to decrease. Emission reductions were estimated for grid-sourced electricity from Bay Area power plants only using current emission factors from PG&E[1]. All PM from domestic natural gas production-based electricity is considered to be < 1 micron and hence classified as $PM_{2.5}$. The energy reduction was assumed to be just from the implementation of cool roofs and not cool paving (which is harder to quantify), which makes the estimates more conservative.

Given that the majority of the implementation actions are voluntary, GHG emission reduction estimates for both 2020 and 2030, and criteria pollutant estimates for year 2020 were revised down by 50 percent.

Exposure Reduction:
This measure would help reduce smog formation by reducing the ambient air temperature, particularly in areas that experience excessive heat. It would be especially effective in reducing population exposure in those areas of the Bay Area that experience higher daily ambient temperatures and contain more impermeable surfaces exposed to sunlight, such as San Jose, Concord, the Tri-Valley and San Leandro/East Oakland.

Emission Reduction Trade-offs:
Caution would have to be taken in compiling the technology specifications to ensure that cool roofing and paving products that could produce toxic emissions during their use are not recommended. Trees can also contribute to emission increases. For example, some trees emit biogenic volatile organic compounds (BVOCs) that can contribute to ozone formation. The Air District will promote trees that emit fewer BVOCs.

Cost:
Cool roofs deflect some desired heat gain during the winter. In general, though, cool roofs result in net energy savings, especially in areas where electricity prices are high. Although costs will vary greatly depending on location and local circumstances, there is often no cost premium for cool roofs versus conventional roofing materials. However, in some cases, cost premiums can range from 1 to 20 percent (5 to 20 cents per square foot).

Co-Benefits:
Heat island mitigation measures bring a number of co-benefits to a community, including:

- Improved air quality
- Improved public health (lower risk of respiratory and heat-related ailments)
- Greater comfort
- Energy savings

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[1] Electricity imported from outside the region was not included in total electricity used to calculate criteria pollutant emission reductions because these emissions have no impact on regional air quality in the Bay Area.

- Financial savings through reduced energy usage
- Green job creation (local suppliers/contractors for installing technologies)

Trees in particular provide for numerous additional benefits that include:

- Sequestering carbon
- Improving water quality by reducing stormwater runoff, a major source of pollution entering wetlands, streams and the San Francisco Bay
- Reducing flood risk and recharged groundwater supplies from captured stormwater
- Making the streetscape more attractive for pedestrians and cyclists
- Providing wildlife habitat in the built environment
- Prolonging the useful life of sidewalks and pavement by reducing the daily heating and cooling and thus expansion and contraction of asphalt
- Increasing property values - research suggests that people are willing to pay 3 to 7 percent more for properties with ample trees versus few or no trees
- Offering social and psychological benefits by beautifying the landscape, promoting social interactions, providing stress relief and noise reduction, contributing to public safety and providing pleasure to humans

Issues / Impediments:

Advocating for local building code requirements that include cool roof standards for re-roofing/roofing upgrades may raise concerns about a potential increase in up-front costs among some stakeholders, such as the construction and development industries or local governments. Similar requirements for cool paving may also raise concerns due to a lack of information on the availability and sourcing of these technologies and products. By promoting and encouraging adoption of these types of policies, the Air District will facilitate demonstration of the actual cost benefits of such policies and work toward overcoming these barriers. It is possible that some local jurisdictions will not have the funding available to increase the number of trees in their communities.

Sources:

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2. Bay Area Air Quality Management District. June 2015. *Report on Advisory Council Activities January-May 2015: Impacts of the Urban Heat Island Effect on Energy Use, Climate, Air Pollution, Greenhouse Gas Emissions, and Health.*
3. California Energy Commission. http://www.energy.ca.gov/title24/coolroofs/.
4. Cool Roof Rating Counsel. http://www.coolroofs.org/coolroofing.html.
5. Gartland, Lisa Mummery. 2008. *Heat Islands: Understanding and Mitigating Heat in Urban Areas*. New York: Earthscan.
6. Levine, Kendra K. 2011. *Cool Pavements Research and Technology*. Preliminary research conducted for Caltrans's Division of Research and Innovation.
7. Li, Hui. 2012. *Evaluation of Cool Pavement Strategies for Heat Island Mitigation*. Doctoral dissertation. Civil and Environmental Engineering, University of California, Davis.

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11. Taha H. 2013b. Air-quality impacts of heat island control and atmospheric effects of urban solar photovoltaic arrays. Project Final Report prepared by Altostratus Inc. for California Energy Commission. http://energy.ca.gov/2013publications/CEC-500-2013-061/CEC-500-2013-061.pdf.

AG1: Agriculture Guidance and Leadership

Brief Summary:
This measure includes broad actions to reduce GHGs from the agriculture sector, including working to obtain funding for on-farm GHG reduction activities; promoting carbon farm plans; providing guidance to local governments on including carbon-based conservation farming measures and carbon sequestration in local climate actions plans and reducing conversion of agricultural lands to urban/suburban uses; and conducting outreach to agriculture businesses on best practices, including biogas recovery, to reduce GHG emissions.

Purpose:
The purpose of this measure is to reduce emissions of GHGs related to agricultural practices and preserve and enhance agricultural lands. This measure is also intended to emphasize and promote the opportunities for GHG capture, including carbon sequestration and biogas recovery, and the associated economic and environmental co-benefits.

Source Category:
Agricultural operations, including animal waste and soil tillage.

Regulatory Context and Background:
Reduce Emissions of GHGs Related to Agricultural Practices
The Bay Area has more than 8,500 agricultural operations on over 350,000 acres of productive agricultural land that provide a diversity of goods including fruits, vegetables, meat, dairy and wines. The $1.8 billion agriculture industry in the region provides jobs, contributes to the local economy, and offers other public benefits including scenic beauty, environmental value as undeveloped watersheds and wildlife habitat, and historic significance. Most agricultural operations in the Bay Area are small farms selling niche products locally, with relatively few large agricultural operations growing thousands of acres of product.

Sources of air pollution from agricultural operations can include on- and off-road trucks and farming equipment, agricultural aircraft, pesticide use, crop residue burning, animal waste, travel on unpaved roads and soil tillage. These sources can result in air pollution emissions such as ozone precursor emissions of nitrogen oxides and reactive organic gases, particulate matter (PM_{10} & $PM_{2.5}$), greenhouse gases (carbon dioxide, methane, and nitrous oxide), ammonia, hydrogen sulfides and nitrogen. While Bay Area agricultural operations contribute to air pollution levels in the region, their overall contribution is relatively small in comparison to other Bay Area sources. This measure will seek to reduce overall GHG emissions related to agricultural operations, and also promote opportunities to sequester CO_2 through carbon capture in the soil, and biogas recovery (from animal waste).

The majority (62 percent) of GHG emissions in the agriculture sector is associated with animal waste (methane from enteric fermentation and manure management). There are statewide programs addressing animal waste, but these programs are primarily focused on large-scale operations and thus have little impact on Bay Area farms.

The Air District's regulatory authority in the agricultural sector varies. The Air District does not have regulatory authority over soil management, but does have authority related to biomass burning (Regulation 5) as well as the potential to impose permit limits on emissions associated with animal waste (per Regulation 2-10). The Air District is pursuing limits on emissions associated with animal waste (see AG-4).

Prevent Conversion of Agricultural Lands
Over the past 50 years, a large amount of agricultural land has been converted to urban/suburban uses in the Bay Area, with losses of over one-third of farmland. Agricultural lands are currently under threat from development in the Bay Area. In addition to the loss of habitat, carbon sequestration, and other ecological benefits of agriculture, conversion of farmland to urban/suburban uses also results in higher emissions of GHGs, as urban/suburban land use is associated with greater emissions of GHGs and other air pollutants.

The state's Sustainable Agricultural Land Conservation Program (SALCP) aims to reduce GHG emissions through projects that support agricultural land conservation. The SALCP compliments investments made in urban areas through the purchase of agricultural conservation easements, development of agricultural land strategy plans, and other mechanisms to result in GHG emissions reductions.

In order to address open space and agricultural preservation, *Plan Bay Area* identifies Priority Conservation Areas (PCAs), which are open spaces that provide agricultural, natural resource, scenic, recreational, and/or ecological values and ecosystem functions. These areas are identified through consensus by local jurisdictions and park/open space districts as lands in need of protection due to pressure from urban development or other factors. Plan Bay Area includes a target to direct all non-agricultural development within the year 2010 urban footprint, which represents existing urban development and urban growth boundaries. The Air District can play a role in agricultural preservation through collaborating with the state's SALCP and through implementation of Plan Bay Area (See TR10: Land Use Strategies).

Implementation Actions:
The Air District will:

- Work with the agricultural community through existing organizations to obtain funding for on-farm GHG reductions activities. Research and track state, federal, regional, or private grant opportunities, including the availability of Cap and Trade funds for agriculture GHG reduction activities. Facilitate applications for Cap and Trade funds on behalf of farms in the Bay Area. Funding could target activities such as:
    - Demonstration projects (methane digesters, soil sequestration, land management best practices, other new technologies);
    - Preservation and/or acquisition of agricultural land;

  - Implementation of GHG reduction technologies/strategies specific to agriculture; and
  - Fostering emerging ideas/technologies.
- Track and participate in state level working groups formed to reduce GHG emissions from the agriculture sector, including the Dairy Digester Workgroup, the Bioenergy Interagency Workgroup, and the Interagency Workgroup on Local and Regional Land Use.
- Disseminate information on carbon-based farming techniques in the Bay Area. Develop guidance materials on carbon sequestration and carbon-based conservation farming techniques (complementary to and in support of NW1: Carbon Sequestration in Rangelands). This could include:
  - Updating the Air District's GHG Plan Level Guidance to include carbon-based conservation farming measures as components of a local climate action plan;
  - Providing information to local government staff on carbon sequestration and incorporating the potential for carbon capture into local climate actions plans. This includes how carbon sequestration may impact baseline emissions, what the emission reduction potential of carbon sequestration is, and how to incorporate carbon sequestration into a local GHG inventory;
  - Providing county-specific GHG reduction strategies and best practices specific to agriculture;
  - Identifying agriculture-related practices appropriate for climate action plans and local general plans (specific to each county); and
  - Providing county-specific goals for reducing agriculture-related GHG emissions which will align with any goals set at the state and Bay Area levels.
- Launch a public education/outreach campaign promoting the alternatives to and benefits of low-GHG diets.
- Explore the feasibility of matching Air District grant monies with Cap and Trade Funds to support the protection/acquisition of agricultural and natural lands as a GHG reduction action.
- Collaborate with the state's Sustainable Agricultural Land Conservation Program and counties that are implementing farmland protection projects to prevent premature land conversion resulting in higher GHG emissions, including through strategic grant making.
- Work with local governments to discourage conversion of agricultural and natural lands in PCAs identified in Plan Bay Area.

Emission Reductions:
Due to the voluntary nature of this measure, estimating potential emission reductions would rely on many assumptions and speculations, and is therefore not possible at this time.

Emission Reduction Trade-offs:
None identified.

Cost:

Costs would vary. Available resources would be determined through the Air District's budget process.

Co-Benefits:
Aside from reducing emissions of GHGs, full implementation of this measure has many environmental and economic co-benefits.

The measure promotes "carbon farm plans," which connect on-farm practices directly with ecosystem processes, including climate change mitigation and increases in on-farm climate resilience, soil health and farm productivity. Carbon farm plans seek to reduce GHGs from common agricultural practices, such as driving a tractor, and tilling the soil, while also promoting soil carbon sequestration to remove CO_2 from the atmosphere at a faster rate. In addition to reducing GHGs from the atmosphere, carbon farming provides economic benefits to farmers by increasing forage production, improving the soil quality, decreasing the risk of water and wind erosion and increasing nutrient and water availability for vegetation. Additionally, demonstration farms in Marin County have shown reduced water demand after an addition of compost was applied to grazed grasslands.

This measure will also promote the installation of anaerobic digesters on livestock farms and the use of the biogas these digesters produce. Benefits of biogas recovery, aside from reduced emissions of methane into the atmosphere, include cleaner air and water (pathogens are reduced through anaerobic digestion); enhanced nutrient management; reduced odors; stabilized organics; and importantly, a potential source of revenue or cost-recovery mechanism for farms. The revenue stream/cost recovery is from the recovered biogas, which can be used as a source for distributed energy generation in rural areas; to generate electricity or be used as fuel for boilers or furnaces; or to be sold as renewable fuel through a biogas pipeline or compressed natural gas. In addition, farmers could create revenue through the sale of energy or carbon credits from the implementation of biogas recovery systems. Biogas recovery systems also generate additional bi-products for use on farms, including animal bedding and high quality fertilizer.

This measure will promote the conservation and preservation of agricultural land, which will help to protect the Bay Area's regional food supply, as well as provide additional public benefits such as wildlife habitat and open space protection.

Issues/Impediments:
Due to the relatively small size of Bay Area agricultural operations, the implementation of GHG reduction activities requiring sizeable infrastructure investments such as biogas recovery systems may be economically limiting or infeasible.

Sources:
1. EPA's AgStar Program, http://www2.epa.gov/agstar/benefits-biogas-recovery.

2. NY Times, "A Price Tag on Carbon as a Climate Rescue Plan," http://www.nytimes.com/2014/05/30/science/a-price-tag-on-carbon-as-a-climate-rescue-plan.html?_r=0.
3. American Farmland Trust, Greenbelt Alliance, & Sustainable Agriculture Education, "Sustaining our Agricultural Bounty, an Assessment of the Current State of Farming and Ranching in the San Francisco Bay Area," http://www.sagecenter.org/wp-content/uploads/2009/05/sustaining-our-agricultural-bounty-an-assessment-of-agriculture-in-the-sf-bay-area_march-20111.pdf.
4. Marin Carbon Project, http://www.marincarbonproject.org.

AG2: Dairy Digesters

Brief Summary:
This measure will promote implementation of dairy digester facilities (also known as biogas recovery) at farms to capture methane as an energy source and to reduce methane emissions.

Purpose:
The purpose of this measure is to reduce emissions of methane, a potent greenhouse gas (GHG), and to promote associated economic and environmental co-benefits, by supporting expansion of dairy digesters.

Source Category:
Stationary sources – Dairies and electricity use

Regulatory Context and Background:
Biogas recovery provides farmers an opportunity not only to reduce methane emissions, but also to generate renewable energy and use it on-site, or sell it to generate revenue or recover costs. At this time, biogas systems across the country are capturing methane from farming operations and using it to generate renewable energy that provides enough power for the equivalent of almost 70,000 average American homes. For example, in Sacramento, the New Hope and Van Warmerdam dairies installed digester systems as part of a utility-sponsored project. These systems generate enough electricity to power roughly 500 single-family homes in Sacramento, while also capturing and destroying methane that would have otherwise been released into the atmosphere. In addition, dairy digesters can stabilize manure, reduce odor and flies, and produce byproducts that could be sold such as compost or bedding material.

The Bay Area has more than 8,500 agricultural operations on over 350,000 acres of productive agricultural land that provide a diversity of goods including fruits, vegetables, meat, dairy and wines. Most agricultural operations in the Bay Area are small farms selling niche products locally, with relatively few large agricultural operations growing thousands of acres of product. However, studies indicate that dairy digesters can be viable on small farms as well as large farms. An analysis conducted by the University of Wisconsin compared the per-cow electricity demands of different scale farms, and found that small dairies use more than twice as much electricity per-cow as their larger counterparts. There is therefore an incentive for small farm operations to utilize anaerobic digesters for on-site renewable energy. For example, a small, 200-cow dairy farm in Chaseburg, WI installed a “small-farm” digester created by the Universal Sanitary Equipment Manufacturing Company; this small scale dairy digester system, capable of serving a farming operation with as few as 100 cows, allowed the farm to recoup its investment within seven years.

The Air District’s Regulation 5 controls emissions related to biomass burning at agricultural facilities. The Air District currently does not have any regulations targeted at controlling methane emissions at agricultural facilities. At this time, the Air District is not proposing to pursue regulatory requirements to limit methane emissions at dairy facilities due to their small size, and the relatively small contribution to the overall GHG emissions inventory in the region (total agriculture emissions represent ~1.5 percent of total GHG emissions). However, the Air District is pursuing supportive actions to promote the implementation of dairy digesters, including working with the animal farming community to explore the feasibility of dairy digesters, to promote the many benefits, and to identify barriers to the widespread use of dairy digesting facilities.

Implementation Actions:
The Air District will:

- Work with the animal farming community to:
  - Explore the feasibility of biogas recovery/anaerobic digester systems at farms;
  - Promote the many benefits of anaerobic digester systems; and
  - Identify barriers to widespread use of anaerobic digesters throughout the Bay Area.
- Explore the feasibility of:
  - Creating a biogas pipeline to transport raw dairy biogas to either a centralized clean-up facility or directly to a utility;
  - Marketing digested solids for residential and commercial uses;
  - Negotiating and securing carbon credits; and
  - Organizing the co-digestion of dairy wastes with other waste streams.
- Research the number, size and location of dairy facilities throughout the Bay Area. Identify examples and case studies (if possible) where dairy digesters have been implemented at dairy farms similar in size to those in the Bay Area. Share information with farmers throughout the region.
- Participate in and track progress of the state's BioEnergy Interagency Workgroup and the State Dairy Digester Workgroup. Develop implementation measures for any strategies identified through these working groups that would be cost effective in reducing GHG emissions in the Bay Area.

Emission Reductions:
More information on the exact number and size of dairy or cattle operations within the Bay Area is needed to assess the potential emission reduction as a result of full implementation of this measure. However, case studies from dairy and/or cattle operations within California and other parts of the U.S. demonstrate significant reductions of methane emissions from implementation of digester systems.

Emission Reduction Methodology:
To be developed.

Exposure Reduction:
N/A

Emission Reduction Trade-offs:
None

Cost:
Establishing digester facilities, even small scale, will involve up-front costs to farmers. The Wisconsin example above indicates that current technologies could have relatively short payback periods. Costs can be reduced when offset by selling emissions credits through ARB's protocol for Livestock Projects within the Cap and Trade program, or by generating electricity to be used onsite.

Co-Benefits:
Benefits of biogas recovery via dairy digesters, aside from reduced emissions of methane into the atmosphere, include cleaner air and water (pathogens are reduced through anaerobic digestion); enhanced nutrient management; reduced odors; stabilized organics; and importantly, a potential source of revenue or cost-recovery mechanism for farms. The revenue stream/cost recovery is from the recovered biogas, which can be used as a source for distributed energy generation in rural areas, to generate electricity or be used as fuel for boilers or furnaces, or to be sold as renewable fuel through a biogas pipeline or compressed natural gas. In addition, farmers could create revenue through the sale of energy or carbon credits from the implementation of biogas recovery systems. Biogas recovery systems also generate additional by-products for use on farms, including animal bedding and high quality fertilizer.

Issues/Impediments:
It is not yet clear if the relatively small size of most Bay Area dairy operations will be a disincentive for implementation of dairy digesters. The feasibility of putting biogas into a regional pipeline network is unresolved and not fully understood.

Sources:

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2. US Department of Energy, http://energy.gov/eere/articles/energy-department-works-sacramento-municipal-utility-district-renewable-electricity.
3. Roberts, Guy, Intervale Innovation Center, "Small-Scale Manure Digesters: Potential for On-Farm Heat and Energy," http://www.uvm.edu/~cmorriso/AltEnergy/smallmanure.pdf.
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5. American Farmland Trust, Greenbelt Alliance, and Sustainable Agriculture Education, "Sustaining Our Agricultural Bounty: An Assessment of the Current State of Farming and Ranching in the San Francisco Bay Area," http://www.sagecenter.org/wp-content/uploads/2009/05/sustaining-our-agricultural-bounty-an-assessment-of-agriculture-in-the-sf-bay-area_march-20111.pdf.

AG3: Enteric Fermentation

Brief Summary:
This measure includes actions to engage the animal farming community in developing and implementing best practices to reduce methane emissions from enteric fermentation.

Purpose:
The purpose of this measure is to reduce emissions of methane, a potent greenhouse gas (GHG). The methane emissions from enteric fermentation comprise approximately 30 percent of total Bay Area agriculture GHG emissions, and approximately 0.5 percent of the total Bay Area GHG emissions.

Source Category:
Livestock

Regulatory Context and Background:
Livestock emit methane as part of their regular digestive processes; this is referred to as enteric fermentation. According to the US EPA, (nationwide) cattle emit more than 90 percent of the methane from livestock (other livestock animals include sheep, goats, and pigs). The amount of methane produced is influenced significantly by animal and feed characteristics, including the quantity of feed consumed, and the efficiency by which an animal converts feed to product (i.e., meat or milk).

