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 (ACS 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, ABAG, and the PUC designed to implement scalable regional initiatives that deliver effective energy savings. BayREN programs include such initiatives 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 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 of 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. 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 in an effort 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
    - 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 the CALGreen (Title 24) statewide 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

- 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 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 CEC, USDOE, RECS and AHS/ACS (U.S. Census) reports. These figures were then multiplied by the most recent CO_2e emission factors from 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.

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.

[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.

Exposure Reduction:
This measure could help to reduce exposure in impacted communities that are located near power plants, particularly "peaker plants," due to the reduction in electricity use. 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, however,

provision of financial incentives would depend upon 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.

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.
- 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 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.

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 emissions (GHGs), criteria pollutants and toxic air contaminants (TACs) 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 adopting 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 government 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 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. For example, the U.S. Department of Energy has offered grant funding for the development of new infiltration diagnostic technologies that can be used for large buildings because existing technologies are unable to adequately quantify air leaks in the envelopes of these structures.

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:
NA

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 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, it 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, urban heat islands 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;
- 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 only 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 a very high level of volatile organic compounds (VOCs) whereas other trees emit very few. 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) have the ability to adopt local energy efficiency requirements that are more stringent than the State Standards, however, air districts do not have this authority. Without direct authority to adopt building codes, the 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 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, 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)

[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.

- Greater comfort
- Energy savings
- 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 urban forest.

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