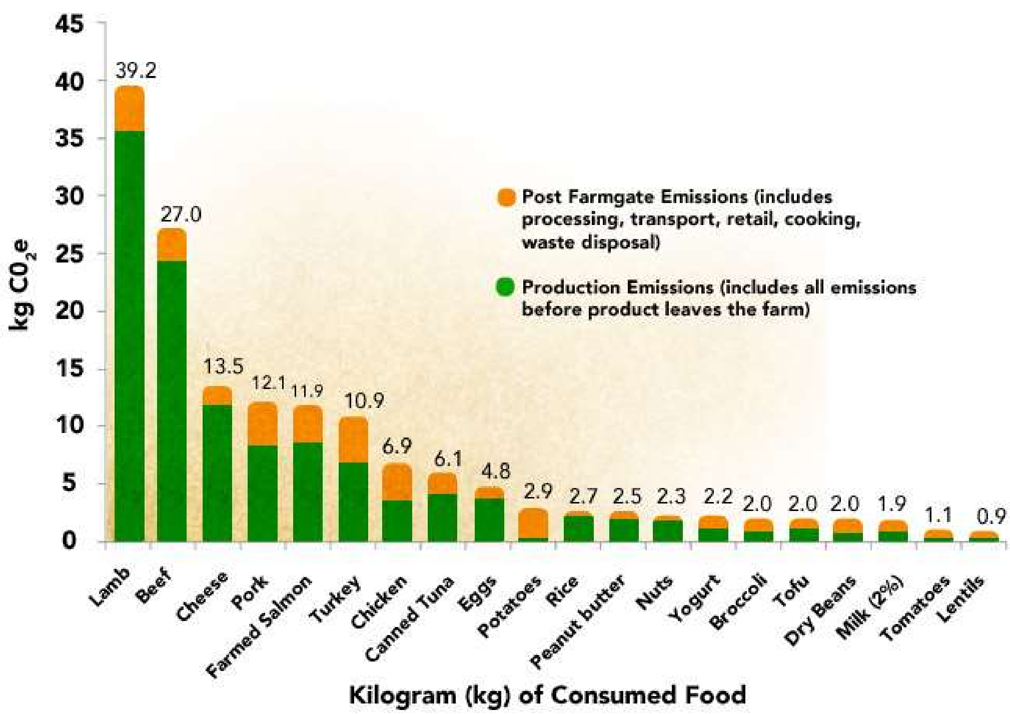
Improving animal productivity decreases methane emissions per unit of product. For example, if a cow produces more meat or milk, then meeting consumer demand is possible with fewer animals. In the US, the dairy industry has demonstrated the ability to improve productivity and therefore lower methane emissions. From 1960 – 1990, annual milk production increased by ten million tons with 7.4 million fewer cows, thereby reducing methane emissions (US EPA, Enteric Fermentation). Dairy and beef producers can increase production efficiency by implementing management techniques to improve animal nutrition and reproductive health. Feed that is tailored to the metabolic requirements of the animal and that can be digested efficiently results in a greater proportion of the energy consumed going towards production (e.g., milk) and less to waste and methane emissions.

Another strategy to reduce methane emissions is grazing management. According to the US EPA, implementing proper grazing management practices to improve the quality of pastures increases animal productivity and has a significant impact on reducing methane emissions. For example, "intensive grazing" involves rotating animals regularly among grazing paddocks, to maximize forage quality and quantity (unlike continuous grazing). This leads to more vigorous plant growth, healthier soils, and a more constant source of nutritious food for cattle.

Another method shown to reduce methane emissions from enteric fermentation is diet manipulation. Diet manipulation can reduce methane by decreasing the fermentation of organic matter in the rumen, allowing for greater digestion in the intestines – where less enteric fermentation takes place (Center for Climate & Energy Solutions, Enteric Fermentation Mitigation). Research has shown that increasing animal intake of dietary oils helps to curb enteric fermentation *and* increase yields of product by limiting energy loss due to fermentation. Studies have found that added dietary oils (such as cottonseed, sunflower, or coconut) can decrease methane emissions from enteric fermentation by 6-22 percent.

The Air District recently conducted a consumption-based GHG emissions inventory for the Bay Area. The inventory indicates that food choices can significantly influence household GHG emissions. Reducing consumption of beef and/or dairy products would involve changes in consumer behavior, and could lead to reductions in methane emissions from enteric fermentation. Choosing other meat products such as turkey or chicken, or non-meat protein such as lentils, has been found to be much less GHG-intensive than beef (see Figure 1). Practices such as switching to vegetarian or vegan meals one or more days a week would contribute to lowering the GHG intensity of diets. Additionally, there are other environmental co-benefits from reducing consumption of beef and dairy products. Research has shown that beef production requires 28 times more land, 11 times more irrigation water, and produces 5 times more GHGs, and 6 times more nitrogen on average than other livestock categories such as poultry.

Figure 1: Full Lifecycle Greenhouse Gas Emissions from Common Proteins and Vegetables (Source: Environmental Working Group, Meat Eater's Guide to Climate Change + Health



Implementation Actions:

The Air District will:

- Collaborate with appropriate state agencies and working groups and engage the animal farming community in developing and implementing best practices to reduce methane emissions from enteric fermentation. Specific tasks may include:
  - Collaborate on a literature review and/or additional research to further determine the effectiveness of dietary strategies, grazing management, and other techniques in reducing methane emissions from enteric fermentation; and
  - Identify and circulate best practices to the agriculture community.
- Engage the public to provide information on the GHG emissions associated with beef and/or dairy, and on the environmental benefits of choosing other sources of protein (such as chicken, turkey, or non-meat foods).

Emission Reductions:

This measure focuses on engaging the public and the animal farming community in a discussion about reducing GHG emissions associated with enteric fermentation. Estimating emission reductions would rely on many assumptions and ensuring an acceptable level of accuracy would be difficult.

Emission Reduction Methodology:

See above.

Exposure Reduction:

N/A

Emission Reduction Trade-offs:

No emissions reduction trade-offs are identified at this time.

Cost:

This measure focuses on outreach and education regarding livestock diet and consumer habits. More research would need to be conducted to determine if changes to feed or feeding practices would involve any significant costs.

Co-Benefits:

Improving efficiency of feedstock and production to reduce methane emissions from enteric fermentation could provide economic benefits to farmers. According to the Climate and Land Use Alliance, improving forage and feed processing, as well as providing supplements (such as lipids, nitrates, ionophores, and growth hormones) are win-win opportunities (due to increased productivity) for farmers in most livestock systems, and have significant greenhouse gas emission reduction potential. Reducing consumption of beef or dairy, while politically difficult, has a number of co-benefits. Aside from reduced methane from both enteric fermentation and animal waste, there are a number of other environmental co-benefits including reduced deforestation, reduced impacts from overgrazing, improved water quality (and reduced water demand), and reduction in impacts from nitrogen fertilizer.

Issues/Impediments:
It is not anticipated that there would be significant impediments due to the voluntary nature of this control measure.

Sources:

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AG4: Livestock Waste/Confined Animal Facilities

Brief Summary:
This control measure includes actions to reduce particulate matter (PM), ammonia, and organic emissions from livestock waste by requiring best management practices already being implemented in the San Joaquin Valley Air Pollution Control District (SJVAPCD) and South Coast Air Quality Management District (SCAQMD) to be applied at Bay Area dairies and other confined animal facilities (CAFs).

Purpose:
Reduce PM, volatile organic compounds (VOC), methane, and ammonia emissions from livestock facilities (feedlots, dairies, and poultry facilities) operating in the Bay Area.

Source Category:
Area Source – confined animal facilities

Regulatory Context and Background:
California law and Air District regulations have historically exempted many agricultural sources of air pollution from obtaining air quality permits, or complying with most air quality regulation. This exemption was revoked in 2003 with the passing of Senate Bill 700 (SB 700), which requires air districts to adopt regulations for large CAFs and amends air pollution control requirements of the California Health and Safety Code related to agricultural sources of air pollution, effective January 1, 2004. As a result, SCAQMD Rule 1127 was adopted in August of 2004 to implement best management practices to reduce emissions of ammonia, VOC and PM_{10} from livestock waste from dairies. In April of 2005, SCAQMD also amended Rule 403 to require applicable conservation management practices for the remaining CAFs. In 2006, the Air District adopted Regulation 2, Rule 10 (Rule 2-10) on Large Confined Animal Facilities, in accordance with SB 700 requirements. However, Rule 2-10 did not result in emission reductions since no Bay Area CAFs met the size applicability requirements.

SCAQMD Rule 1127 requires best management practices to reduce emissions of ammonia, VOCs and PM_{10} from livestock waste regardless of the animal facility size. SCAQMD Rule 223 establishes mitigation requirements as part of the permitting process for large confined animal facilities. Reducing pH level in manure through the application of acidifiers is one of the potential mitigations for ammonia included in the rule. Specifically, sodium bi-sulfate (SBS) is considered for use in animal housing areas where high concentrations of fresh manure are located. SBS can also be applied to manure stock piles and at fence lines and upon scraping manure to reduce ammonia spiking from the leftover remnants of manure and urine. SBS application may be required seasonally or episodically during times when high ambient $PM_{2.5}$ levels are of concern.

SJVAPCD adopted Rule 4570 in June of 2006, addressing the same facilities addressed by SB 700. At the time, Rule 4570 represented the most stringent emissions regulation for CAFs in the nation and identified handling of solid and liquid animal waste as the largest source of VOC emissions at CAFs, based on the prevalent research findings of the time. Current research indicates a significant portion of VOC emissions are attributable to handling of feed and silage (fodder preserved through fermentation in a silo). Additionally, a greater variety of dairy practices are found in the large CAFs in SJVAPCD than are found in the smaller Bay Area CAFs. In October of 2010, Rule 4570 was amended to provide better clarity in its definitions, to lower the exemption limits based on facility size (milking cows and poultry reduced from SB 700 values down to: 500 milking cows; 4000 chicken or ducks; and all other limits unchanged), and to provide greater flexibility for dairy and feedlot facilities to meet emission reductions. For poultry operations, mitigation measures were changed from a menu of options to mandatory measures in order to address EPA concerns regarding enforceability and efficacy.

Air District Rule 2-10 defines a large CAF by size limits consistent with SB 700 (1,000 milking cows; 3,500 beef cattle; 7,500 calves, heifers or other cattle; 100,000 turkeys, 650,000 chickens, laying hens, or ducks; 3,000 swine, 15,000 sheep, lambs or goats; 2,500 horses; 30,000 rabbits or other animals). This regulation requires that CAFs at or above these size limits obtain a permit to operate and implement control measures to reduce emissions of VOC, NOx, and PM_{10} from the facility. The rule allows the Air District's Air Pollution Control Officer (APCO) to establish a reasonable compliance schedule for facilities to implement these measures within one year of the date on which the permit is issued. Currently, the Air District does not provide a list of control measures that are applicable under this regulation. Based on the Air District's review of USDA census data, no facility in the Bay Area currently meets the applicability requirements of Rule 2-10, due to the smaller size of CAFs in the Bay Area.

In general, the facilities in the Bay Area are far smaller than the exemption limits found in SJVAPCD Rule 4570. According to the California Agricultural Statistics Review for 2012, there are approximately 100 dairies in the San Francisco Bay Area with an average herd size of 350 milking cows. In addition to milking cows, the Bay Area also supports a small stock of chicken, turkey, goat, and swine farms. Ongoing research by Air District staff will determine the number of facilities in operation and the average amount of livestock being supported at these facilities. Most of these dairies and other facilities are located in Sonoma and Marin Counties with a smaller number in Alameda, Contra Costa, Napa, San Mateo, Santa Clara, and Solano Counties.

Implementation Actions:

The Air District will

- Further investigate the number and size of CAFs in operation in the Bay Area, and quantify the ammonia and methane emission reduction potential for this industry.
- Evaluate research conducted in support of 1) SJVAPCD rule development efforts with regard to feed and silage handling, and 2) SCAQMD rule development efforts with regard to livestock waste emission reductions.

Emission Reductions:

Pollutants	2020	2030
ROG	400	400

**criteria pollutants are reported in lbs/day*

Emission Reduction Methodology

Bay Area emissions from all livestock sources (cattle, poultry, pigs, etc.) were estimated to account for 4,960 pounds/day of PM_{10}, 110,400 pounds/day of total organic gases (TOG), 4,620 pounds/day of reactive organic gases (ROG), and 7.21 tons/day of ammonia in 2011. In addition, livestock within the Air District's jurisdiction were estimated to emit 19,568 metric tons of methane per year by a recent study (LBNL, 2015). In fact, livestock is the second-highest emitting source category for methane, and a major source category for ammonia in the Bay Area. Adoption of VOC mitigation measures mandated by SJVUAPCD Rule 4570 for medium-size dairies is estimated to reduce ROG by approximately 400 pounds/day in the Bay Area. Since the number of dairy cows in the Bay Area is relatively small, additional emission reductions could be obtained when applying best practices to other livestock sources with a greater population such as non-dairy cattle. In addition, the emission reduction potential for methane and $PM_{2.5}$ may be significant and needs to be further investigated.

Emission Reduction Trade-Offs:

None

Costs:

The annual cost to adopt mitigation measures similar to those required by SJVAPCD Rule 4570 is estimated at approximately $20 per cow for medium-size dairies. For an average dairy in the Bay Area that houses 350 dairy cows, the implementation cost is estimated at $7,000 per year.

Co-Benefits:

None

Issues/Impediments:

The best management practices developed under the SJVAPCD rule were developed through a collaborative effort with affected parties in the SJVAPCD, and were supported by most industry representatives. Facilities in the Bay Area are much smaller, and thus costs of operation would probably be higher. Collaboration with local industry representatives will be necessary to tailor control efforts to best meet local conditions and to thereby reduce opposition from affected facilities.

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5. SCAQMD Rule 403: Fugitive Dust. Amendment proposal Memo under Agenda Item 40, June 3, 2005.
6. SCAQMD Rule 1127: Emission Reductions from Livestock Waste, Final Staff Report, dated 8/6/2004.
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NW1: Carbon Sequestration in Rangelands

Brief Summary:
This control measure would increase carbon sequestration in rangelands across the Bay Area by providing technical and research assistance to local governments, regional agencies and private owners of rangelands.

Purpose:
Encouraging good soil management and enhancement practices will increase the uptake and sequestration of carbon dioxide (CO_2) by the soils and vegetation of these habitats.

Source Category:
Area sources - rangelands

Regulatory Context & Background:
Nearly 2.8 million acres in the Bay Area, approximately two-thirds of the region's land mass, are undeveloped lands. Forested and woodland areas make up nearly 50 percent, grasslands over one-third and shrub lands composed of chaparral and coastal shrub make up the remaining nearly 15 percent. Approximately two-thirds of these undeveloped areas (some 1.9 million acres) function as rangelands, lands that produce vegetation suitable for livestock grazing.

Some 70 percent of the rangelands in the Bay Area (about 1.35 million acres) are privately owned. In addition, approximately 26 percent of the rangelands (nearly 500,000 acres) are permanently protected from development through conservation easements, or through outright purchase of a property for conservation purposes.

To understand the role rangelands play in carbon sequestration, it is critical to understand the carbon cycle, the role of soils in this cycle, and what carbon sequestration is. Carbon is found in all living organisms on Earth and exists predominately as plant biomass, soil organic matter, and CO_2 in the atmosphere and dissolved in seawater. Carbon sequestration is the storage of carbon in oceans, soils, vegetation, and geologic formations. Although oceans store most of the Earth's carbon, soils contain approximately 75 percent of the carbon pool on land, three times more than the amount stored in living plants and animals. Through photosynthesis, plants absorb and store atmospheric carbon as they grow. Some portion of this carbon migrates from plant roots into the surrounding soil in other organic forms; this carbon can remain in the soil, i.e., become sequestered in the soil, to varying degrees depending on how the soil and vegetation is managed. As such, rangelands, and other ecosystems such as forestlands, play a critical role in sequestering carbon at a global scale.

In agricultural systems, the amount and length of time carbon is stored is determined predominately by how the soils are managed. One practice that has been found to increase carbon storage is the addition of organic matter, and compost in particular, to agriculture and/or rangeland soils. The addition of compost results in the slow release of fertilizer to the soils as the compost decomposes, and improved soil moisture conditions; both result in increased plant production. In turn, more plant growth leads to more CO_2 being removed from the atmosphere through photosynthesis and thus more CO_2 being transferred (i.e., sequestered) through the plant to the soil as roots and detritus.

The Marin Carbon Project (MCP) has conducted extensive studies of the effects of organic matter soil amendment. MCP is a consortium of the leading agricultural institutions and producers in Marin County, university researchers, county and federal agencies, and nonprofit organizations seeking to understand and demonstrate the potential of enhanced carbon sequestration in Marin's agricultural and rangelands soils. Beginning in 2006, MCP launched an intensive research effort to determine if the application of compost on grazed rangelands could increase the land's carbon-sequestering ability.

Results from MCP's work indicate that a single application of a half-inch layer of compost on grazed rangelands significantly increases plant growth (by 40 to 70 percent), and increases soil water holding capacity. Modeling results further indicate that soil carbon sequestration could increase by at least 0.4 metric tons (MT) per acre annually for 30 years without re-application. Scaling up from MCP's results indicates that applying compost at this rate on 50 percent of the rangeland area in California could offset 42 million metric tons (MMT) of CO_2e annually, an amount equivalent to the annual GHG emissions from energy used by the commercial and residential sectors in California.

Other studies have confirmed that amending rangelands and other managed lands with compost and other organic materials increases carbon sequestration of these lands. For example, studies in California coastal and valley grasslands found that adding compost resulted in annual sequestration rates after three years ranging from 0.2 to 1.7 MT CO_2e per acre. Scaling up to 5 percent of California's rangeland, these sequestration rates would mitigate between 0.7 and 4.7 MMT CO_2e annually. A recently released study (Ryals et. al, 2015) based on field data and modeling indicates that sequestration rates ranged from 0.51 to 0.67 MT CO_2e per acre annually when assessed over a 10-year time period and 0.25 to 0.38 MT CO_2e per acre annually over a 30-year time period. Some of the variability noted was ascribed to the carbon-to-nitrogen ratio of the amendments (amendments with lower carbon-to-nitrogen ratios resulted in higher sequestration rates over time) and the application rates (i.e., single or multiple applications). Nevertheless, in all cases all compost amendment scenarios analyzed led to net GHG sinks that persisted for several decades.

Implementation Actions:
The Air District will:
- Include off-site mitigation of GHG emissions through carbon-sequestration projects using the MCP GHG reduction protocol in Air District CEQA guidance and comments, and the CAPCOA GHG Reduction Exchange or other third-party protocols approved for use by the Air District.
- Work with the MCP, resource conservation districts, and local farms to apply compost amendments on grazed grasslands and rangelands across the Bay Area.

- Develop climate action plan guidance and/or best practices on soil management for local agencies and farmers and their associations to maximize GHG sequestration on rangelands.

Emission Reductions:

Pollutant*	2020	2030
CO_{2e}	16,667	57,500

** CO_{2e} is reported in metric tons/year (100-yr GWP)*

Emission Reduction Methodology:
Table 1 displays the total amount of carbon that would be expected to be sequestered (as a range in MMT CO_2e) on rangelands if various percentages of rangelands in the nine-county Bay Area (total of approximately 1.9 million acres) received soil amendments. These estimates are based on extrapolations of the results from the studies described above.

Table 1. Expected range of total carbon sequestration (MMT CO_2e) with soil amendment over specific time period

	Percent of total rangeland in Bay Area amended			
	10%	25%	50%	100%
Over 3 years	0.1 – 0.9	0.3 – 2.4	0.7 – 4.7	1.4 – 9.5
Over 10 years	1.0 – 1.3	2.4 – 3.2	4.9 – 6.4	9.8 – 12.8
Over 30 years	1.4 – 2.2	3.5 -5.4	7.0 – 10.8	14.1 – 21.7

Emissions reductions were determined by using the midpoint value of expected carbon sequestration from the 10 percent of total rangeland amended column in the Table above and assumed that 1 percent of all rangelands were amended by 2020 and 5 percent by 2030. Specifically, for 2020, the midpoint value of total expected carbon sequestered over three years (0.5 MMT CO_2e) was divided by 10 (equal to 1 percent of all rangelands), while for 2030, the midpoint value of total expected carbon sequestered over 10 years (1.15 MMT CO_2e) was divided by 2 (equal to 5 percent of all rangelands). Both values were then converted into a per-year estimate of CO_2e reductions by 2020 and 2030.

Exposure Reduction:
This measure will reduce CO_2 in the atmosphere by sequestering CO_2 into rangelands and other managed agricultural lands.

Emission Reduction Trade-Offs:
Adding compost to rangelands can result in the release of other GHGs, nitrous oxide (N_2O) in particular, from these same amendments. Ryals et al. (2015) found that amendments with lower carbon-to-nitrogen ratios, which resulted in higher sequestration rates, also experienced greater N_2O fluxes. In addition, multiple smaller compost additions resulted in lower cumulative N_2O emissions, but also a time lag in sequestration. These results demonstrate that there is a trade-off between maximizing carbon sequestration and minimizing N_2O emissions following addition of soil amendments. Therefore, potential increases in the emission of these other GHGs should be considered when managing agricultural lands for carbon sequestration.

Cost:
Cost estimates will be further developed during program implementation.

Co-Benefits:
Removing CO_2 from the atmosphere is only one significant benefit of enhanced carbon storage in soils. Improved soil and water quality, decreased nutrient loss, reduced soil erosion, increased water conservation, and greater crop production may result from increasing the amount of carbon stored in agricultural soils. In addition, diverting manure, yard and food wastes to composting systems can lead to significant GHG offsets.

Issues/Impediments:
Successful implementation of this measure would require adequate availability of appropriate sources of composting material.

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NW2: Urban Tree Planting

Brief Summary:
The control measure promotes the planting of trees in urbanized settings to take advantage of the myriad benefits provided by these trees, including: shading to reduce both the "urban heat island" phenomenon and the need for space cooling, and the absorption of ambient criteria air pollutants as well as carbon dioxide (CO_2).

Purpose:
The purpose of this control measure is to reduce criteria pollutants and GHGs by promoting the planting of trees in urban settings. These efforts will also serve to mitigate the urban heat island phenomenon and lower cooling and heating energy costs.

Source Category:
Area sources – urban trees

Regulatory Context & Background:
In urban areas, where buildings and paved surfaces have replaced the natural landscapes, solar energy is absorbed into roads and rooftops, causing the surface temperature of urban structures to increase and radiate heat. These higher temperatures in turn lead to higher overall ambient air temperatures, a phenomenon known as the "urban heat island." The average ambient temperature of an urban center can be 2-5 degrees Fahrenheit higher than surrounding areas. This difference can be more pronounced at night as urban infrastructure continues to slowly release heat well into the evening, with a potential temperature increase over surrounding areas of as much as 22 degrees Fahrenheit (USEPA 2015).

The resulting higher temperature caused by the urban heat island has numerous effects with air quality implications, including:

- With increased temperatures, there is increased demand for cooling-related energy use in commercial and residential buildings. The increased electricity generation required to meet the increased demand for energy leads to increased emissions of numerous pollutants at power plants, including SO_2, CO, NO_x, and PM, as well as CO_2.
- The increased temperatures in these settings can accelerate the formation of smog, as ozone precursors (i.e., NO_x and VOCs) react with increased temperatures to produce ground level ozone.

Numerous studies have shown that increasing the tree canopy in an urban setting can provide various environmental and economic benefits, including ameliorating the urban heat island effect. Details on these benefits are provided below.

Carbon sequestration

Trees absorb CO_2 from the atmosphere during photosynthesis and store this carbon as biomass.[1] The rate at which carbon is absorbed, and then released through decay and decomposition, varies based on numerous factors, including tree species and local environmental conditions. It is estimated that U.S. urban trees and forests store 2,358.4 million metric tons (MMT) CO_2 and sequester a net total of 69.3 MMT CO_2 per year (Nowak et al. 2013a). This same analysis estimated that California urban trees store 115.1 MMT CO_2 and sequester nearly 4.3 MMT CO_2 annually. An analysis of street trees in California (a subset of all urban trees) indicates that California's 9.1 million street trees store 7.78 MMT CO_2 and sequester 567,758 MT CO_2 annually (McPherson et al. 2014). At a more local scale, net sequestration by the 6.6 million urban trees in the San Francisco Bay Area was calculated at 696,686 MT CO_2 annually (McPherson et al. 2010). Even finer scale studies found that Berkeley's 36,485 municipal trees sequester 3,025 MT CO_2 annually and that the approximate 669,000 trees in the San Francisco urban forest sequester some 19,067 MT CO_2 annually (Nowak et al. 2007, McPherson et al. 2010).

Reduction in Pollution Concentrations

Trees reduce ambient concentrations of criteria pollutants as well. Trees absorb pollutants such as ozone, NO_2 and SO_2 primarily through leaf stomata as well as on plant surfaces and bark pores. In fact, the U.S. EPA has recognized tree planting as a measure for reducing ozone in state implementation plans. Trees affect ambient concentrations of PM by intercepting small airborne particles, which deposit on trees' leaves, twigs and bark.

Table 1 summarizes the findings from various analyses and modeling studies of the rate of annual ambient pollution removal of various criteria pollutants by urban trees. As indicated in the table's note, these studies use the percent of the urban landscape covered by trees (i.e., percent tree cover) in their calculations of the emission reductions achieved by these trees.

Table 1. Metric tons of air pollution removal by urban trees annually

	O_3	PM_{10}	$PM_{2.5}$	NO_2	SO_2	CO	*Source*
Conterminous United States	523,000		27,000	68,000	33,000		Nowak et al. 2014
	305,100	214,900		97,800	70,900	22,600	Nowak et al. 2006
San Jose	305	243		188	28	34	
San Francisco	80	107		63	12	15	
	83	84		45	13	11	Nowak et al. 2007
			5.5				Nowak et al. 2014, Nowak 2014

The percent of tree cover in each study varied as follows: from 11.9 percent (Nowak et al. 2007) to 27 percent (Nowak et al. 2006) to 34.2 percent (Nowak et al. 2014) to 36.1 percent (Nowak 2014 and Nowak et al. 2014).

[1] This discussion distinguishes between the amount of carbon trees absorb from the atmosphere each year ("to sequester") and the amount of carbon that is contained in the trees' biomass ("to store").

Lastly, urban trees can lead to lower evaporative emissions. Specifically, by shading asphalt surfaces and parked cars, trees serve to reduce hydrocarbon emissions (i.e., ozone precursors) from gasoline that evaporates from leaky tanks and hoses.

Reduction in Ambient Temperatures
One of the functions performed by trees in urban settings that is most easily recognizable is the shade these trees provide to outdoor areas, buildings and urban structures such as sidewalks and parking lots. This shade has the direct effect of lowering ambient temperatures; these lower temperatures result in less ozone formation. Moreover, trees directly cool the air through transpiration – the evaporation of water from plants.

Energy Savings
If appropriately placed around buildings, trees can lower the energy demands for heating and cooling from these buildings, leading to energy savings. Specifically, the lower temperatures resulting from shade trees can reduce the energy demands to cool structures on hotter days. These energy savings are particularly critical when they occur at the hottest time of the day and thus reduce peak energy consumption. In addition, trees can provide for energy savings in the winter. Specifically, by reducing wind speed, trees can mitigate the infiltration of outside air into interior spaces. In this manner, trees can lower the heat loss from cool winter winds, resulting in heating savings.

The energy savings provided by trees throughout the year can be substantial. A study of all of California's 177 million trees found that these trees reduce annual electricity used for cooling by 6,407 gigawatt hour (GWh), enough energy to power 730,000 homes (McPherson and Simpson 2001). Similarly, California's 9.1 million street trees are estimated to save 684 GWh of electricity annually, equal to the amount of energy required to air condition 530,000 households in California each year (McPherson et al. 2015). Similarly, the 6.6 million existing urban trees in the San Francisco Bay Area are estimated to provide annual energy savings valued at $327 million (reported in McPherson et al. 2010). Likewise, an analysis of the 36,485 municipal trees in Berkeley found a citywide annual energy savings of $553,066 ($15.16/tree), 17 percent from winter heating and 83 percent from summer air conditioning (McPherson et al. 2010). Specifically, annual electricity use for air conditioning was reduced by 3,469 megawatt hour (MWh) ($12.58/tree) and annual savings of natural gas for heating was 7,209 million British thermal units (MBtu) ($2.58/tree).

Implementation Actions:
The Air District will:
- Develop or identify an existing model municipal tree planting ordinance and encourage local governments to adopt such an ordinance.
- Provide assistance to local governments to increase tree canopy by assisting in identifying and securing incentive funds that are available for the planting of trees.
- Include tree planting recommendations in Air District's guidelines for local plans and CEQA review.

- Provide information via technical guidance, best practices, outreach materials, presentations and workshops to local government planning and public works staff on how to maximize air quality, GHG and public health benefits from municipal tree planting programs.

Emission Reductions:
Due to the level of uncertainty in terms of the impact this program may have on number of trees planted, emission reductions have not been estimated.

Emission Reduction Methodology:
N/A

Exposure Reduction:
Tree planting in urban settings would serve to reduce ambient concentrations of numerous criteria pollutants as well as sequester CO_2. Additionally, studies have demonstrated that access to trees within an urban setting is a direct reflection of income (Jenerette et al. 2011). Increasing urban trees in low-income communities, therefore, may not only reduce cooling expenses of residents and improve air quality, but may also reduce disparity.

Emission Reduction Trade-Offs:
It is important to take into account that trees can also contribute to emission increases. For example, some trees emit biogenic volatile organic compounds (BVOCs) that can contribute to ozone formation. The contribution of BVOC emissions from city trees to ozone formation depends on complex geographic and atmospheric interactions, and differs considerably across tree species, and has not been studied in most cities (McPherson et al. 2010). Additional research would need to be conducted to identify the tree species that are most beneficial to air quality overall. It is also important to consider that trees also emit particles such as pollen and particles captured on plant surfaces can be re-suspended into the air. In addition, equipment used for tree planting and maintenance (e.g., vehicles, chain saws, chippers) releases CO_2.

Cost:
An analysis of small, medium and large broadleaf trees and a coniferous tree in the Northern California Coast Region (which covers large portions of the nine-county Bay Area) found that the benefits conveyed by trees outweigh the costs of maintaining these trees. Table 2 presents the average annual benefits, costs and net benefits per tree for a 40-year period (McPherson et al. 2010).

Table 2. Average annual benefits, costs and net benefits per tree for a 40-year period

	Average Annual:		
Tree type	**Benefits**	**Costs**	**Net Benefits (Benefits – Costs)**
Small broadleaf	\$41 to \$51	\$10 to \$17	\$31 to \$34
Medium broadleaf	\$57 to \$71	\$11 to \$24	\$46 to \$47
Large broadleaf	\$115 to \$135	\$13 to \$28	\$102 to \$107

Conifer	\$161 to \$176	\$15 to \$33	\$142 to \$143

The largest portion of the benefits results from increased property value and energy savings; additional benefits are derived from reduced storm water runoff, lower levels of air pollutants and reduced ambient CO_2. The majority of costs are associated with tree planting, pruning and removal.

Co-Benefits:
Trees in urban settings provide for numerous additional benefits – ranging from environmental to economic to psychological and social. For example, trees:

- Improve water quality by reducing storm water runoff, a major source of pollution entering wetlands, streams and the San Francisco Bay.
- Reduce flood risk and recharging groundwater supplies by capturing storm water.
- Provide wildlife habitat in the built environment.
- Prolong the life of sidewalks and pavement by reducing the daily heating and cooling and thus expansion and contraction of asphalt.
- Have been found to increase property values - research suggests that people are willing to pay 3 to 7 percent more for properties with ample trees versus few or no trees.
- Provide social and psychological benefits by beautifying the landscape, promoting social interactions, providing stress relief and noise reduction, contributing to public safety and providing pleasure to humans.

It is also important to consider the additional benefits associated with planting native and/or drought-tolerant or drought-resistant trees. Specifically, since native plants have evolved in and with the local environment, they tend to be better adapted to local conditions (e.g., soil type, rain regime) and less susceptible to pest and diseases than non-native trees. As such, they require little long-term maintenance if they are properly planted and established. In addition, native trees provide food and habitat for native wildlife, birds, bees and butterflies; these animals in turn play key roles in the local ecosystem. Drought-tolerant and -resistant trees (whether native or not) require far less water than exotic trees, especially once established. Encouraging water-wise landscaping will become increasingly important as a result of the altered weather patterns expected with climate change.

Issues/Impediments:
Due to the voluntary nature of this measure, significant impediments to implementation are not anticipated.

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NW3: Carbon Sequestration in Wetlands

Brief Summary:
This control measure would increase carbon sequestration in wetlands in the San Francisco Bay by providing technical and research assistance, policy support, and incentive funding to local governments and regional agencies to ensure the preservation and restoration of wetlands.

Purpose:
Ensuring the preservation and restoration of wetlands in the Bay Area will (1) reduce the emissions of CO_2 that results when wetlands are destroyed and/or degraded, and (2) increase the uptake and sequestration of atmospheric CO_2 within these habitats when they are re-established and protected.

Source Category:
Area sources - wetlands

Regulatory Context & Background:
The development and urbanization of the nine-county Bay Area, in particular since the mid-1850s following the Gold Rush, has affected and changed nearly all the region's natural habitats. Among the most severely affected were the wetlands that once ringed the San Francisco Bay. By the 1960s, filling of shallow areas of the San Francisco Bay had reduced the Bay's size by one-third and destroyed 90 percent of the Bay's tidal marsh.

The Save San Francisco Bay Association (now Save the Bay) was established in 1961 to stop unregulated filling of San Francisco Bay and to open the Bay shoreline to public access. This movement helped support the establishment in 1969 of the San Francisco Bay Conservation and Development Commission (BCDC) as a permanent state agency to regulate shoreline development and increase public access. BCDC has jurisdiction over the open water, marshes and mudflats of greater San Francisco Bay, the first 100 feet inland from the shoreline around the Bay as well as managed wetlands that have been diked off from the Bay.

Efforts by governmental agencies and non-profit groups have been on-going across the Bay to preserve and restore wetlands. Of note, in the 1990s, in response to the growing recognition of the importance of wetlands, nine state and federal agencies and dozens of concerned scientists came together to produce a guide for restoring and improving the wetlands and adjacent habitats of San Francisco Bay to establish a long-term vision for a healthy and sustainable baylands ecosystem. This effort was called the San Francisco Bay Area Wetlands Ecosystem Goals Project (Goals Project 1999).[1] Among the key recommendations of the Goals Project was to increase the total area of tidal marsh across the Bay from 40,000 acres to about 95,000 to

[1] An update to the 1999 Goals Project report was released in 2015 (Goals Project 2015). This updated report synthesizes the latest science, including advances in the understanding of climate change, and provides new recommendations for achieving healthy baylands ecosystems. The habitat acreage goals set in 1999 remain the same.

105,000 acres, requiring the restoration of large areas of diked habitats such as salt ponds, managed marshes and agricultural flatlands. Re-establishing extensive areas of tidal marsh would have major environmental benefits, including improving the Bay's natural filtering system and enhancing water quality, increasing primary productivity of the aquatic ecosystem, and reducing the need for flood control and channel dredging. In addition, Goals Project 2015 specifically addresses the carbon sequestration benefits that would result from restoration of these wetlands.

The scientific foundation for the protection and re-establishment of wetlands across the Bay provided by the Goals Project in 1999 has served to guide wetlands restoration and enhancement around the Bay for well over a decade. For example, the San Francisco Bay Joint Venture, a partnership organization that works to protect, restore and enhance wetlands in the Bay Area, has completed over 150 wetland habitat projects resulting in the conservation of over 70,000 acres of habitat. Additional wetlands restoration projects have taken place in the South and North Bay regions, or are planned on lands purchased by government agencies such as the U.S. Fish and Wildlife Service, the California Department of Fish and Game and the California Coastal Conservancy, and by private organizations and land trusts. Overall, since the Goals Project report was published in 1999, over 12,000 acres of tidal marsh and wetlands have been restored, and nearly 30,000 more are now under way (Goals Project 2015).

Fundamental to the successful re-establishment of wetlands is attracting significant funding for land acquisition and restoration as well as maintenance and protection of re-established wetlands. Efforts to secure funding for restoration included the passage of AB 2954 in 2008 which established the San Francisco Bay Restoration Authority (Restoration Authority) as a regional body with the power to raise and allocate local resources for the "restoration, enhancement, protection, and enjoyment of wetlands and wildlife habitat in the San Francisco Bay and along its shoreline." In June 2016, a $12 per year parcel tax placed on the ballot by the Restoration Authority (the "San Francisco Bay Clean Water, Pollution Prevention, and Habitat Restoration Program," also known as the Clean and Healthy Bay Ballot Measure) was approved by the required two-thirds majority of voters in all nine counties of the Bay Area. The measure is expected to generate approximately $25 million per year and $500 million over its 20-year life to protect and restore the San Francisco Bay.

There is existing federal and state funding for wetlands restoration projects in the Bay Area. Specifically, the United States Environmental Protection Agency's (EPA) San Francisco Bay Water Quality Improvement Fund (SFBWQIF) has been available since 2008. This Fund has invested almost $16 million in 26 projects to restore over 4,000 acres of wetlands around the Bay; these projects have leveraged additional funds from partner agencies and organizations, resulting in $100 million being invested in San Francisco Bay and its watersheds since 2008. In addition, the new Wetlands Restoration for Greenhouse Gas Reduction Grant Program, administered by the California Department of Fish and Wildlife, granted its first awards to 12 projects throughout California (one in the Bay Area) in April 2015. This Program allocates Greenhouse Gas Reduction Funds (GGRF) from California's Cap-and-Trade proceeds to restore wetlands that sequester GHGs and provide other ecological benefits in mountain meadow ecosystems, the Sacramento-San Joaquin Delta and coastal wetlands.

In addition, in late 2015, a new protocol for wetland carbon finance was approved by the Verified Carbon Standard. Specifically, the Wetlands Restoration and Conservation project category provides a framework for accounting for emission reductions in mangroves, tidal and coastal wetlands, marshes, seagrasses, floodplains, deltas, and peatlands among others tidal wetlands and seagrass restoration. These groundbreaking requirements are the first for crediting restoration and conservation activities across wetland ecosystems.

Implementation Actions:
The Air District will:
- Collaborate with other local, regional, state and federal agencies to protect, restore and enhance existing wetlands that provide carbon sequestration value in the Bay Area.
- Develop or identify guidance based on acceptable quantification methods for local climate action plans on estimating GHG sequestration associated with wetlands restoration and protection.
- Partner with other local and regional agencies to apply the Wetlands Restoration and Conservation methodology or other applicable third-party protocols to potential carbon offset projects.
- Include offsite mitigation strategies for GHG emissions through carbon sequestration from wetland restoration and preservation in CEQA guidance and comments.
- Identify federal, state and regional agencies, and collaborative working groups that the Air District can assist with technical expertise, research or incentive funds to enhance carbon sequestration in wetlands around the Bay Area.
- Provide technical assistance as needed for SFBWQIF and GGRF projects.
- Assist agencies and organizations that are working to secure the protection and restoration of wetlands in the San Francisco Bay to reach the Goals Project recommendation of 100,000 acres.

Emission Reductions:

Pollutants*	2020	2030
CO_{2e}	90,000	90,000

**CO_{2e} is reported in metric tons/year (100-yr GWP)*

Emission Reduction Methodology:
Expected emissions reductions were calculated based on the sequestration potential of wetlands and the recommended area of wetlands to be restored. It is estimated that every acre of healthy salt marsh captures and converts at least 0.87 metric tons (MT) of CO_2 into plant material annually (Save the Bay 2007). Therefore, if full restoration of the 100,000 acres recommended by the Goals Project is achieved, it would be expected that nearly 90,000 MT of CO_2 would be sequestered annually.

Exposure Reduction:

This measure will reduce CO_2 in the atmosphere by sequestering CO_2 into wetlands.

Emission Reduction Trade-Offs:
The creation, restoration and maintenance of wetlands can result in criteria and GHG emissions associated with on-road vehicles and off-road heavy equipment that may be used to restore and or maintain the wetlands.

Cost:
The main costs for this control measure will be funding for the acquisition, planning and maintenance of restoration projects. Save The Bay's 2007 report, "Greening the Bay," estimated that it would cost $1.43 billion over 50 years to fully restore the over 36,000 acres of shoreline property that had already been acquired and awaiting restoration to tidal wetlands at that time. The report did not estimate the costs of acquiring and restoring the remaining 20,000 acres or so to reach the 100,000-acre goal. Overall, most of the expenses are a one-time investment, with more than 80 percent needed for planning, construction and monitoring of the restoration projects. Once restored, tidal marshes require little maintenance with expenses focused on ongoing operations and maintenance, security, public access facilities and protecting other infrastructure at restored marshes.

Co-Benefits:
Restoring and preserving wetlands not only ensures increased capture and storage of carbon by these areas, but also provides a multitude of environmental co-benefits from these areas:

- Protection and buffer from floods, erosion and sea-level rise as these area act as sponges, slowing down and soaking up large quantities of runoff and water from rain storms and high tides;
- Habitat for over 500 species of fish and wildlife;
- Improved water quality by trapping and filtering out pollutants and toxins;
- Open space and recreation for visitors to and residents of a highly urbanized Bay Area; and
- Economic benefits from tourism, fishing, and recreation opportunities in and around wetlands.

In addition, it is critical to note that wetlands provide economic benefits that are not reflected in the costs outlined in the section above. Specifically, Save the Bay's report noted that wetlands produce $4,650 per acre in flood control and dredging cost savings compared to engineered dams, reservoirs and channels and, since they purify water so well, they are often used for tertiary treatment by municipal sewage plants.

Issues/Impediments:
The major issue/impediment to restoring and preserving wetlands for all the associated environmental benefits, including carbon sequestration, is adequate funding. Wetland restoration requires long-term, consistent funding for acquisition, planning, on-the-ground construction, and operations and maintenance.

Sources:

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WA1: Landfills

Brief Summary:
This control measure would reduce emissions of methane and non-methane organic compounds from landfills by increasing standards for landfill gas collection control devices and fugitive leaks. Revisions to Regulation 8, Rule 34 (Rule 8-34) would also improve consistency with State and Federal rules governing solid waste disposal sites.

Purpose:
Reduce emissions of methane and non-methane organic compounds (NMOC) and improve enforceability of Rule 8-34.

Source Category:
Stationary source and area source – solid waste disposal sites.

Regulatory Context and Background:
On May 2, 1984, the Air District adopted Rule 8-34 to control emissions of methane and other organic compounds from landfill gas. The rule has been amended several times since then to tighten standards and improve application of the rule requirements, with the most recent amendment occurring in October 1999. In March 1996, the U.S. Environmental Protection Agency (US EPA) adopted Emission Guidelines and Compliance Times for Municipal Solid Waste Landfills into the Code of Federal Regulations. The 1999 amendments to Rule 8-34 were intended to meet the Air District's obligation to implement the federal emission guidelines, and to streamline compliance with new source performance standards, emission guidelines, and Air District requirements by providing a single rule containing all applicable requirements. As a result of these amendments to achieve consistency with the federal rule, the emissions standards for gas collection systems were changed from organic compounds and methane control requirements to NMOC control requirements. This effectively removed control requirements for methane from the collection systems, but the rule retained a "measured as methane" requirement for fugitive emissions from the landfill surface as well as collection system component leaks.

On June 17, 2010, California adopted the Landfill Methane Control Measure (LMCM) to reduce methane emissions from municipal solid waste landfills. This measure was identified in 2007 as a discrete early action greenhouse gas (GHG) emission reduction measure pursuant to the California Global Warming Solutions Act of 2006 (AB 32). The measure requires smaller and other uncontrolled landfills to install gas collection and control systems and also includes requirements to ensure that existing gas collection and control systems operate optimally to control methane emissions.

The requirements set forth in the LMCM differ from those in Rule 8-34 and the federal rule, well beyond the methane versus NMOC issue and lower threshold for gas collection noted above. The LMCM includes a 99 percent methane capture and control requirement for gas collection systems and an instantaneous 500 parts per million by volume (ppmv) standard for fugitive emissions from surface leaks and component leaks under positive pressure (after the blower). There is also a 25 ppmv integrated surface monitoring standard in the LMCM. Rule 8-34 includes 98 percent NMOC destruction efficiency for gas collection systems, a 1,000 parts per million (ppm) “measured as methane” standard for component leaks, and an instantaneous 500 (ppmv) expressed as “methane above background” standard for surface leaks. Both rules have somewhat relaxed emission limits for energy recovery control systems used as control in place of flares. Each rule contains requirements for plan submittals for construction, collection and control system design and alternative compliance, with different criteria for each rule leading to overlap and inconsistency.

In addition to amendments to Rule 8-34 that would improve consistency with the state rule, Air District staff has identified several potential avenues for further emissions reductions. Control equipment at facilities in the Bay Area routinely meets the current control levels of both rules, so increasing the stringency to 99 percent control for NMOC and 99.5 percent for methane is technically feasible with little added costs for facilities utilizing flares. More research is needed to determine if lean burn engines can meet more stringent standards. The time allowed for installation of gas collection in expanded areas of active landfills can be shortened and thereby reduce fugitive emissions. Enacting consistent component leak standards (500 ppmv versus 1000 ppmv, and the entire system rather than just the positive side of the blower) would reduce fugitive emissions of both methane and NMOC.

Air District staff will evaluate methane emissions from facilities currently exempt from Rule 8-34 and LMCM requirements including smaller facilities and closed landfills. Higher tipping fees at larger landfills may cause diversion of organic waste to smaller active landfills with no gas collection system in place. Recent research suggests that some closed landfills with no gas collection systems may emit significant amounts of methane. Air District staff will measure fugitive methane emissions at these facilities to determine emission levels and evaluate appropriate amendments to Rule 8-34 or management practices if necessary.

Implementation Actions:
The Air District will:

- Propose amendments to Rule 8-34 to increase stringency of control and fugitive leak standards, and improve consistency with the LMCM and federal rules.
- Evaluate methane emissions at smaller or closed landfills where green waste has been accepted and consider amendments to Rule 8-34 to address fugitive methane emissions if deemed significant.

Emission Reductions:

Pollutants*	2020	2030
ROG	400	400
CO_{2e}	233,308	233,308

**criteria pollutants are reported in lbs/day; CO_{2e} is reported in metric tons/year (100 yr GWP)*

Potential emissions reductions from increased standards on control equipment would be somewhat small, but there is potentially greater emission reduction potential for fugitive emissions. The 2011 Air District inventory lists fugitive emissions from landfills at 186.33 tons per day of methane and 3,340 pounds per day ROG, and controlled emissions from landfill gas collection systems at 4.79 tons per day of methane, and 200 pounds per day ROG. Increasing the stringency of control standards would yield emission reductions of 0.01 tons per day of methane, and less than 20 pounds per day ROG. Reducing the time for installation of collection wells in expanded portions of active landfills and tightening the component leak standard while expanding it to more of the gas collection system would result in 2 to 5 percent reduction in fugitive emissions, yielding a reduction of 3.77 to 9.32 tons per day of methane and 60 to 160 pounds per day ROG.

Emission Reductions Methodology

In calculating fugitive emissions from landfills, Air District staff currently assumes that gas collection systems collect 75 percent of both methane and NMOC, and that 25 percent of the landfill gas escapes as fugitive emissions. In the California Air Resources Board's (ARB) Statement of Reasons for the LMCM, ARB has indicated that compliance with the measure will result in 85 percent capture. Amending Rule 8-34 to be consistent with or more stringent than requirements for both methane and NMOC would lead to greater rates of gas collection and would result in emission reductions on the order of 18.8 tons per day of methane and 400 pounds per day ROG. The reduction in methane emissions result in GHG emission reductions equivalent to 590,132 MT CO_2e per year, on a 20-year timeframe, and 233,308 MT CO_2e per year, on a 100-year timeframe.

Emission Reduction Trade-Offs:

There may be minimal increases in combustion emissions as a result of increased capture of landfill gases.

Costs:

Given that most flares have the potential to meet more stringent control standards, only increased labor costs might be incurred as capital costs would be minimal or nonexistent. Similarly, for the elements associated with stricter fugitive emission standards, there would only be increased labor costs. These costs would be offset by elimination of redundant monitoring requirements due to improved consistency between State and Air District requirements.

Co-Benefits:
Increased capture of landfill gases would likely result in less potential for odor complaints.

Monitoring Mechanisms:
Air District staff will monitor compliance of the improved standards through facility inspections.

Issue/Impediments:
There may be some opposition from industry to lower fugitive standards (due to increased labor costs), but improved consistency is likely to be welcomed.

Sources:

1. Proposed Amendments to Regulation 8, Rule 34: Solid Waste Disposal Sites; Regulation 3: Fees, Schedule K; and Regulation 9, Rule 2: Hydrogen Sulfide Staff Report; BAAQMD, September 28, 1999
2. Staff Report: Initial Statement of Reasons for the Proposed Regulation to Reduce Methane Emissions from Municipal Solid Waste Landfills; California EPA, Air Resources Board, Stationary Source Division, Emissions Assessment Branch, May 2009

WA2: Composting & Anaerobic Digesters

Brief Summary:
This control measure would reduce emissions of greenhouse gases (GHGs) and volatile organic compounds (VOCs) from anaerobic digesters and composting operations by requiring best management practices derived from measures adopted by the South Coast Air Quality Management District (SCAQMD) and the San Joaquin Valley Air Pollution Control District (SJVAPCD).

Purpose:
Reduce GHG and VOC emissions, and reduce secondary particulate matter (PM) emissions via ammonia emission reductions from composting operations and related activities.

Source Category:
Area Source – anaerobic digesters and composting operations

Regulatory Context and Background:
As a result of recent changes to directives, policies, and state law surrounding waste management in California, more organic waste is being diverted from landfills to either composting, anaerobic digestion, or a combination of the two. Anaerobic digestion is a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen. One of the end products is biogas, which is combusted to generate electricity and heat, or can be processed into renewable natural gas and transportation fuels.

In 2011, under Strategic Directive 6.1, CalRecycle announced its goal of reducing the amount of organic waste disposed in landfills by 50 percent. In addition to helping conserve landfill capacity, this policy sought to capture the energy value of organic wastes more efficiently thereby reducing emissions of GHGs which contribute to climate change. Subsequent to this effort, CalRecycle adopted the Anaerobic Digestion Initiative to encourage the development of anaerobic digestion facilities (ADFs) as an alternative to landfill disposal of organic solid waste. This initiative provides grants, loans and contracts to develop ADFs, as well as guidance publications to assist operators and local enforcement agencies, and revised regulations regarding design, operation and permitting of ADFs. In October 2014, Governor Brown signed into law AB 1826, requiring businesses to recycle their organic waste on or after April 1, 2016, and requiring local jurisdictions across the state to implement organic waste recycling programs on or after January 1, 2016 to divert organic waste generated by businesses, including multifamily residential properties of five or more units.

The Air District issued an Authority to Construct (A/C) in 2012 for an ADF in Milpitas to process up to 135,000 tons per year of food/green waste, and the facility began operations in December 2013. Operation of this facility is integrated into operations of a nearby landfill, recycling and compost operation, and water treatment facility. Another smaller ADF in South San Francisco was issued an A/C in 2013 to process up to 11,200 tons per year of food/green waste, and operations began in April of 2015. Operations at this ADF are not integrated with a nearby landfill, and a composting operation permitted for this location is in-vessel as opposed to open windrows.

In 2003, the SCAQMD adopted a suite of rules to address emissions from composting and related operations. These were: Rule 1133 – Composting and Related Operations, General Administrative Requirements; Rule 1133.1 – Chipping and Grinding Activities; and Rule 1133.2 – Emission Reductions from Co-Composting Operations. The purpose of these rules was to establish a registration and annual reporting program for composting-related facilities to better characterize the emissions and keep track of activity levels (1133), develop holding and processing time requirements for chipping and grinding activities to prevent inadvertent decomposition of greenwaste and foodwaste (1133.1), and reduce VOC and ammonia emissions from co-composting operations (1133.2). In 2010, SCAQMD amended 1133.1 for consistency with state regulations regarding greenwaste processing requirements and adopted Rule 1133.3 to establish best management practices for greenwaste composting operations.

In March 2007, SJVAPCD adopted Rule 4565, Biosolids, Animal Manure, and Poultry Litter Operations (similar to South Coast's Co-composting Rule 1133.2, but Rule 4565 includes provisions for land application of organic material and sets forth mitigation measures as a means of control for smaller operators). In 2008, SJVAPCD began development of Rule 4566 - Composting Green Waste, but efforts were slowed by perceived overestimation of emissions (62 tons per day in 2007 was revised to 19 tons per day in 2010) combined with a lack of studies demonstrating efficacy of proposed mitigation measures. Collaborating with stakeholders and other regulatory agencies in 2009, SJVAPCD directed a field study designed to measure the effectiveness of four potential best management practices. Based on the field study results, SJVAPCD adopted a new version of rule 4566 (August 2011). Rule 4566 defines organic material to include green material, food material, or a mixture thereof, and may include wood material and up to 100 wet tons per year of biosolids, animal manure, or poultry litter. SJVAPCD adopted rule 4566 – Organic Material Composting Operations on August 18, 2011.

In the Bay Area 2010 Clean Air Plan, composting operations were identified as a potential source for emission reductions in further study measure FSM-15. This further study measure sought to use the results of the San Joaquin field study along with the lessons learned from the rule development efforts of SCAQMD and SJVAPCD. Now that those efforts have been completed there is more information to support potential Air District rulemaking. The potential increase of anaerobic digestion operations in the Bay Area increases the need for regulation of these two integrated operations.

Implementation Actions:
The Air District will:

- Propose a rule to limit emissions from composting operations and anaerobic digesters, similar to San Joaquin Valley Air Pollution Control District Rule 4566 and South Coast Air Quality Management District Rule 1133.
- Review guidance publications from CalRecycle, which may provide additional measures for ADFs.

Emission Reductions:

Pollutants*	2020	2030
ROG	1,440	1,440
Ammonia	1,400	1,400
CO_{2e}	1,241	1,241

**criteria pollutants are reported in lbs/day; CO_{2e} is reported in metric tons/year (100 yr GWP)*

According to the Air District's 2011 emission inventory estimates, emissions from composting operations account for 0.19 tons per day of methane and 2,880 pounds per day of reactive organic gases (ROG). Ammonia emissions from composting are estimated to be approximately 1.40 tons per day. Mitigation measures drawn from the SJVAPCD or SCAQMD rules are estimated to reduce organic emissions by 15 percent to 30 percent, and are more likely to be adopted at small scale composting operations. More capital intensive controls such as construction of aerated static piles and/or biofilters appropriate for larger operations have demonstrated 80 percent control. Assuming a conservative estimate of 50 percent reduction in emissions would yield a reduction of 0.1 tons per day of methane, 1,440 pounds per day ROG, and 1,400 pounds per day of ammonia. The reduction in methane emissions result in GHG emission reductions equivalent to 3,139 MT C02e per year, on a 20-year timeframe, and 1,241 MT CO_2e per year, on a 100-year timeframe.

Emission Reduction Trade-Offs:
As noted in the background section, materials and byproducts of the anaerobic digestion process must be properly integrated into other waste management processes. Leachate and wet (or heavily inoculated) end products can cause pockets of methane to form in landfills or may overwhelm wastewater treatment control systems. A holistic approach to composting and anaerobic digestion regulations will ensure that emissions are not diverted to other operations rather than ultimately controlled. Should the adoption of best management practices prove to be too costly, more organic material may end up being trucked outside of the Air District. This would result in increases in emissions of methane from the landfills and combustion emissions associated with truck traffic.

Costs:
The control costs for the adoption of emission mitigation measures range from $390 per ton of VOC reduced for watering systems to $2,500 per ton of VOC reduced for facilities utilizing watering systems and finished compost cover. Costs for demonstrated 80 percent reductions are likely to exceed a range from $5,000 to $10,000 per ton of ROG reduced, and $9,000 to $13,000 per ton of ammonia reduced. These estimates are based on facilities in SJVAPCD. Costs for the operations in the Bay Area will be estimated during rule development.

Co-Benefits:
The adoption of best management practices may also reduce the potential for odor and subsequent complaints from individuals downwind of these facilities.

Issue/Impediments:
There may be some opposition from this industry to being regulated. CalRecycle as well as local municipalities may claim that regulation of composting operations works against waste diversion goals. The best management practices, however, are supported by most industry representatives and were developed through a collaborative effort with affected parties in the San Joaquin, South Coast, and Mojave Desert air districts.

Sources:
1. San Joaquin Valley Air Pollution Control District, Preliminary Draft Staff Report for Rule 4566, Composting Green Waste, dated 1/10/2008
2. SJVAPCD, Final Draft Staff Report for Rule 4566, Organic Waste Operations, dated 12/18/2008
3. SJVAPCD, Final Draft Staff Report: Revised Proposed New Rule 4566, dated 8/18/2011
4. The Policy Committee for the Central California Ozone Study, and SJVAPCD, Request for Proposal for the Organic Waste Composting Study, dated 12,16,2008
5. South Coast Air Quality Management District, Technology Assessment for Proposed Rule 1133, Emission Reductions from Composting and Related Operations, Dated 3/22/2002
6. SCAQMD, Final 2007 Air Quality Management Plan, Control Measure CM # 2007MCS-04, dated 6/1/2007
7. SCAQMD, Final Staff Report: Proposed Amended Rule 1133.1 – Chipping and Grinding Activities and Proposed Rule 1133.3 – Emission Reductions from Greenwaste Composting Operations, Dated 7/8/2011
8. Anaerobic Digestion Initiative and Statewide Anaerobic Digestion Facility for Treatment of Municipal Organic Solid Waste-Final PEIR-SCH#2011024100, CalRecycle, 6/22/2011
9. Final Statement of Reasons, Compostable Materials and Transfer/Processing Regulations, CalRecycle, 9/2015

WA3: Green Waste Diversion

Brief Summary:
This control measure would reduce the total amount of green waste being disposed in landfills by supporting the diversion of green waste to other uses.

Purpose:
Reduce air pollutants and greenhouse gas (GHG) emissions from the disposal of green waste in landfills. Diverting green waste, which includes both food and yard waste, away from landfills or keeping it out of the waste stream entirely would reduce the amount of methane, nitrous oxide and other volatile organic compounds (VOC)s.

Source Category:
Solid waste: landfills

Regulatory Context and Background:
California has been a leader in reducing emissions from the landfilling of solid waste. In 1989, California adopted landmark legislation that established the State's Integrated Waste Management Board (now called CalRecycle) and required cities and counties to achieve a 50 percent diversion rate of waste going to landfill by 2000. By 2012, California had surpassed this mandate and achieved a 66 percent waste diversion rate. More recent legislation has set a goal to reduce, recycle or compost 75 percent of solid waste by 2020. In response, many local agencies have set zero-waste goals for their communities. Finding ways to divert green waste from landfills is an essential component of achieving these local goals. Doing so will preserve space in local landfills, reducing criteria pollutants and GHGs in the process.

Methane is a significant component of landfill gas, generated largely through anaerobic decomposition[1] of yard and food waste. Reducing methane is a priority due to its high global warming potential.[2] The Air District has long sought to reduce methane and other air pollutants emitted from landfills. In 1984, the Air District adopted Rule 8-34 that targeted methane emissions at large landfills by requiring landfill gas collection systems. The Air District has subsequently amended the rule to further reduce emissions. Despite the effectiveness of this rule, landfills are still responsible for more than half of all methane emissions in the Bay Area.

At the state level, agencies such as CalRecycle have recognized that reducing the amount of green waste going to landfills is key to both the goals of solid waste reduction and reducing GHG emissions. Assembly Bill 1826, for example, requires commercial generators of food or

[1] Anaerobic digestion (AD) is the process whereby bacteria break down organic material in the absence of air. A by-product is biogas, which can be used to produce energy.
[2] "Global warming potential" (GWP) is a relative measure of how much heat a greenhouse gas traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide. For methane, the Air District uses a GWP of 34, according to the Intergovernmental Panel on Climate Protection's 5th Assessment Report.

other green waste to subscribe to composting or anaerobic digestion service for their organics starting in 2016. Another bill, AB 1594, removes the "diversion credit" given to waste management entities when they use green materials such as yard trimmings as alternative daily cover in landfills. Diverting more green waste to composting facilities as well as anaerobic digestion facilities will be an essential step that will help avoid methane emissions from landfills. Feedstock for anaerobic digestion could include food waste and other green materials currently going to landfill instead of being considered for composting.

Local programs have also helped reduce green waste. Many jurisdictions now offer curb-side pickup of both yard and food waste. This is more common for single-family homes, but local waste management agencies are increasingly offering these services to multi-family and commercial customers. Some cities also encourage residents to compost food and yard waste at home by providing training and, in some cases, composting equipment. Composting at home reduces transport emissions and when done on a small scale, the decomposition could emit fewer GHG emissions than landfills depending on how the compost pile is maintained (e.g., if it is turned to allow air to enter the system). In addition, homeowners can use the resulting compost instead of buying new soil or artificial fertilizers, thereby reducing transport-related emissions and energy used to produce chemical fertilizers.

Implementation Actions:
The Air District will investigate the following approaches in an effort to reduce emissions from green waste.

- Identify or develop model policies to facilitate local adoption of ordinances and programs to reduce the amount of green waste going to landfill; partner with stakeholders such as CalRecycle on these efforts. Activities addressed by such model policies may include:
  - developing a zero waste goal for the community and implement programs to achieve the goal while ensuring that these goals do not lead to increased use of incineration to avoid landfilling;
  - requiring large commercial and institutional facilities to use compost in their landscaping operations rather than employ artificial fertilizers.
- Advocate for state and federal legislation that supports efforts to divert green waste from landfills, such as tax incentives for commercial food donation, creation of additional disposal facilities or the establishment of new collection strategies for green waste.
- Collaborate with public agencies and local businesses in seeking support from state, federal or other funding programs to implement green waste diversion programs such as on-site composting.
- Promote use of compost in urban areas and on rangelands for carbon sequestration and to reduce landfill-related GHGs (see NW1: Carbon Sequestration in Rangelands).
- Promote replacement of high-maintenance landscapes (e.g., lawns) with climate-appropriate landscapes that include native and drought-tolerant plants to decrease green waste production.

Emission Reductions:

Pollutants*	2020	2030
ROG	452	542
CO_{2e}	n/a	162,997

**criteria pollutants are reported in lbs/day; CO_{2e} is reported in metric tons/year (100 yr GWP)*

Implementing the actions in this control measure could result in annual emission reductions in 2030 of 408,591 MTC02e per year, on a 20-year timeframe, and 162,997 MTCO2e per year, on a 100-year timeframe. It could also result in a reduction of 452 pounds per day of ROG in 2020 and 542 pounds per day of ROG in 2030.

Emission Reduction Methodology:
This measure would support efforts to achieve a 90 percent diversion rate of suitable organics from the existing waste stream by 2030, which is critical to helping overall diversion rates. Given that recycling rates (including composting) have stagnated, additional efforts need to be made to divert more waste away from landfills both for short-term and long-term goals.

Assuming that the waste from jurisdictions in the Bay Area is proportional to population, the region was responsible for landfilling roughly 1.87 million tons of organic waste suitable for composting or anaerobic digestion in 2010. Achieving a 90 percent reduction would mean diverting 1.68 million tons to composting or anaerobic digestion facilities. Assuming that the organics are evenly distributed between composting or anaerobic digestion facilities, and applying ARB emission factors for each facility type, the amount of GHGs reduced would be approximately 1.02 MMTCO2e per year. Implementation actions were assumed to achieve 10 percent of the total emission reductions.

Emissions of criteria pollutants were calculated assuming that 70 percent of organics are green waste and the remaining 30 percent is a higher-emission producing green waste/food scrap mix. ROG emission factors come from a CalRecycle study, "Emission Testing of VOC from Greenwaste Composting at the Modesto Compost Facility in the San Joaquin Valley." The mid-point value for each of the emission factors was used.

Exposure Reduction:
N/A

Emission Reduction Trade-offs:
Certain strategies may have emission reduction trade-offs. For example, waste that is diverted from a landfill with a high gas capture rate and sent to a compost facility could result in an increase in VOCs, contributing to ozone formation, depending on the type and operation of the facility. In addition, composting facilities that do not implement best available technology or effective operating procedures could generate odors that impact people nearby. Control Measure WA2: Composting and Anaerobic Digesters proposes new rulemaking to minimize emissions and odors from composting facilities.

Cost:
Cost estimates will be determined during specific program implementation.

Co-benefits:
Diverting green waste away from landfills has the potential to generate multiple co-benefits. Local composting of green waste could reduce the number of truck hauling miles while yielding valuable compost that can be used in place of artificial fertilizers and pesticides. The application of compost on urban open space (e.g., parks, planting strips) and rangelands can decrease atmospheric GHG emissions by increasing the carbon sequestration capacity of soils, and indirectly through enhanced plant growth that further increases carbon sequestration. In addition, compost applications can reduce the amount of water needed in agricultural operations and landscaping, reducing the amount of energy required to pump water for irrigation.

This measure also has the potential to stimulate local job growth through the development of more Bay Area-based facilities capable of processing green waste.

Monitoring Mechanisms:
The Air District will track the number of local jurisdictions that adopt a green waste-related ordinance.

Issues/Impediments:
Siting of composting facilities has generated controversy in the past over the potential for odors coming from static piles, but modern composting facilities that implement best-available technology and effective operating procedures can reduce the potential of odors reaching homes and businesses. Some new composting facilities use closed systems that can be located within urban areas without disturbing people nearby. Funding for additional compost facilities to handle more green waste could be needed to support implementation of these action items.

Sources:

1. Arminger, Florian, Stefan Peyr, and Carsten Cuhls. 2008. Greenhouse gas emissions from composting and biological treatment. *Waste Management and Research* 26(1): 47-60.
2. Bay Area Biosolids to Energy. *A Regional Approach to Sustainable Biosolids Management*. http://www.bayareabiosolids.com/yahoo_site_admin/assets/docs/BAB2Efactsheet_Timeline_Nov2013.321120804.pdf.
3. California Air Resources Board (ARB). 2011. *Method for Estimating Greenhouse Gas Emission Reductions from Compost from Commercial Organic Waste*.
4. California Department of Resources Recycling and Recovery (CalRecycle). 2002. *Landfill Facility Compliance Study: Checklist of Pertinent Environmental Regulatory Requirements*. Publication number 520-02-002.
5. California Department of Resources Recycling and Recovery (CalRecycle). 2011. *Final Program Environmental Impact Report (EIR) for Statewide Anaerobic Digester Facilities*

for the Treatment of Municipal Organic Solid Waste. Prepared by ESA. State Clearinghouse No. 2010042100.

6. California Integrated Waste Management Board (CIWMB). 2007. *Emission Testing of VOC from Greenwaste Composting at the Modesto Compost Facility in the San Joaquin Valley*. Publication number 442-2007-0009.
7. U.S. Environmental Protection Agency (USEPA). Website titled *Organics: Anaerobic Digestion*. http://www.epa.gov/region9/organics/ad/.
8. U.S. Environmental Protection Agency (USEPA). *The Benefits of Anaerobic Digestion of Food Waste At Wastewater Treatment Facilities.* http://www.epa.gov/region9/organics/ad/Why-Anaerobic-Digestion.pdf.
9. U.S. Environmental Protection Agency (USEPA). 2014. *Framework for Assessing Biogenic CO2 Emissions from Stationary Sources*.

WA4: Recycling and Waste Reduction

Brief Summary:
This control measure aims to reduce the amount of solid waste that the Bay Area sends to landfills by strengthening recycling programs and developing additional waste reduction strategies.

Purpose:
Reduce greenhouse gas (GHG) emissions by diverting recyclables and other materials from landfills.

Source Category
Landfills

Regulatory Context and Background:
Landfill gas (LFG), which results from decomposition of organic materials, is approximately 50 percent methane, a potent GHG. Diverting materials from landfills by recycling or other waste reduction programs reduces the amount of landfill gas resulting from waste disposal. In addition, recycling reduces the need to use virgin materials in goods production. This reduces the demand for energy for resource extraction and processing, as well transportation – resulting in further reductions of GHGs.

California has long been at the forefront of the recycling movement. The California Beverage Container Recycling and Litter Reduction Act (AB 2020) was passed in 1986 and has led the state to have one of the most effective beverage container recycling programs in the country. In 1989, California adopted landmark legislation (AB 939) that established the state's Integrated Waste Management Board and required cities and counties to achieve a 50 percent waste diversion rate by 2000. AB 939 has been the single most important state-level policy in managing the state's waste stream and its resulting GHG emissions. By 2012, California had surpassed this mandate and achieved a 66 percent overall reduction in waste going to landfill.

In order to reduce the remaining 30 million tons of solid waste being sent to landfills each year and to support the goals set forth by California's Global Warming Solutions Act (AB 32), the legislature adopted AB 341 in 2011. This legislation sets a goal to reduce, recycle or compost 75 percent of solid waste by 2020. AB 341 also specifically targets commercial waste – one of the largest sources of solid waste in California. Achieving this waste reduction goal will result in a yearly GHG reduction between 20 and 30 million metric tons (MMT) of CO_2e statewide. The AB 32 Scoping Plan Update released in 2014 also discusses the possibility of setting even more ambitious goals, including a net zero GHG emissions target for the waste sector. Many local jurisdictions have already adopted policies that support achieving a zero waste goal.

Implementation Actions:

The Air District will:

- Develop or identify and promote model ordinances requiring or facilitating:
    - community-wide zero waste goals;
    - recycling of construction and demolition materials in all commercial and public construction projects.
- Track and disseminate best practices in waste reduction among Bay Area local governments.
- Actively communicate state and federal funding opportunities for waste reduction programs to local governments, and support funding applications.
- Participate in regional efforts to promote low-waste purchasing, such as the Bay Area Green Purchasing Roundtable
- Encourage the reuse of existing asphalt, concrete and cement materials in construction and repaving projects; the reuse of construction, demolition and other building materials, such as fixtures, trim, mulch from lumber, etc. instead of using virgin materials on building projects; and deconstruction (i.e., the selective dismantlement of building components) where demolition is required by including this actions among recommended mitigation measures in the Air District's CEQA Guidelines and comments.
- Collaborate with and track progress of the state and regional working groups working on waste management issues.

Emission Reductions:

Pollutants*	2020	2030
CO_{2e}	n/a	45,185

** CO_{2e} is reported in metric tons/year (100 yr GWP)*

The implementation of this control measure is anticipated by 2030 to reduce 72,838 MTCO2e annually, on a 20-yr timeframe, and 45,185 MTCO2e annually, on a 100-yr timeframe, from the increased recycling of materials currently being landfilled.

Emission Reduction Methodology:

Emission reduction estimates are based on individual analyses of the reductions possible to the waste stream of lumber, cardboard, carpet, aluminum cans, and glass, using factors from the March 2015 Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM).

Exposure Reduction:

This control measure could reduce TACs from landfills and transfer stations that process solid waste by diverting certain materials (e.g., electronics, compact florescent lighting) to recycling facilities that can properly handle them.

Emission Reduction Trade-offs:
Certain strategies may have emission reduction trade-offs depending on where the solid waste stream is processed. For example, waste that is exported out of the region for recycling could result in increased transportation emissions.

Cost:
Cost estimates will be determined during specific program implementation.

Co-benefits:
Beyond protecting air quality, reusing and recycling products can protect the environment by preserving natural lands that would have been used for resource extraction or landfills. Reducing the amount of natural resources (metals, wood, etc.) needed to produce new products also reduces the use of energy associated with extraction, processing and transport of these materials.

Issues/Impediments:
No significant issues or impediments are anticipated due to the voluntary nature of this control measure.

Sources:

1. CalRecycle EPP program: http://www.calrecycle.ca.gov/EPP/Resources/default.htm.
2. California Air Resources Board (ARB). 2014. *First Update to the Climate Change Scoping Plan: Building on the Framework*.
3. California Department of Resources Recycling and Recovery (CalRecycle). 2002. *Landfill Facility Compliance Study: Checklist of Pertinent Environmental Regulatory Requirements*. Publication number 520-02-002.
4. City of Palo Alto. 2013. *Waste Characterization Report.*

WR1: Limit GHGs from POTWs

Brief Summary:
This measure will explore regulatory action to reduce GHG emissions from publicly owned treatment works (POTWs), as well as work with POTWs to obtain funding for green infrastructure or demonstration projects. Finally, this measure will explore the potential to streamline the Air District's permitting process relating to POTW permits.

Purpose:
The purpose of this measure is to reduce direct emissions of nitrous oxide and methane, related to water and wastewater treatment. This measure is also intended to promote additional emission reduction opportunities within the water sector, including the potential for methane capture and re-use at POTWs through biogas recovery systems.

Source Category:
Stationary sources – water and wastewater treatment.

Regulatory Context and Background:
California's water system includes a complex infrastructure that has been developed to support the capture, use, conveyance, storage, conservation, recycling and treatment of water and wastewater. Statewide, the majority of developed water resources (80 percent) are used for agriculture. However, a significant amount of water is also used to support residential, commercial, and industrial activities. In the Bay Area, over 400 billion gallons of water is used each year. This water use results in air pollutant emissions, including greenhouse gases (GHG), criteria air pollutants, and toxic air contaminants (TACs).

Greenhouse gas emissions from the water sector are primarily associated with the energy required to pump, convey, recycle, and treat water and wastewater throughout the Bay Area; these are referred to as *indirect* GHG emissions. Greenhouse gases are also *directly* emitted from POTWs which treat water and wastewater. Greenhouse gases are emitted from wastewater collection, treatment, and storage systems through the volatilization of organic compounds (VOCs) at the liquid surface. Methane is emitted from wastewater when it is treated in anaerobic conditions. Nitrous oxide (N_2O) emissions are also emitted during the wastewater treatment process. In addition, combustion sources at POTWs emit GHGs, as well as criteria air pollutants and TACs.

The water sector also provides opportunities. Greenhouse gas emissions, primarily methane, can be captured and reused in POTWs through biogas recovery systems. Anaerobic digestion captures the methane that might otherwise be released into the atmosphere. This biogas can be used on-site for heat, electricity, or mechanical energy, or can be purified for off-site vehicle use or use as a natural gas substitute. For example, the Las Gallinas Valley Sanitary District's wastewater treatment plant in San Rafael operates a biogas-fueled internal combustion engine which generates renewable heat and power for on-site use.

The Air District regulates criteria pollutants and TACs at POTWs, and could expand these activities to include rules to reduce GHGs at POTWs as well. The Air District intends to work closely with POTWs to explore regulatory action to reduce GHGs. The first step in this process is to better understand total GHG emissions at each POTW. The Air District will also increase its efforts by exploring potential monetary incentives and/or assisting POTWs in securing funding to implement biogas recovery systems and to foster other emerging ideas and technologies.

Implementation Actions:
Air District will:

- Initiate a process to better understand and quantify GHG emissions at POTWs.
- Explore rulemaking to reduce GHGs emitted directly within POTWs.
- Work with the POTW operators and existing organizations such as the Bay Area Clean Water Agencies (BACWA) to obtain funding for the development of green infrastructure in POTWs.
- Collaborate with POTWs on potential streamlining of the Air District's permitting processes to promote biogas recovery, as well as address potential cross-media regulatory issues such as State Water Resources Control Board regulations on nutrient removal (which may increase GHG emissions).

Emission Reductions:
Emission reductions will be identified and quantified during the formal rule development phase of this control measure, if rulemaking is pursued.

Emission Reduction Methodology:
Emission reductions will be identified and quantified during the formal rule development phase of this control measure, if rulemaking is pursued.

Emission Reduction Trade-offs:
Emission reduction trade-offs will be identified and quantified during the formal rule development phase of this control measure, if rulemaking is pursued.

Cost:
Implementation of this control measure may include costs to POTWs for new equipment and technologies. These costs could be offset by securing grant funding or financing. Costs could also be offset if projects included production and use of on-site energy. Precise cost estimates (pertaining to POTWs and the Air District) will be identified and quantified during the formal rule development phase of this control measure, if rulemaking is pursued.

Co-Benefits:
Aside from reducing GHGs, this measure has the potential to provide economic benefits to POTWs. This measure will promote biogas recovery systems in wastewater treatment facilities. Benefits of biogas recovery, aside from reduced emissions of GHGs, include production of on-site renewable power (potentially at a cost below retail electricity), and enhanced power reliability.

Issues/Impediments:

The BACWA Air Issues and Regulations Committee has expressed concern regarding potential Air District regulatory action targeting POTWs. According to BACWA, Air District regulations inadvertently discourage biogas recovery and use as a fuel substitute. For example, Air District Best Performance Standards for limiting air emissions from engines and boilers are difficult for bio-gas fired engines and boilers to meet cost-effectively. The Air District is therefore investigating these potential conflicts through implementation of this control measure.

Sources:

1. US EPA, "Opportunities for and Benefits of Combined Heat and Power at Wastewater Treatment Facilities" April 2007: http://water.epa.gov/infrastructure/sustain/upload/2009_5_13_wwtf_opportunities.pdf
2. California Air Resource's Board Scoping Plan: http://www.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf
3. "Bay Area Integrated Regional Water Management Plan", September 2013: http://bairwmp.org/docs/2013-bairwm-plan-update/2013-final-plan/San%20Francisco%20Bay%20Area%20IRWMP%20Final_September%202013.pdf/view
4. Letter dated June 6, 2014, from Bay Area Clean Water Agencies to Air District.
5. CAPCOA, Organic Waste Digestion Project Protocol Version 2.0: https://www.valleyair.org/notices/Docs/2013/12-17-13_CAR/provisionally-approved-organic-waste-digestion-protocol.pdf
6. California Air Resource's Board Scoping Plan: http://www.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf
7. SPUR, "The Future of Water", March 2013: http://www.spur.org/publications/article/2013-03-07/future-water

WR2: Support Water Conservation

Brief Summary:
This measure will promote water conservation, including reduced water consumption and increased on-site water recycling, in residential, commercial and industrial buildings for the purpose of reducing greenhouse gas (GHG) emissions.

Purpose:
The purpose of this measure is to reduce indirect emissions of GHGs associated with the electricity use required to capture, use, convey, store, conserve, recycle and treat water and wastewater in the Bay Area.

Source Category:
Water conveyance and wastewater treatment.

Regulatory Context and Background:
California's water system includes a complex infrastructure that has been developed to support the capture, use, conveyance, storage, conservation, recycling and treatment of water and wastewater. Statewide, the majority of developed water resources (80 percent) are used for agriculture. However, a significant amount of water is also used to support residential, commercial, and industrial activities. The State Water Resources Control Board (State Water Board) ensures high water quality by setting statewide policy for waste and storm water discharge. Regional water quality control boards make water quality decisions for their regions, issuing permits and setting standards for water discharge.

In 2009, Governor Schwarzenegger signed into law the Water Conservation Act, which requires that urban water demand be reduced by 20 percent by the year 2020. The Act also requires urban water suppliers to calculate their baseline water use and set water use targets for 2015 and 2020 based on guidance from the Department of Water Resources (DWR). A report to the Legislature on progress meeting these targets is scheduled for 2016. On April 1, 2015, Governor Brown issued an Executive Order directing the State Water Board to implement mandatory water reductions in urban areas to reduce urban water use by 25 percent statewide. In response, the State Water Board adopted an emergency conservation regulation setting this target, taking effect on May 18, 2015. The Governor's Executive Order also directed DWR to update the State's Model Water Efficient Landscape Ordinance, which promotes the benefits of landscaping practices that go beyond traditional water conservation practices. Local agencies had until early 2016 to adopt the Ordinance or a local ordinance that is at least as effective in conserving water.

In the Bay Area, over 400 billion gallons of water is used each year. Energy associated with this water consumption results in air pollutant emissions, including GHGs, criteria air pollutants, and toxic air contaminants. Greenhouse gas emissions from the water sector are primarily associated with the energy required to pump, convey, recycle, and treat water and wastewater throughout the Bay Area. These are referred to as *indirect* GHG emissions, as they are generated at electric power plants, rather than at the point of water use. Greenhouse gases are also *directly* emitted from publicly owned treatment works (POTW) that treat water and wastewater (see WR1: Limit GHGs from POTWs).

The Air District does not have regulatory authority over water consumption and the resulting indirect GHG emissions. Therefore, the Air District is taking a supportive and collaborative role to encourage reductions in water use throughout the Bay Area.

Implementation Actions:
Air District will:

- Support efforts of local governments in achieving and exceeding state water use reduction goals by:
  - Disseminating best practices that reduce water consumption and increase on-site water recycling in new and existing buildings;
  - Encouraging the adoption of water conservation ordinances; and
  - Incorporating public outreach and education on water conservation into the Air District's outreach programs.
- Incorporate best practices for water use into local plan guidance, CEQA guidance, and other resources for cities and counties.

Emission Reductions:
Due to the voluntary nature of this measure, estimating potential emission reductions would rely on many assumptions and speculations, and is therefore not possible at this point in time.

Emission Reduction Trade-offs:
None identified.

Cost:
Costs would vary. Available resources would be determined through the Air District's budget process.

Co-Benefits:
Aside from reducing indirect GHGs, this measure has the potential to reduce water consumption throughout the Bay Area which is increasingly important during periods of drought. Water conservation and recycling will continue to be crucial as population and demand increase. In addition, a Stanford University study has argued that the on-going drought in California is linked to climate change, which could mean that future periods of drought could be more frequent or prolonged. Thus, water conservation helps reduce GHGs *and* is a critical adaptation strategy.

Issues/Impediments:
It is not anticipated that there would be significant impediments due to the voluntary nature of this control measure.

Sources:

1. California Air Resource's Board Scoping Plan: http://www.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf
2. SPUR, "The Future of Water", March 2013: http://www.spur.org/publications/article/2013-03-07/future-water
3. Bay Area Integrated Water Management Plan, September 2013: http://bairwmp.org/docs/2013-bairwm-plan-update/2013-final-plan/San%20Francisco%20Bay%20Area%20IRWMP%20Final_September%202013.pdf/view
4. Bulletin of the American Meteorological Society, "The Extraordinary California Drought of 2013/2014: Character, Context, and the Role of Climate Change" Tsiang, M., Haugen, M., Singh, D., Charland, A., Rajaratnam, B., Diffenbaugh, N. S. 2014; 95 (9): S3-S7

SL1: Short-Lived Climate Pollutants

Brief Summary:
This measure describes actions that the Air District will implement to reduce emissions of short-lived climate pollutants (SLCPs), also known as super-GHGs.

Purpose:
The purpose of this measure is to protect the climate by reducing emissions of super-GHGs. Reducing super-GHG emissions can help to restrain global warming in the near term, thereby complementing efforts to reduce CO_2 emissions over the long term.

Source Category:
The term "short-lived climate pollutant", or super-GHGs, refers to a diverse group of climate forcers[1] that have a relatively short lifetime in the atmosphere, but high global warming potential (GWP). GWP is a measure of how much heat a greenhouse gas traps in the atmosphere relative to CO_2 and can be expressed in either a 100-year or 20-year timeframe. A 100-year GWP works well for most of the proposed control measures in the 2017 Plan. However, for short-lived climate pollutant measures, it is more relevant and appropriate to use a shorter 20-year time horizon. Emission reductions expressed using a 20-year time frame highlight the much greater near-term benefit of actions to address short-lived climate pollutants that have a high GWP.

Super-GHGs addressed in this measure, with their GWP values[2], include:

- Methane (100-year GWP = 34; 20-year GWP = 86)
- Black carbon (BC) (100-year GWP = 900; 20-year GWP = 3,200)
- Fluorinated gases (F-gases)[3] (100-year GWP ranges from 140 to 23,900; 20 year-GWPs generally increase by a factor of 2-3)

Methane is the second leading GHG in the Bay Area inventory, after CO_2. Three source categories currently account for approximately 84 percent of total methane emissions in the Bay Area:

- Landfills: 53 percent
- Livestock: 16 percent
- Natural gas production and distribution: 15 percent

[1] A "climate forcer" is defined as any gas or particle that alters the Earth's energy balance by absorbing or reflecting solar radiation.
[2] GWP values are derived from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (2013). See Chapter 8 of Working Group 1 report.
[3] In this document, we use the term "fluorinated gases" for this category of climate forcers to be consistent with terminology at the State level. The term "high GWP gases" is also sometimes used to describe this category of climate pollutant.

Recent studies indicate that current federal, state and regional methods for estimating methane emissions may be under-reporting methane by as much as 50 percent.[4] The Air District will pursue a Basin-wide Methane Strategy (see control measure SS16) to address methane emissions in the region. The strategy includes an effort to better quantify and characterize Bay Area methane emissions, as described in control measure SL3: Greenhouse Gas Monitoring and Measurement Network.

Black carbon, often referred to as soot, is a component of fine particulate matter. In addition to its effects in heating the climate, BC also has negative impacts on public health. Leading sources of BC emissions in the Bay Area include diesel engines and residential wood-burning. As climate change intensifies droughts in California, emissions of BC from wildfires are expected to increase. Some wildfires occur within Air District boundaries, but the Bay Area is also affected by wildfires in surrounding counties. Besides heating the climate, emissions of BC from wildfires impact public health in the Bay Area on an episodic basis.

Fluorinated gases are man-made compounds, many of which are potent climate forcers. Hydrofluorocarbons (HFCs) are the most prevalent F-gases in the Bay Area. HFCs are used in refrigeration and air conditioning systems in commercial, industrial, and residential applications, as well as air conditioning in motor vehicles.

Regulatory Context and Background:
Collectively, super-GHGs account for a significant portion of the total Bay Area GHG inventory, especially if global warming potential is measured over a twenty-year timeframe rather than 100 years. Because super-GHGs have a relatively short atmospheric lifetime, reducing SLCP emissions offers an effective means to reduce GHG emissions in the near term, while strategies to reduce emissions of longer-lived GHGs such as CO_2 are developed and implemented. In addition to directly reducing GHG emissions, near-term actions to decrease super-GHGs can slow climate feedback mechanisms in the Arctic and elsewhere (such as the release of CO_2 and methane caused by the thawing of permafrost) that would otherwise further accelerate global warming. According to the Air Resources Board (ARB), reducing emissions of super-GHGs on a global scale can:

- Cut global warming in half, by 0.6°C in 2050, and by 1.4°C in 2100.
- Reduce warming in the Arctic by two-thirds (0.7°C) by 2040.
- Reduce sea level rise by 25 percent.
- Increase chances of keeping average warming below 2°C to greater than 90 percent by 2050.

In his January 2015 inaugural address, Governor Brown identified reducing SLCP emissions as one of five key pillars of the state's climate protection strategy. The ARB released a draft SLCP Reduction Strategy in April, 2016. Once the final SLCP Reduction Strategy has been reviewed and

[4] For example, a recent study by a team of Stanford University researchers published in the February 14, 2014 edition of *Science* found that leakage from natural gas pipelines may be a significant source of methane emissions. See http://www.nytimes.com/2014/02/14/us/study-finds-methane-leaks-negate-climate-benefits-of-natural-gas.html?_r=0

approved by the ARB Board, the Air District will take appropriate actions to help implement and support the statewide SLCP strategy. In September 2016, Governor Brown signed SB 1383, known as the Super Pollutant Reduction Act, which targets the following reductions in SLCPs to meet the State's long-term GHG reduction goals: 50 percent black carbon, 40 percent methane and 40 percent HFC gases in California by 2030.

Because of their high global warming potential and relatively short atmospheric lifetime, the various SLCPs are often grouped together as a single, separate category of climate pollutants. However, the SLCPs differ in terms of their sources, their projected emission trends, and the specific mechanism by which they contribute to global warming. Therefore, the emission reduction measures for each type of SLCP must be tailored to reflect its specific attributes.

The Air District has been working to reduce emissions of super-GHGs, in conjunction with federal, state, and local efforts to regulate these pollutants. The US EPA and the California ARB have both been pursuing measures to reduce methane emissions. The Air District already limits emissions from key sources of methane via regulation and/or permits from landfills (e.g., Regulation 8-34), composting operations, and natural gas production and distribution (e.g., Regulation 8-37). Additional Air District measures to further reduce methane emissions are described in the "Implementation Actions" section below.

Over the past 10-15 years, there has been great progress in reducing black carbon in response to (1) ARB regulations to reduce emissions from diesel engines, (2) Air District grant programs to reduce emissions from heavy-duty diesel vehicles and equipment, and (3) reductions in wood smoke as a result of the Air District's efforts to reduce wood-burning during winter months. Bay Area BC emissions are projected to continue decreasing through 2020. However, in the absence of additional policies and programs (beyond those already adopted), BC emissions are projected to begin increasing once again from 2020 through 2030 as the Bay Area economy grows and the number of diesel engines increases. Therefore, additional measures may be needed to prevent an increase in BC emissions and to protect public health from exposure to harmful particulate matter.

Emissions of F-gases are regulated at the international, national, and state level. At the global scale, in October 2016, international negotiators reached an important binding agreement, an amendment to the Montreal Protocol, to phase out the production and use of HFCs. In addition, some 50 nations, including the US as well as 50+ partner organizations, have joined the *Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants*. The Air District works to enforce State of California F-gas regulations in the Bay Area. For example, to promote compliance with the state regulation to reduce HFC emissions from commercial and industrial refrigeration systems, the Air District entered into a memorandum of understanding with ARB to ensure that regulated sources register their facilities with ARB and comply with program requirements. Although the State's regulation requires detected leaks to be fixed within 14 days, smaller systems that are subject to the regulation only have to perform leak inspections once a year. For leaks that go undetected in these and larger systems, it is possible a system could lose its entire charge of high-GWP refrigerant and still be in compliance if the leak is then fixed. Also, many systems have higher leak rates than the estimated average of 20-25 percent annually, leaving opportunities for better control of these emissions.

Additionally, the regulation does not include comfort cooling systems (such as air conditioning units in office buildings), multi-family residences, hotels or other commercial, industrial or institutional spaces such as schools. F-gas emissions from these systems that occur during normal operation or maintenance are not reported and may be significant.

Implementation Actions:
Key Air District implementation actions to reduce emissions of super-GHGs are summarized below, with reference to control measures that address super-GHG emissions from several different economic sectors. For additional detail, see the control measures cited in parentheses.

Reduce methane emissions:

- Reduce methane emissions from landfills by amending Rule 8-34 to increase stringency of control and fugitive leak standards, and improve consistency with the State of California Landfill Methane Control Measure federal rules (see WA1).
- Reduce the amount of waste material entering landfills by expanding recycling and waste diversion (see WA4).
- Reduce the amount of waste material entering landfills by increasing the amount of organic material diverted to composting (see WA3).
- Develop model policies that can be employed by local agencies, such as adopting a zero waste ordinance, requiring large commercial and institutional facilities to use compost in their landscaping operations rather than employ artificial fertilizers, and requiring the recycling of construction and demolition materials in all commercial projects and public infrastructure projects (see WA3 and WA4).
- Promote the use of biogas recovery/anaerobic digester systems at Bay Area farms (see AG2).
- Work with the animal farming community to reduce methane emissions from enteric fermentation (see AG3).
- Collaborate with ARB and/or CPUC to develop a rule or rule amendments to reduce methane emissions from natural gas production, processing and storage operations (see SS13: Natural Gas and Crude Oil Production, Processing and Storage) and natural gas pipelines and processing operations (see SS15: Natural Gas Processing, Storage and Distribution).
- Reduce methane emissions from capped natural gas wells (see SS14).
- Continue to implement the amendments to Regulation 8-18, adopted in December 2015, to reduce emissions of methane and other organic gases from equipment leaks at oil refineries (see SS2: Equipment Leaks).

Reduce black carbon emissions:

- Continue and intensify Air District efforts to reduce residential wood-burning (see SS34: Wood Smoke).
- Implement programs to further reduce emissions from diesel-powered back-up generators (see SS32: Emergency Backup Generators).

- Provide grants and incentives to reduce emissions of particulate matter and BC from heavy-duty vehicles (see TR19: Medium- and Heavy-Duty Trucks).
- Continue to enforce ARB diesel regulations in the Bay Area communities most impacted by PM emissions.
- Monitor and support ARB efforts to promote more efficient drive trains in heavy-duty vehicles.
- Pursue strategies to reduce motor vehicle use, as described in various transportation measures, and to decarbonize the transportation sector by promoting alternative fuel vehicles, as described in TR14 (Cars and Light Trucks).

Reduce F-gas emissions:

- Continue to enforce ARB's regulation to reduce leaks from commercial and industrial refrigeration systems that use high-GWP refrigerants.
- Explore potential regulatory options to identify and reduce F-gas emissions in large refrigeration and/or air conditioning systems
- Incentivize leak detection and remediation in large refrigeration and air conditioning systems.
- Develop and promote best practices for leak avoidance, identification and remediation in refrigeration and air conditioning systems
- Incentivize early adoption of low-GWP refrigerants in commercial, industrial and residential refrigeration and air conditioning system retrofits and new installations, including a requirement that disposal of any replaced high-GWP refrigerant follow stringent practices.
- Support the adoption of more stringent regulations by ARB and/or US EPA, such as production phase-downs and sales restrictions of high-GWP refrigerants.
- Encourage better HFC disposal practices of high-global warming potential refrigerants.
- Develop or identify an existing model high-GWP refrigerant disposal ordinance and encourage local governments to adopt such an ordinance.
- Promote measures, such as the Air District's vehicle buy-back program described in control measure TR14 (Cars and Light Trucks), to accelerate turnover in the vehicle fleet of older model vehicles using high-GWPs in their air conditioning systems to vehicles that use low-GWP refrigerants.

Emission Reductions:
The potential emission reductions for many of the implementation actions described above are discussed in specific control measures which those implementation actions proposed for the agriculture, energy, stationary source, and waste sectors. The implementation actions related to F-gases are not duplicative of other control measures and their estimated emission reductions are discussed here. Total emission reductions of F-gases from this control measure are estimated to be 13,200 MT CO2e per year, on a 20-year timeframe, and 6,600 MT CO2e on a 100-year timeframe in 2020. In 2030, reductions are estimated to be 57,200 MT C02e per year, on a 20-year timeframe and 28,600 MT CO2e per year, on a 100-year time frame.

Pollutants*	2020	2030
CO_{2e}	6,600	28,600

**CO_{2e} is reported in metric tons/year (100 yr GWP) in this table*

Emission Reduction Methodology:
Reductions of F-gas emissions for this control measure focus on the impacts of providing incentives for early adoption of low-GWP refrigerants in commercial and industrial refrigeration systems. These reductions are considered additional to State and federal policies. Emission reductions for this measure were calculated based on ARB's proposed Short-Lived Climate Pollutant Reduction Strategy released in April 2016. ARB estimates 2 $MMTCO_2e$ reductions (20 year GWP) could be achieved statewide through a $20 million investment. This dollar per ton cost effectiveness was multiplied by 0.20 to account for the District's portion of the State's population. A typical leak rate of 15-20 percent for large commercial refrigeration systems was assumed.

Exposure Reduction:
Decreasing emissions of black carbon will reduce population exposure to soot and thus help to reduce the wide-ranging health effects related to fine PM and the cancer risk associated with exposure to diesel PM.

Emission Reduction Trade-offs:
Some technologies that reduce PM emissions from vehicles may slightly decrease fuel efficiency. In these cases, it is possible that emissions of CO_2 may slightly increase.

Cost:
The potential costs for many implementation actions described above are discussed in the specific control measures proposed for the agriculture, energy, stationary source, and waste sectors.

The cost/benefit data provided in the table below illustrates that prior regulatory actions at the State level associated with reducing emissions of F-gases associated with refrigerants appear to be cost effective (data is from ARB's Refrigerant Management Program). However, potential Air District regulatory and/or programmatic activities are unknown at this time and therefore a cost/benefit analysis will be performed when and if specific regulatory actions are identified for the Bay Area.

Annual costs	Facilities with small systems (50-200 lbs. high GWP refrigerant)	Facilities with medium systems (200 – 2,000 lbs.)	Facilities with large systems (>2,000 lbs.)
Total gross cost	$651	$2,770	$5,410
Refrigerant savings	$637	$2,740	$14,130
Total net annual cost	$14	$30	$8,720 (savings)

Co-benefits:
Decreasing emissions of black carbon will protect public health by reducing population exposure to fine PM. Mitigating leaks of F-gases in refrigeration and air conditioning increases the efficiency of the system and offsets the cost of mitigation.

Issues/Impediments:
None identified at this time.

Sources:

1. Air Resources Board. *Proposed Short-Lived Climate Pollutant Reduction Strategy*. April 2016
2. Air Resources Board. *Initial Statement of Reasons for Proposed Regulation for the Management of High Global Warming Potential Refrigerants for Stationary Sources Appendix C: Economic Estimates*. October 23, 2009.

SL2: Guidance for Local Planners

Brief Summary:
The Air District will develop guidance to help local agencies address short-lived climate pollutants (SLCPs), or super-GHGs, in their climate action plans and programs.

Purpose:
The purpose of this measure is to encourage local agencies to include actions to reduce super-GHG emissions in their climate plans and programs.

Source Category:
The term "short-lived climate pollutants", or super-GHGs, refers to a diverse group of climate forcers[1] that have a relatively short lifetime in the atmosphere, but have high global warming potential (GWP).[2] Super-GHGs addressed by this control measure include:

- Methane
- Black carbon (BC)
- Fluorinated gases (F-gases)

Methane is the second leading GHG in the Bay Area inventory, after CO_2. Three source categories currently account for 90 percent of total methane emissions in the Bay Area:

- Landfills: 50 percent
- Animal waste: 27 percent
- Natural gas production and distribution: 13 percent

Leading sources of BC emissions in the Bay Area include diesel engines and residential wood-burning.

Hydrofluorocarbons (HFCs) are the most prevalent of the fluorinated gases in the Bay Area. HFCs are used in refrigeration and air conditioning systems in commercial, industrial, and residential applications, as well as air conditioning in motor vehicles.

Regulatory Context and Background:
As described in control measure SL1, super-GHGs account for a significant portion of the total Bay Area greenhouse gas (GHG) inventory. Current and proposed regulatory measures to reduce super-GHG emissions are also described in SL1. Because super-GHGs have a relatively short atmospheric lifetime, reducing super-GHG emissions offers an effective means to reduce GHG emissions in the near term, while strategies to reduce emissions of longer-lived GHGs such as carbon dioxide (CO_2) are developed and implemented. In addition to directly reducing GHG

[1] A "**climate forcer**" is defined as any gas or particle that alters the Earth's energy balance by absorbing or reflecting solar radiation.

[2] In this document, we use the term "short-lived climate pollutants" for this category of climate forcers in order to be consistent with terminology at the State level. However, the term "high GWP gases" might be more accurate to describe this category since most fluorinated gases have long lifespans in the atmosphere, as discussed below.

emissions, near-term actions to decrease super-GHG emissions can slow climate feedback mechanisms in the Arctic and elsewhere (for example, the release of CO_2 and methane caused by the thawing of permafrost) that would otherwise further accelerate global warming. According to the Air Resources Board (ARB), reducing emissions of super-GHGs on a global scale can:

- Cut global warming in half, by 0.6°C in 2050, and by 1.4°C in 2100.
- Reduce warming in the Arctic by two-thirds (0.7°C) by 2040.
- Reduce sea level rise by 25 percent.
- Increase chances of keeping average warming below 2°C to greater than 90 percent by 2050.

In his January 2015 inaugural address, Governor Brown identified reducing SLCP emissions as one of six key pillars of the state's climate protection strategy. The ARB released a draft statewide SLCP Reduction Strategy in April 2016. The draft statewide SLCP strategy identifies a number of potential opportunities for local actions to reduce super-GHG emissions. ARB staff is currently preparing a final version of the strategy for review and approval by the ARB board.

Many local agencies in the Bay Area play an important role in reducing emissions of GHGs by implementing policies that complement state and regional programs. Some local agencies already address super-GHGs in their climate action plans, primarily via measures that would help to reduce methane emissions from landfills, water treatment, or agriculture. In addition, several local climate action plans include measure to address F-gases. For example, the Marin County climate action plan includes a measure to implement best management practices to reduce F-gas emissions from the use and disposal of refrigerants. The City of Livermore climate action plan includes several potential measures to reduce emissions of F-gases, and the City of El Cerrito climate action plan calls for developing a local policy to reduce emissions of F-gas refrigerants to the lowest achievable and practical levels.

To date, however, most of the 60+ local climate action plans adopted by Bay Area cities and counties primarily focus on reducing emissions of CO_2. Local governments can potentially increase the scope and effectiveness of their climate action plans by adding super-GHGs to their local GHG inventories and including measure to reduce super-GHGs in their climate action strategies.

Implementation Actions:

The Air District will encourage local agencies to help reduce emissions of super-GHGs in the Bay Area by:

- Providing information to local agencies to describe the current and projected emissions of super-GHGs and their contribution to the overall regional GHG inventory.
- Explaining why reducing super-GHG emissions can be an important element of a comprehensive local
climate action plan and providing technical assistance to develop or update climate action plans to address super-GHGs.
- Suggesting potential policies or measures that local agencies can implement to reduce super-GHG emissions (see examples of potential actions described below).

- Tracking progress in adoption of super-GHG reduction measures in local plans via its database that catalogs local GHG policies.

Examples of potential actions that local agencies can take to reduce super-GHG emissions are described below.

Methane reductions:

- Reduce methane emission from landfills by diverting food waste and organic materials from the waste stream (see WA2).
- Work with the farming community to promote practices and projects that reduce methane from agriculture, such as promoting dairy digesters (see measures AG1 and AG2).

Black carbon reductions:

- Promote the use of alternative fuel vehicles in local fleets and communities in order to reduce emissions of black carbon from diesel engines.
- Promote the use of the cleanest available construction equipment in local projects, promote the use of clean construction equipment as a CEQA mitigation measure, and monitor project implementation to ensure compliance with clean equipment requirements.
- Support the Air District's efforts to reduce residential wood-burning.
- Consider collaborating with land management and fire agencies to promote land use and forestry practices that reduce the chance of large-scale wildfires.

F-gas reductions:

- Take action to minimize F-gas emissions from use and/or disposal of air conditioning systems, motor vehicles, refrigeration units, and other sources.

Emission Reductions:
No emission reduction estimates have been quantified for this measure.

Exposure Reduction:
Decreasing emissions of black carbon will reduce population exposure to soot and thus help to reduce the wide-ranging health effects related to fine PM and the cancer risk associated with exposure to diesel PM.

Emission Reduction Trade-offs:
None identified.

Cost:
No significant costs associated with this measure are identified at this time.

Co-benefits:

Decreasing emissions of black carbon will protect public health by reducing population exposure to fine PM.

Issues/Impediments:

No significant issues or impediments are identified at this time.

Source:

1. Air Resources Board. *Draft Short-Lived Climate Pollutant Reduction Strategy*. April 2016

SL3: Greenhouse Gas Monitoring and Measurement Network

Brief Summary:
This measure facilitates the Air District's continued efforts to operate a fixed site greenhouse gas (GHG) monitoring network across the San Francisco Bay Area.

Purpose:
This control measure will increase the Air District's knowledge of methane and other GHG emission sources in the Bay Area by identifying emission 'hotspots', facilitate verifying and validating the Air District's regional methane emissions inventory, and to ultimately evaluate the efficacy of policy measures and regulatory actions adopted and implemented by the Air District.

Source Category:
This measure is related to information gathering and is not specific to any particular source category.

Regulatory Context & Background:
The Air District traditionally estimates emissions for the regional GHG inventory using a bottom-up methodology. In this approach, emission factors (e.g. the amount of methane emitted per unit of biomass burned), based on accepted studies and practices, are combined with activity data (e.g. population density, fuel consumed) to generate source-specific emissions estimates. This approach is consistent with how the Air Resources Board (ARB) and the U.S. Environmental Protection Agency (EPA) develop statewide and national GHG inventories, respectively. As methane measurement technologies have improved over the last decade, there is increased interest within the scientific community to verify and validate the estimates in the bottom-up inventories using a variety of top-down observational techniques that depend on direct measurement of methane concentrations in the atmosphere. Recent literature suggests that traditional bottom-up methods of generating emission inventories in California may be significantly under-estimating actual emissions of methane (Wunch et al., 2009; Hsu et al., 2010; Wennberg et al., 2012; Peischl et al., 2013; Jeong et al., 2014). In a recent study that utilizes methane data collected over the last two decades from several Air District monitoring stations (Fairley and Fischer, 2015), the authors conclude that the resulting methane emissions are 1.5 to 2 times greater than the Air District's bottom-up inventory estimates. With this control measure, the Air District intends to resolve this data gap through source-specific measurements of methane throughout the Bay Area.

The first phase of this program focused on setting up a long-term GHG monitoring network at four sites. One of the four sites is located north and generally upwind of the urban core at Bodega Bay along the Pacific Coast. This site receives clean marine inflow from the west-northwest and hence provides a regional background level of ambient methane. The other three sites are strategically located at exit points for Bay Area wind paths that contain concentration enhancements generated from Bay Area GHG sources added to the prevailing background concentrations. These stations are at San Martin, which is located south and generally downwind of the San Jose metropolitan area; at Patterson Pass, which is at the cross section of the eastern edge of the Bay Area with California's Central Valley; and at Bethel Island at the mouth of the Sacramento-San Joaquin Delta. At all sites, carbon dioxide and methane are being measured continuously, along with carbon monoxide (acting as a source tracer for combustion emissions) and other air pollutants.

The second phase of the program will include use of a van to serve as a mobile GHG measurement platform, equipped with state-of-the-art instruments capable of measuring not only methane, carbon dioxide and carbon monoxide, but also nitrous oxide (N_2O), isotopic methane and the hydrocarbon tracer ethane. There are a variety of local stationary GHG sources in the Bay Area including landfills, wastewater treatment plants, dairies, oil refineries, natural gas cogeneration plants, gas pipelines etc. Measurements of concentrations of GHGs conducted upwind and downwind of such sources will be combined with short-range measurement techniques and an atmospheric dispersion model to verify source emission rates. The isotopic information will aid in source attribution. These measurements from local sources will allow verification and validation of the Air District's regional GHG emissions inventory for the Bay Area.

Implementation Actions:

- Continue development of a GHG monitoring plan for the Bay Area that includes strategic selection of measurement locations, selection of relevant measurement technologies and procurement of appropriate GHG instrumentation, calibration gas standards and sampling logistics.
- Operate and maintain the fixed-site GHG monitoring network.
- Report monitoring data on the Air District's website for access by the public and scientific community alike.
- Utilize an ultraportable methane analyzer to detect emissions hotspots in the Bay Area.
- Analyze date from fixed-site network data to develop future source-specific investigation plans.
- Fabricate and equip the Air District's mobile measurement van with high resolution instrumentation, meteorological devices, and related equipment for localized GHG measurements.
- Collaborate with the scientific community to use different methods to estimate regional methane emissions for the Bay Area utilizing top-down observations, estimate methane mass emission rates from individual sources and facilities, and develop spatially resolved maps of methane emissions.

Emission Reductions:
This control measure will inform policy, program and rule development efforts targeted at methane emission reductions.

Emission Reduction Methodology:
This control measure will not directly reduce emissions.

Exposure Reduction:
This control measure will not directly impact emission exposure.

Emission Reduction Trade-Offs:
This control measure will not directly impact emissions.

Cost:
To date, approximately $600,000 has been invested in the GHG monitoring network. The majority of this amount (~ $570,000) has been spent on procuring eight sophisticated and top-of–the-line GHG instruments that will be the core of the GHG stationary and mobile network. Existing Air District staff operate and maintain the equipment and evaluate the data collected.

Co-Benefits:
In addition to improving the Air District's methane emissions estimates, the GHG monitoring and measurement network also includes CO_2 measurements at the fixed-site locations, and both CO_2 and N_2O aboard the mobile platform. There is significant uncertainty in ARB's bottom-up N_2O emissions inventory especially in the transportation sector (Guha et al., 2015) that needs to be investigated through top-down studies. The N_2O measurement capability is a powerful tool to better understand the Bay Area's N_2O emission sources. Additionally, the methane measurement infrastructure will attract potential collaborators in academic and research institutions, building knowledge which will be critical to the implementation of other control measures in the 2016 Plan.

Issues/Impediments:
Methane source identification and attribution becomes more robust when accompanied by simultaneous measurement of source markers e.g. volatile organic compounds like ethane (to detect methane from fugitive oil and gas sources) and methanol (to detect methane from dairy and livestock sources). Adding additional measurement capability to the GHG mobile platform would require additional financial resources.

Sources:

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FSM_SS1: Internal Combustion Engines

Brief Summary:
This measure is based on San Joaquin Valley Air Pollution Control District (SJVAPCD) Rule 4702 which appears to have lower NO_x emission limits for some categories of internal combustion (IC) engines, compared to BAAQMD Regulation 9-8. Rule 4702 also applies to smaller engines than Regulation 9-8.

Purpose:
Further emission reductions of NO_x from IC engines.

Source Category:
Stationary IC engines.

Further Study Measure Description:
San Joaquin Valley APCD Rule 4702 was significantly revised in 2011 to incorporate new emission limits for IC engines. [The latest, November 2013 amendment of SJVAPCD Rule 4702 was entirely editorial and administrative.] The analogous BAAQMD rule – Regulation 9-8 – was last amended in 2007.

The differences between SJVAPCD Rule 4702 and BAAQMD Regulation 9-8 may be summarized as follows:

1) SJVAPCD Rule 4702 has standards for agricultural and non-agricultural engines, while BAAQMD Regulation 9-8 exempts agricultural engines entirely.

2) SJVAPCD Rule 4702 applies to engines as small as 25 bhp, while Regulation 9-8 applies to engines larger than 50 bhp. It should be noted that the South Coast AQMD Rule 1110.2 (September 2012) applies only to engines larger than 50 bhp.

SJVAPCD Rule 4702 does not set emission limits for engines in the 25 to 50 bhp size range. Instead, it requires that engines sold in this size range comply with EPA's New Source Performance Standards (NSPS) for both spark-ignition and compression ignition engines (40 CFR 60, Subparts JJJJ and IIII, respectively), and only if the engines are not used in agricultural operations. This requirement is also not applicable to leased engines. Because Rule 4702 does not require existing engines in the 25 to 50 bhp size range to meet any particular standard, and does not require that existing engines be phased out, SJVAPCD claimed no emission reductions for engines in the 25 to 50 bhp size range and also concluded that "there is no cost associated with adding engines between 25 bhp and 50 bhp" [to rule 4702].

The 2011 BAAQMD emissions inventory includes an element for "reciprocating engines / liquid fuel (area)" which includes all engines rated 50 bhp and less which do not require permits. The total NO_x emissions for this inventory element is 0.27 ton/day. This emission figure is not based on direct data about engines rated less than 50 bhp that are operated in the Bay Area since neither BAAQMD, nor any other agency, requires permits or registration of such engines. Also, this total emission figure includes emissions from engines rated less than 25 bhp.

Typically, for engines and other combustion devices such as boilers, smaller devices are more numerous than larger devices. Therefore, if all engines rated less than 50 bhp have total emissions of 0.27 ton/day, engines rated 25 to 49 bhp might reasonably be expected to have about half of these emissions, or no more than 0.14 ton/day NO_x. The staff report for the 2007 amendments to Regulation 9-8 estimated NO_x emission reductions of 45 percent to 71 percent for each category of engine for which new emission limits were imposed. Assuming the highest reduction (71 percent) could be achieved on engines rated 25 to 49 bhp, the resulting NO_x emission reduction would be slightly less than 0.1 ton/day. So, even making these conservative assumptions, the potential NO_x emission reduction appears to be marginal, and realization of this reduction would require that older engines be replaced on an accelerated basis. If the requirement applied only to new engine sales, without applying to existing engines, then the quantifiable emission reductions would be negligible. In other words, Rule 4702's provisions with regard to small engines do not represent a significant improvement beyond the current provisions of BAAQMD Regulation 9-8.

3) SJVAPCD Rule 4702 imposes lower NO_x limits than BAAQMD Regulation 9-8 for engines larger than 50 bhp, and includes emission limits for agricultural engines that BAAQMD Regulation 9-8 exempts entirely. SJVAPCD regulates spark-ignition and compression-ignition engines in different ways. For spark-ignition engines, the differences in these rules may be summarized as follows:

Table 1: Spark-Ignition NO_x Limits in SJVAPCD Rule 4702 and BAAQMD 9-8 (at 15% oxygen)

Application	SJVAPCD 4702	BAAQMD 9-8
Agricultural (spark-ignition), installed after 6/16/05	•Rich-burn: 90 ppmv •Lean-burn: 150 ppmv	•Unregulated •Unregulated
Agricultural (spark-ignition), installed on or before 6/16/05	CARB certified to be <0.6 g/bhp-hr for NO_x and VOC (combined)	•Unregulated •Unregulated
Non-Agricultural (spark-ignition), phase 1: 1/1/12 thru 1/1/17	•Rich burn, waste gas: 50 ppmv •Rich burn, fossil fuel: 25 ppmv •Lean-burn, all fuel: 65 ppmv	•Rich burn, waste gas: 70 ppmv •Rich burn, fossil fuel: 25 ppmv •Lean burn, waste gas: 70 ppmv •Lean burn, fossil fuel: 65 ppmv
Non-Agricultural (spark-ignition), phase 2	•Rich burn, waste gas: 50 ppmv •Rich burn, ≤4,000 hr/yr: 25 ppmv	No change from phase 1

	•Rich burn, all others: 11 ppmv •Lean burn, waste gas: 65 ppmv •Lean burn, ≤4,000 hr/yr: 65 ppmv •Lean-burn, all others: 11 ppmv	

For compression-ignition engines, SJVAPCD Rule 4702 and BAAQMD Regulation 9-8 use completely different regulatory schemes. BAAQMD Reg 9-8 simply applies a NO_x limit of 180 ppmv (at 15 percent oxygen) to engines rated 51 to 175 bhp, and a limit of 110 ppmv to larger engines.

To understand SJVAPCD's regulatory scheme for compression-ignition engines, it is necessary to understand US EPA's emission limits for non-road compression-ignition engines, which are generally known as the "Tier" standards. US EPA imposed a set of emission limits (Tier 1 through Tier 4). These limits applied to new, compression ignition engines. Each tier was in effect for 3 or 4 years and during that time, was phased in for different engine size ranges. Because each tier was phased in over a period of years, on any date different tiers may have been in effect for different engine size ranges. In 2014 and 2015, the "final" Tier 4 limits are being implemented. Each tier applies only to engines manufactured while that tier is in effect, and each subsequent tier reduces the emission limits. The tier limits do not apply to existing engines and therefore the emission reductions associated with the tier limits are realized as pre-Tier 1 engines are retired, as well as Tier 1, Tier 2 and Tier 3 engines. Under this federal scheme, eventually only Tier 4 engines will remain in service. SJVAPCD Rule 4702 requires that existing engines (agricultural and non-agricultural) meet specific EPA tier requirements, and addresses pre-Tier 1 differently than later engines. For pre-Tier 1 engines, depending on the engine size, Rule 4702 requires compliance with either Tier 3 or Tier 4 emission limits or a NO_x limit of 80 ppmv. For Tier 1 and Tier 2 engines, Rule 4702 requires compliance with Tier 4 limits by no later than 2018. For Tier 3 and Tier 4 engines, Rule 4702 has no other requirements.

Considering Table 1 for spark-ignition engines and the discussion of both districts' treatment of compression-ignition engines, SJVAPCD has more stringent standards than BAAQMD because:

1) SJVAPCD imposes emission limits on spark-ignition, agricultural engines while BAAQMD does not,

2) While current emission limits for non-agricultural engines are similar at both districts, SJVAPCD has adopted a next phase of emission limits for these engines that are significantly lower, although these limits apply only to engines that operate more than 4,000 hr/yr, and

3) For compression-ignition engines (agricultural and non-agricultural) SJVAPCD requires existing engines to eventually comply with either US EPA Tier 3 or Tier 4 emission limits or an 80 ppmv NO_x limit, while BAAQMD has a NO_x limit of either 110 or 180 ppmv NO_x (depending on engine size, all at 15% oxygen). These NO_x limits are equivalent to 2.5 and 3.7 g NO_x/bhp-hr, respecitively, according to the 2007 staff report for Regulation 9-8 amendments.

A final factor to consider in comparing SJVAPCD and BAAQMD requirements is that, for compression-ignition engines, CARB has issued an ATCM that imposes emission limits on virtually all stationary, compression-ignition engines in California. The final compliance date for the ATCM is 12/31/2015, although this date is extended for recently-installed and relatively low-emitting engines. Although the main purpose of the ATCM was to reduce toxic diesel PM emissions, the ATCM imposes combined NO_x and non-methane volatile organic compound (MHC) limits for new, emergency and prime-use engines. For existing, emergency and prime-use engines, the ATCM simply requires that NO_x and NMHC emissions not increase over "baseline" levels.

The potential areas for improvement in BAAQMD Regulation 9-8 that are discussed above were anticipated in the 2007 staff report for the last amendments to Regulation 9-8. The staff report indicates that:

• For spark-ignition and compression-ignition engines, the 2007 emission limits represented "the most stringent demonstrated retrofit control technology available".

• For compression-ignition engines, the new limits "incorporate the most stringent future-effective EPA standards", which refers to the "Tier" standards.

• With regard to agricultural engines, the staff report indicates that CARB data was used to estimate total annual NO_x emissions of 0.076 ton/day, and that these emissions did not justify including agricultural engines in the rule.

Based on the discussion above, BAAQMD will:

1) No action to reduce NO_X emissions from agricultural engines, based on the previous emission estimates for these devices in the 2007 Regulation 9-8 staff report. However, because the BAAQMD emissions inventory does not have an element for stationary, agricultural IC engines, the inventory should be improved in this area.

2) As discussed above, SJVAPCD Rule 4702 imposes a low 11 ppmv NOx limit on high-use, non-agricultural, spark-ignition engines (>4,000 operating hr/yr). The 2007 Regulation 9-8 staff report considers spark-ignition engines used >100 hr/yr to be "prime" engines and imposed a NOx limit ranging from 25 to 70 ppmv. SJVAPCD further identified "high-use" engines where SCR would be cost-effective and imposed an 11 ppmv limit on these engines. Neither the 2007 Regulation 9-8 staff report, nor the BAAQMD base-year 2011 inventory identifies high-use engines in the Bay Area. However, even after implementation of the emission controls in Regulation 9-8, prime spark-ignition engines would still have a total NOx emission inventory of 2.6 ton/day (based on the emission and emission reduction data in Table 12 of the 2007 staff report). Therefore, depending on how many of these engines are "high-use", further NOx controls might be justified.

Sources:

1. San Joaquin Valley APCD: Final Draft Staff Report with Appendices for Revised Proposed Amendments to Rule 4702, August 2011.
2. BAAQMD: Staff Report for Proposed Amendments to Regulation 9-8, July 2007.
3. BAAQMD: Base Year 2011 Emissions Inventory.

FSM_SS2: Boilers, Steam Generator and Process Heaters

Brief Summary:
This measure is based on Measure D.1.2 from the 2012 San Joaquin Valley Air Pollution Control District (APCD) $PM_{2.5}$ Plan. Measure D.1.2 examined the possibility of further emission reductions from Boilers, Steam Generators and Process Heaters from 2MM to 5 MM BTU/hr in size through San Joaquin's Rule 4307.

Purpose:
Further reductions of oxides of nitrogen (NO_X) emissions from small boilers, steam generators and process heaters.

Source Category:
Combustion

Further Study Measure Description:
Air District Regulation 9, Rule 7 regulates all Bay Area boilers, steam generators and process heaters with a rated heat input above 2 MM BTU/hr, while San Joaquin has a rule specifically for the size category of 2MM to 5MM BTU/hr.

Rule 9-7 was last amended in 2011. For devices rated above 2 to 5 MM BTU/hr (both new and existing), Rule 9-7 imposes a 30 ppmv NO_X limit at 3% oxygen, and requires certification of models by manufacturers and registration of installed devices by owner or operators. The 30 ppmv limit was effective on January 1, 2013 with multi-unit facilities able to extend full compliance by as much as 2 years to January 1, 2015.

San Joaquin Rule 4307 also imposes a 30 ppmv NO_X limit for existing devices, but has more stringent limits of either 12 or 9 ppmv for new or replacement devices (atmospheric and non-atmospheric devices, respectively). Both limits for new devices have been in effect in San Joaquin since 2010. The question presented by this measure is whether to reduce the current 30 ppmv NO_X limit in Rule 9-7 for new devices.

As of July 2014, San Joaquin has certified only a single compliant device, so it is unclear if devices that comply with the 12 and 9 ppmv limits are generally available. South Coast AQMD's Rule 1146.2 applies to boilers, steam generators and process heaters in a smaller size category (above 400,000 to 2MM BTU/hr) and South Coast maintains an extensive list of certified devices on their website. These smaller devices are certified for an emission limit of 20 ppmv NO_X.

Further actions the Air District could take include verifying the actual commercial availability of boilers, steam generators and process heaters in the size range above 2MM BTU/hr with certified NO_X emission rates less than 30 ppmv. Depending on the availability of lower-NO_X devices, estimate potential emission reductions and cost-effectiveness of a reduced NO_X limit for new devices in this size range.

Source:

1. San Joaquin Valley Unified APCD 2012 PM2.5 Plan, Control Measure D.1.3: "Boilers, Steam Generators and Process Heaters-0.075 MM BTU/hr to less than 2.0 MM BTU/hr".

FSM_ SS3: GHG Reductions from Non Cap-and-Trade Sources

Brief Summary:
This measure will use quantitative analysis to evaluate greenhouse gas (GHG) reduction opportunities from stationary sources that are not covered under the California Air Resources Board's (ARB's) Cap-and-Trade Program.

Purpose:
The purpose of this measure is to complement the State's Cap-and-Trade program by achieving GHG emission reductions from stationary sources within the Bay Area that do not fall under the Cap-and-Trade program

Source Category:
Small-scale stationary sources not covered by the State Cap-and-Trade program.

Further Study Measure Description:
At the state level, the California Global Warming Solutions Act of 2006 (AB 32) requires a 20 percent reduction in the State's GHG emissions below 1990 levels by 2020. The first AB 32 Scoping Plan identified a cap-and-trade program as one of the strategies California would employ to meet the State's GHG reduction goals. ARB's Cap-and-Trade program established a cap on GHG emissions from certain categories of sources, set to decline approximately 3 percent each year beginning in 2013. Facilities subject to this cap are able to trade allowances to emit GHGs in order to minimize compliance costs.

The Cap-and-Trade program includes exemptions such as fugitive emissions from certain industrial processes, and facilities with emission levels below the reporting threshold of 25,000 MT CO_2e/yr. In the Bay Area, there are over 5,700 stationary sources that emit GHGs. Of these, approximately fifty exceed this reporting threshold. This figure indicates that there is an opportunity to explore options for reducing stationary source emissions outside of the Cap-and-Trade program. Preliminary analyses indicate that the bulk of these emissions occurred in the biofuel, natural gas distribution, sewage treatment, and landfills sectors. At the regional level, the Air District has adopted a GHG reduction target of 80 percent below 1990 levels by 2050. In an effort to complement ARB's climate work and meet its own goals, Air District staff will analyze GHG data for Bay Area stationary sources not covered under ARB's Cap-and-Trade program. These analyses can help the Air District prioritize its climate protection efforts by highlighting Bay Area stationary sources having the largest emissions not covered under Cap-and-Trade. Further analysis of the data may uncover new rulemaking opportunities.

Sources:
1. Assembly Bill No. 32: California Global Warming Solutions Act of 2006
2. California Air Resources Board's Cap-and-Trade Program: http://www.arb.ca.gov/cc/capandtrade/capandtrade.htm
3. California Air Resources Board's Greenhouse Gas Inventory Data:

http://www.arb.ca.gov/cc/inventory/data/data.htm

FSM_SS4: Methane Exemptions from Wastewater Regulation

Brief Summary:
The Air District's regulation regarding waste water, Regulation 8, Rule 8, currently does not apply to methane emissions. As outlined in SS16, the Air District proposes to evaluate and eliminate methane exemptions in Regulation 8 where feasible and relevant.

Purpose:
This measure seeks emission reductions of methane, a powerful greenhouse gas (GHG). Removing the methane exemption from Rule 8-8 may also improve the rule enforceability.

Source Category:
Stationary Sources – waste water systems

Further Study Measure Description:
Regulation 8, Rule 8 currently applies to "wastewater collection and separation systems that handle liquid organic compounds from industrial processes." The regulation applies to oil/water separators and air flotation (AF) devices and associated equipment, but does not apply to "secondary treatment" processes downstream of the separator and AF device. Methane is excluded in the definitions of both "Organic Compound" and of "Critical Organic Compound." The term "Organic Compound" is used in the vapor leak standard for separators and the required efficiency of abatement devices. The concentration of "Critical Organic Compounds" is the basis for the exemption in 8-8-112 for refinery and non-refinery separators, and for associated records.

A draft scoping paper for the amendment of Rule 8-8 was prepared in early 2015. In the scoping paper, Air District staff assumed that add-on controls, such as thermal oxidizers, could be installed on various parts of the wastewater system to combust methane. However, rule development on Rule 8-8 was suspended because methane concentration data at Bay Area refinery wastewater systems suggested that concentrations were too low to justify such add-on controls. Instead, additional research and testing will be required to identify significant methane sources farther upstream in the process, where methane concentrations may be higher.

The Air District will conduct research and testing to identify significant methane sources in the refinery wastewater collection systems, and to determine how these sources may be minimized or controlled. In addition, the Air District will seek to better understand methane emissions from non-refinery wastewater systems, such as those used in publicly owned treatment works (POTWs), and quantify potential emission reductions for methane, as well as for volatile organic compounds (VOC), in order to determine if Reg. 8-8 should be expanded to additional non-refinery sources. See WR1: Limit GHGs from POTWs for more detail.

Sources:

1. BAAQMD Regulation 8, Rule 8

FSM_SS5: Controlling SSMM Emissions

Brief Summary:
Existing Air District regulations and permit conditions limit criteria pollutant emissions from equipment at chemical plants, bulk terminals, and petroleum refineries. However, most requirements apply to routine operations and have exemptions from emissions limits during startup, shutdown, maintenance, and malfunction (SSMM) events. This measure would consider further addressing emissions from SSMM events.

Purpose:
Reduce NO_X, $PM/PM_{10}/PM_{2.5}$, SO_2, VOC, and TAC emissions by considering implementing requirements to minimize SSMM emissions through abatement technology, equipment design considerations, revised activity scheduling, or planned redundancy.

Source Category:
Equipment at chemical manufacturing plants, bulk terminals, and petroleum refineries that undergo SSMM activities.

Further Study Measure Description:
Other than malfunctions, SSMM activities may be either planned or unplanned. Planned SSMM activities may result in unplanned SSMM events. Depending on the activity, emissions from SSMM activities can be significant (a single refinery turnaround in 2015 lasted 56 days and emitted 180 tons of VOC and 394 tons of SO_2).

Planned SSMM activities include:

- Process unit de-inventory
- Process unit depressurization
- Equipment cleaning, purging, repair, rebuild
- Equipment installation or removal
- Catalyst installation or removal
- Refractory installation, repair, or removal

Unplanned SSMM activities include:

- Plant upset
- Equipment failure

Emissions during SSMM activities may result from bypassing control devices, purging vessels, pressure relief valve venting, flaring, or usage of temporary combustion sources (e.g. diesel generators, steam boilers, thermal oxidizers, etc.).

During maintenance periods, a petroleum refinery flare or flare gas recovery system may have limited capacity or availability and flare gas loading can exceed the capacity of the flare gas recovery system. Such “high loading” events can cause upsets to entire facility operations.

Several Air District regulations limit emissions from some SSMM activities but there is no comprehensive SSMM rule that applies to all SSMM activities.

Regulation 8, Rule 10 limits organic compound emissions from process vessel depressurizing but does not apply when either the internal pressure or internal organic compound concentration (regardless of mass) is low.

Regulation 8, Rule 28 limits organic compound emissions from pressure relief devices at petroleum refineries and chemical plants. However, this rule does not apply to devices handling heavy liquids (e.g. diesel, jet fuel, gas oil, etc.).

Regulation 12, Rule 12 requires minimizing flaring events through facility-developed flare minimization plans. However, there is a large variation in the specificity and comprehensiveness of each refinery plan. In addition, refineries are required to notify, determine, and report the cause of only large flaring events.

Title 40 of the Code of Federal Regulations Part 63 (National Emission Standards for Hazardous Air Pollutants for Source Categories), Subpart A (General Provisions) includes requirements to develop a startup, shutdown, and malfunction plans. However, these plans only apply to those sources that are subject to a NESHAP rule.

Techniques to reduce or eliminate SSMM emissions include:

- Implementing a management of change/SSMM process
- Optimal scheduling (scheduling to minimize emissions)
- Implementing best practices
- Permanent or temporary emission control technology
- Usage of lower emitting equipment (e.g. scrubbers)
- Implementing redundancy for critical equipment
- Using vapor recovery rather than combustion technology

In order to investigate controlling these emissions, the Air District will:

- Complete study on SSMM emissions.
- Complete study of regulatory efforts on largest, most cost effective SSMM emission reductions and mitigation steps.
- Explore the number, types, and durations of SSMM activities and events at chemical manufacturing plants, bulk terminals, and petroleum refineries in the Air District.
- Explore potential design, equipment, scheduling, and process variability considerations that affect SSMM emissions.
- Estimate potential emission reduction and costs.

Sources:

1. Air District Regulation 8, Rule 10

2. Air District Regulation 8, Rule 28
3. Air District Regulation 9, Rule 10
4. Air District Regulation 12, Rule 12
5. Title 40 Code of Federal Regulations Part 63 Subpart A
6. Texas Administrative Code Title 30 Part 1 Chapter 115 Subchapter D Division 1 (Process Unit Turnaround and Vacuum-Producing Systems in Petroleum Refineries) Rule 115.312 (Control Requirements)
7. SCAQMD Rule 1123 (Refinery Process Turnarounds)
8. SJVUAPCD Rule 4454 (Refinery Process Unit Turnaround)

FSM_SS6: Carbon Pollution Fee

Brief Summary:
The measure would explore options for placing a fee on fossil fuels based on the carbon intensity of the fuel.

Purpose:
Placing a fee on the carbon pollution generated by fossil fuels creates an incentive to all those that consume these fuels – individuals, businesses, industry – to reduce use. This reduction in consumption would reduce emissions of criteria pollutants, toxic air contaminants and greenhouse gases (GHGs) not only because less fuel is combusted but also because less fuel is processed and manufactured in response to reduced demand.

Source Category:
Consumption of fossil fuel for all uses – e.g., heating, fueling vehicles, manufacturing.

Further Study Measure Description:
A carbon pollution fee, or carbon tax, is a form of carbon pricing that assesses a fee on fuel based on the carbon content of that fuel. Since the carbon content of every form of fossil fuel - and thus the CO_2 emissions from burning these fuels - is precisely known, a carbon tax is, in fact, a tax on the CO_2 emissions from burning fossil fuels. For example, since generating a unit of energy (Btu) from coal produces 30 percent more CO_2 than a Btu from oil, and 80 percent more CO_2 than a Btu from natural gas, a carbon fee could follow these proportions and tax coal more heavily than oil, and much more heavily than natural gas. Fuels that do not require combustion for power generation, and thus do not result in emissions of CO_2 (e.g., wind, solar), would not be taxed.

A fee on carbon pollution creates broad incentives to encourage decision-makers in all areas of society – individuals, businesses, and industry - to reduce fossil fuel consumption and thus CO_2 emissions. These reductions would take place as a result of a range of changes in behavior, from conservation to fuel substitution to technological innovation. In addition, a carbon fee creates incentives at every link in the chain of decision and action — from individuals' choices and uses of vehicles, appliances, and housing, to businesses' choices of new product design, capital investment and facility location.

It should be noted that there are currently two existing fee programs in place in the Bay Area associated with GHG emissions. Specifically, since 2008, the Air District has imposed a GHG fee - the first in the nation - on permitted facilities based on the facility's annual CO_2e emissions. The funds raised are used to recover the costs of climate protection activities from the Air District's core programs including environmental review, air pollution regulations and emissions inventory development. In addition, California's Cap and Trade Program, which began in 2012, sets a firm and declining cap through 2020 on GHG emissions from major sources. This cap is translated into tradable emission allowances that are auctioned or allocated to covered sources; this system establishes a price signal to drive long-term GHG reductions.

There are numerous factors that are critical in the design of a carbon fee that would require further study, including the appropriate level of the fee and how the revenues should be spent. It would be quite useful to study carbon fee efforts worldwide – some successful and on-going and some flawed and short-lived – to learn the lessons from these experiences. For example, British Columbia's carbon tax introduced in 2008 was North America's first economy-wide carbon pricing policy and is widely regarded as a success. Among the design elements that have contributed to its success are the facts that the tax: (1) is revenue neutral (i.e., taxes are returned to those taxed via individual and corporate income tax cuts and low-income tax credit) and (2) was phased in, giving individuals and businesses time to adapt. In contrast, Australia's national carbon tax was approved in 2012, but then repealed in 2014. The failure of this tax was in part tied to the program's lack of transparency as well as uncertainty surrounding how the tax revenues would be spent.

Implementation of a carbon pollution fee would require approval by the California Legislature by one of two avenues. One approach is for the Legislature to impose a carbon tax on the Bay Area by way of a 2/3^{rds} majority vote. The second way is for the Legislature, via a simple majority, to approve regional legislation enabling such a tax to be implemented in the Bay Area. This legislation would then require approval by 2/3^{rds} of the voters in the Bay Area. There is precedent for this second approach. Specifically, in 1997, MTC was granted authority by the Legislature for a regional gas tax of up to 10 cents/gallon, although MTC has not placed this measure on the ballot. Given the need for legislative and/or voter approval, further development of this measure may require a survey or other research to gauge the public's opinion of a carbon pollution tax.

This further study measure takes a broader view of pollution-based taxing than that described in transportation control measure TR11: Value Pricing. TR11 is limited in scope to a transportation fuel-based tax, and does not address fuel and energy use related to manufacturing and industry, or building energy use. The Air District will work with MTC on implementation of TR11, but will also explore options for economy-wide carbon-based pricing through this further study measure.

Sources:

1. Carbon Tax Center, http://www.carbontax.org/.
2. Center for Climate and Energy Solutions, 2015, *Market Mechanisms: Understanding the Options.*
3. Clean Energy Canada, 2015, *How to Adopt A Winning Carbon Price: Top Ten Takeaways from Interviews with the Architects of British Columbia's Carbon Tax*.
4. Eberhard, Kristin, 2014, *All the World's Carbon Pricing Systems in One Animated Map*, http://daily.sightline.org/2014/11/17/all-the-worlds-carbon-pricing-systems-in-one-animated-map/.

5. Sustainable Prosperity, 2012, *British Columbia's Carbon Tax Shift: The First Four Years – Research Report*, University of Ottawa.

FSM_SS7: Vanishing Oils and Rust Inhibitors

Brief Summary:
Research VOC reductions from vanishing oils and rust inhibitors.

Purpose:
Reduce VOC emissions.

Source Category:
Stationary Source

Further Study Measure Description:
Vanishing oils are lubricants used in metalworking (such as cutting oil) or other oil used in manufacturing. Rust inhibitors are fluids used to inhibit, protect or prevent corrosion on metal surfaces. Vanishing oils and rust inhibitors are used in various metal working operations at facilities and operations such as aerospace, machine shops (job shops), steel mills, auto rebuild, screw machine operations, steel tubes (pipes) manufacturing, steel springs manufacturing, maintenance operations, and captive machine shop operations (captive machine shops are machine shops located inside of another type of business that supports the business, but is not the primary aspect of that business). The South Coast AQMD adopted Rule 1144 in 2009 to reduce VOC emissions from vanishing oils and rust inhibitors. The South Coast Rule 1144, does not apply to oils and inhibitors that have a flash point of less than 200^{o}F. It sets an interim VOC limit for rust inhibitor at 300 grams VOC per liter of material, and a final limit for both inhibitor and oil at 50 grams VOC per liter of material. The staff report projects emissions reductions of 2.7 tons per day (tpd) from a 3.2 ton per day inventory. BAAQMD inventory for rust preventives is 1.7 tpd of VOC emissions. Businesses using these materials include machine shops (job shops), aerospace facilities, steel mills, auto part rebuilders, screw machine shops, steel tube (pipe) manufacturers, steel spring manufacturers and captive machine shops located inside of other types of businesses. Staff will investigate the emissions from this sector to determine the feasibility of establishing regulatory limits that would achieve emissions reductions in a cost-effective manner.

Source:

1. South Coast AQMD Rule 1144, Staff Report, SCAQMD, March 6, 2009

FSM_SS8: Dryers, Ovens and Kilns

Brief Summary:
This further study measure would investigate potential further emission reductions of nitrogen oxide (NO_X) from combustion devices that are currently exempt from the requirements of Regulation 9, Rule 7: *NO_X and CO from Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters*, specifically, devices in the category of “kilns, ovens, and furnaces used for drying, baking, heat treating, cooking, calcining, or vitrifying” (9-7-110.6).

Purpose:
Further emission reductions of NO_X, an ozone and fine particulate matter ($PM_{2.5}$) precursor.

Source Category:
Area sources – dryers, ovens and kilns

Further Study Measure Description:
Regulation 9-7 is a non-industry-specific rule that applies NO_X and CO emission limits to a broad range of combustion devices, but generally exempts “kilns, ovens, and furnaces”.

In December 2005, the San Joaquin Valley Air Pollution Control District (SJVAPCD) adopted Rule 4309 to limit emissions of NO_X from dryers, dehydrators and ovens with a rated heat input of 5 MM BTU/hr or more. Rule 4309 was fully implemented in December 2008.

In December 2008, the South Coast Air Quality Management District (SCAQMD) adopted Rule 1147 to limit NO_X emissions from combustion devices, including "ovens, dryers, dehydrators, heaters, kilns, calciners, [and] furnaces” among others. Rule 1147 was fully implemented in July 2014.

The Air District’s 2011 emissions inventory includes emissions from natural gas-fired devices of this type under 3 sub-categories for Combustion – Other External Devices:

“Natural gas (point source)” referring to permitted devices:	3.50 ton/day NO_X
“Natural gas (area source), industrial” referring to non-permitted devices:	2.94 ton/day NO_X
“Natural gas (area source), commercial” referring to non-permitted devices:	2.41 ton/day NO_X

Air District staff estimates that over 90 percent of the NOx emissions from dryers, overs and kilns in the 2011 stationary source (permitted) inventory either have been addressed by Regulation 9-13 (adopted in 2012 to address Lehigh Cement) or were evaluated for further control (with no further control proposed as of this date) in Regulation 9-14. Therefore, further study should focus on area (non-permitted) sources. For area sources, Air District staff will refine the NO_X inventory to determine if NO_X emissions from the “kilns, ovens, and furnaces” sector justifies further action, and if so, to determine an appropriate methodology.

Sources:

1. SJVAPCD Rule 4309, December 15, 2005
2. SCAQMD Rule 1147, September 9, 2011

FSM_ SS9: Omnibus Rulemaking to Achieve Continuous Improvement

Brief Summary:
This measure seeks to accelerate the pace of greenhouse gas (GHG) emission reductions in the Bay Area by exploring the feasibility of broad-sweeping, or "omnibus," rulemaking. Omnibus rules could achieve larger GHG emission reductions by targeting multiple sources and/or sectors simultaneously. However, the complexity associated with omnibus rules might present significant challenges to the socioeconomic and environmental analyses required for good rulemaking.

Purpose:
The purpose of this measure is to reduce GHG emissions in order to protect the global climate.

Source Category:
Stationary and area GHG sources

Further Study Measure Description:

In response to the immediate threat from climate change to our region, the Air District has adopted the goals of reducing Bay Area greenhouse gas (GHG) emissions 40 percent below 1990 levels by 2030, and 80 percent below 1990 levels by 2050.[1] Meeting these aggressive mid- and long-term targets will likely require implementing new approaches and streamlining existing processes to accelerate the pace of GHG reductions. Traditionally, the Air District's rulemaking process focuses on developing a unique rule to address a specific pollutant from a particular source-type. While this approach has achieved significant criteria and air toxic emission reductions in the Bay Area over the past decades, there might be alternative approaches that are more effective in reducing GHG emissions at the rate needed. Thus, the Air District is planning to evaluate a more encompassing rulemaking process –omnibus rules that could address GHG emissions from multiple source-types or entire source sectors, simultaneously– as a future approach. These "omnibus" rules could address GHG emissions more broadly and systematically, therefore yielding faster and larger GHG emission reductions. For example, approximately half of Bay Area GHG emissions (~40 MMT CO_2e) result from stationary combustion across industrial, commercial and residential sectors. The Air District is currently developing a basin-wide combustion strategy to systematically address these emissions (see **SS18: Basin-Wide Combustion Strategy**). Phase 1 of the combustion strategy will explore establishing a regulatory cap on the carbon intensity, or CO_2 emitted per unit of product, of all major industrial combustion sources at current levels. Phase 2 calls for source-by-source rulemaking to increase combustion efficiency. An omnibus rule could offer an alternative or parallel approach to accelerate the efforts of Phase 2.

There are important challenges that the Air District would need to overcome in order to

[1] These goals are consistent with the State of California's GHG 2030 reduction target, per SB 32 (Pavley, 2016), and the State's 2050 GHG reduction target per Executive Order S-3-05.

develop, evaluate, adopt and enforce omnibus rules. In order for rules to be legally defensible and free from unintended negative consequences, the rulemaking process must comply with federal Clean Air Act requirements, the requirements of the California Health and Safety Code, include a robust and comprehensive public engagement process, and the development of technical, socioeconomic and environmental impacts analyses. The complexity that would be necessarily associated with an omnibus rule would present challenges to the Air District in completing these legal and administrative requirements in a timely and thorough manner, therefore increasing the possibility of legal challenges and the chance of unanticipated negative environmental and/or economic consequences.

Particularly, there are significant concerns in four areas of the rulemaking process:

- *transparency and public outreach*
  An omnibus rule, encompassing multiple sectors and source-types, would likely involve a much higher number of stakeholders from affected communities, industries, environmental groups, as well as other regulatory agencies, than the traditional rulemaking process. Reaching and engaging all relevant parties in the rule development, while maintaining process transparency, will probably become more difficult as the number and geographic variety of stakeholders increase.
- *technical development and evaluation of the rule*
  The complex nature of an omnibus rule would present substantial challenges during the technical analysis of the rule. For instance, the greater variety of sources, in terms of type of equipment and potential emission controls, means longer and more complex technical research and analyses. Among these analyses, the H&SC requires the Air District to detail all existing rules and control requirements for each source-type or equipment included in the proposed rule as well as any conflict, difference or duplication that may occur between these regulations.
- *socioeconomic and California Environmental Quality Act (CEQA) analyses*
  The significant increase in the number of stakeholders and technical complexity might also make it difficult to conduct accurate and comprehensive socioeconomic and environmental impacts (CEQA) analyses; there simply might be too many factors to consider in each analysis.
- *implementation and enforcement*
  Air District staff might need to develop individual implementation plans and enforcement strategies for each source-type affected by an omnibus rule, in order for these to be useful to our Compliance and Enforcement staff and to relevant industries.

The challenges described above would need to be further investigated to assure that developing an effective, legally-defensible, and enforceable omnibus rule would achieve greater emissions reductions and/or efficiencies than developing individual rules to accomplish the same objectives. Air District staff will consider all these issues as they evaluate whether omnibus rulemaking might be a feasible and effective strategy to accelerate the pace of GHG emission reductions. The Air District will also explore the omnibus rulemaking concept for criteria and toxic air contaminant emissions.

Source:

1. OEHHA (2013) Indicators of Climate Change in California. Available at: http://oehha.ca.gov/climate-change/document/indicators-climate-change-california

FSM_BL1: Large Residential and Commercial Space Heating

Brief Summary:
Regulation 9, Rule 4 regulates NO_X emissions from central furnaces in the size range typically found in single-family homes. This measure addresses larger furnaces rated above 175,000 BTU per hour that are found in multi-family residential buildings and large commercial spaces.

Purpose:
This measure seeks to reduce NO_X emissions from large residential building central furnaces, and from commercial space heating. While the intent of this measure is to reduce NO_X emissions, in a broader context, the Air District is working with local governments and others to phase out the use of fossil fuel-based technologies in buildings, as part of the Air District's large-scale effort to reduce greenhouse gas emissions (see measure BL2: Decarbonize Buildings). When it is not feasible to install a non-fossil fuel-based furnace, this measure explores ensuring that in the future, large furnaces use Best Available Control Technology (BACT). This measure explores options for establishing maximum allowable NO_X emission levels for large size furnaces.

Source Category:
Stationary Source – large space heating furnaces (above 175, 000 BTUs)

Further Study Measure Description:
While smaller central residential and commercial furnaces in this and other air quality jurisdictions have been regulated for many decades, larger space heating applications have not been regulated anywhere in the state. Specifically, regulation of central furnaces in the Bay Area has been restricted to residential and commercial furnaces with a heat capacity of less than 175,000 BTU per hour (Rule 9-4), requiring a 40 ng/joule NO_X limit since the 1980s. Rules with these same limits are also in place in the South Coast Air Quality Management District (AQMD) (Rule 1111) and the San Joaquin Valley Air Pollution Control District (APCD) (Rule 4905) jurisdictions.

While there are no adopted rules in any of these three air districts that limit NO_X emissions from larger devices, these devices are subject to permit requirements. For example, in the Bay Area, natural gas combustion devices must be permitted if they are larger than 10 million BTU per hour (MM BTU/hr). The South Coast AQMD requires permits for large commercial furnaces with a heat input rating or more than 2 MM BTU/hr; these units are subject to new source review and a BACT NO_X limit of 30 ppmv at 3 percent oxygen (about 21 ng/joule).

As described above, the Air District has no direct experience in limiting NO_X emissions from furnaces in the size range covered by this measure. As part of this measure, Air District staff will investigate appropriate future NO_X limit for space-heating gas furnaces larger than 175,000 BTU/hr, and will coordinate development and adoption of consistent NO_X limits and certification methods for these devices with the South Coast AQMD, San Joaquin Valley APCD and other air districts. Staff may also investigate a state-wide model rule that will be developed cooperatively, or under the auspices of the California Air Resources Board (ARB) or the California Air Pollution Control Officers Association (CAPCOA).

Sources:

1. Bay Area Air Quality Management District, Regulation 9, Rule 4
2. South Coast Air Quality Management District, Rule 1111
3. San Joaquin Valley Air Pollution Control District, Rule 4905.

FSM_AG1: Wineries

Brief Summary:
Study potential to reduce VOC's from fermentation at wineries.

Purpose:
Reduce VOC emissions from fermentation at wineries and breweries.

Source Category:
Stationary Source

Further Study Measure Description:
In 2005, San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) adopted rule 4694 to control emissions from wineries that emit over 10 tons/year of organic emissions (primarily ethanol) based on formulae in the rule. The rule requires a reduction of fermentation emissions of 35 percent, and also requires that storage tanks of 5,000 gallon size or greater be equipped with a pressure/vacuum valve and be kept at a temperature of no greater than 75^{o} F. San Joaquin staff estimated that 18 wineries would be subject to the rule, 14 of which were major stationary sources subject to federal Title V permits. The rule achieves emission reductions of between 0.6 to 0.7 tons per day from a total inventory of 4.6 tons per day ROG from wineries.

In 2009, SJVUAPCD adopted rule 4695 to control emissions from wine and brandy aging operations. This rule increased the control requirements for storage tanks to raise emission reductions from 35 to 50 percent. In their 2007 ozone plan, SJVUAPCD investigated further control to remove alternative compliance provisions in Rule 4694 to require operators to achieve an 86 percent VOC capture and control efficiency on fermentation tanks. Due to significant technical uncertainty and high costs associated with installing additional controls (greater than $100,000 per ton of VOC reduced per year), these additional requirements were not part of the rule, and SJVUAPCD staff recommended future study on equipment advancements that may produce additional reductions.

The Air District is not aware of any existing rules addressing emissions from breweries beyond permit requirements resulting from Reg. 2, New Source Review. Further research is needed to determine the number and size of breweries in the Bay Area.

The Air District inventory for winery emissions is 0.79 tons per day of ROG, as compared with SJVUAPCD at 4.6 tons per day. SJVUAPCD counted 109 wineries in their district in 2007. Whereas, there are over 300 wineries in Napa County alone that collectively account for about 60 percent of the Bay Area winery emissions. Further research will have to be done to determine whether any of the Bay Area wineries meet the San Joaquin threshold of 10 tons ROG emissions per year, or whether cost-effective controls could be applied to Bay Area facilities.

District staff will investigate the number and size of winery facilities in operation in the Bay Area and their estimated emissions. In addition, staff will investigate the number and size of breweries to determine if capture and control methods may be applied to this industry.

Sources:

1. SJVAPCD, Rule 4694: Wine Fermentation and Storage Tanks, Dec 15, 2005
2. SJVAPCD 2007 Ozone Plan, measure S-IND-12, dated April 30, 2007
3. SJVAPCD, Rule 4695: Brandy Aging and Wine Aging Operations, dated September 17, 2009