DRAFT REPORT ON THE SEPTEMBER 11, 2013 ADVISORY COUNCIL MEETING ON BLACK CARBON: HEALTH EFFECTS OF EXPOSURE

SUMMARY

The following presentations were made at the September 11, 2013 Advisory Council meeting on Black Carbon and Climate Change- Health Impacts:

1. Health Impacts Associated with Climate Change by Dr. Linda Rudolph, MD, MPH. Dr. Rudolph is co-director of the Climate Change and Public Health Project at the Public Health Institute in Oakland, CA. She is also principal investigator on a Public Health Institute project to advance integration of health into all policies in local jurisdictions around California. She holds an MD from the University of California at San Francisco and a Master of Public Health from the University of California at Berkeley. Previously, Dr. Rudolph served as the Deputy Director of the California Department of Public Health in the Center for Chronic Disease Prevention and Health Promotion and as the Health Officer and Public Health Director for the City of Berkeley.

2. Black Carbon- Health Effects of Exposure by Professor Michael Kleinman. Dr. Kleinman is Professor of Occupational and Environmental Medicine in the Department of Medicine at the University of California at Irvine. He is also Co-Director of the Air Pollution Health Effects Laboratory in the Department. He holds a Master in Chemistry from the Polytechnic Institute of Brooklyn and a Ph.D. in Environmental Health Sciences from New York University. He has published more than 100 articles in peer-reviewed journals dealing with environmental contaminants and their effects on cardiopulmonary and immunological systems, and has directed more than 50 controlled exposure studies of human volunteers and laboratory animals to ozone, particulate matter (PM), and other pollutants.

   This is Prof. Kleinman's second presentation to the Advisory Council in two years. On October 12, 2011 he discussed his research on neurological and cardiopulmonary effects of inhaled particles on humans and laboratory animals. In that presentation, Prof. Kleinman demonstrated that semi-volatile components of $PM_{2.5}$ and ultrafine particles (UFP) can promote airway allergies and accelerate development of cardiovascular disease, and that they can increase production of inflammatory mediators, damaging brain cells. The September 11th presentation provided an update on Prof. Kleinman's research, including the unique effects of nanoparticles.

KEY POINTS

Dr. Linda Rudolph

1. Climate change is the greatest public health challenge of the 21st century. Climate change will continue to result in direct and indirect health impacts, including: heat-related illness and death, asthma and other respiratory disease, cardiovascular disease, vector-borne disease, water- and food-borne disease, increased allergies from increased pollen counts, other infectious disease (e.g., valley fever), mental health disorder, malnutrition, and food insecurity (see Glossary).

2. The Intergovernmental Panel on Climate Change (IPCC) in their *Managing the Risks of Extreme Events and Disasters to Advance Climate Change,*[1] predict that extremes in weather events will increase in frequency and intensity under projected climate change scenarios. Severe climate events have already been shown to result in significant negative health effects. Examples include:

    a. During the 2006 heat wave in California, 650 excess deaths occurred, and an even greater number of excess emergency room visits and hospitalizations resulted. A large number of excess deaths occurred in areas typically cooler and lacking air conditioning; about 45% of those who died lived alone.[2]

    b. Acute health care costs from just six major climate events (i.e., from heat waves, wildfires, ozone pollution, hurricanes, flooding, and infectious disease) in the U.S. between 2000 and 2009 totaled $14 billion and led to 1,699 premature deaths.[3]

3. Climate change threatens our survival by disrupting systems upon which humans depend, such as water, food, and shelter, and thus peace and social stability. Faster and more aggressive action is needed to avert the worst effects of climate change and to avoid catastrophic impacts on future generations.

4. Climate change will impact vulnerable populations to the greatest extent. Those already most at risk for adverse health problems (e.g., poor, young, old, and disenfranchised) may not be as resilient at responding to climate events (e.g., due to lack of air conditioning or transportation).

5. The effects of climate change may overwhelm ongoing air quality improvement efforts. For instance, warmer temperatures throughout inland California are expected to result in up to 30 more days per year of unhealthy ground-level ozone concentrations. This is known as a "climate penalty."

6. According to Dr. Dan Cayan, Director of the Climate Research Division at the Scripps Institution of Oceanography, annual average temperatures in the Bay Area are expected to increase 3.5-11^{0}F by 2050, depending on the specific location within the Bay Area,

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[1] IPCC, 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp. Also available online at: http://www.ipcc.ch/publications_and_data/ publications_and_data_reports.shtml#SREX. Accessed October 15, 2013.

[2] Hoshiko S, English P, Smith D, Trent R. A simple method for estimating excess mortality due to heat waves, as applied to the 2006 California heat wave. Int J Public Health. 2010 Apr; 55(2):133-7. doi: 10.1007/s00038-009-0060-8. Epub 2009 Aug 13. PMID: 19680599.

[3] Knowlton K, Rotkin-Ellman M, Geballe L, Max W, Solomon GM. Six climate change-related events in the United States accounted for about $14 billion in lost lives and health costs. Health and Environment Program, Natural Resources Defense Council, New York City, NY, USA. Health Aff (Millwood). 2011 Nov; 30(11):2167-76. doi: 10.1377/hlthaff.2011.0229.

with inland areas most affected. The Bay Area may be particularly vulnerable because the population is not well-adjusted to high temperatures and its existing infrastructure is not well suited for adaptation (e.g., buildings are designed for coastal mild climates and lack air conditioning systems).

7. A public health climate strategy requires dramatic reductions in greenhouse gas (GHG) emissions, preparation, and building climate resilient communities. Strategies should include greater energy efficiency standards (for buildings and vehicles), greater use of pervious surfaces, cool roofs, urban greening, and development of plans to protect vulnerable populations from extreme heat and other severe weather events.

8. Many climate-focused efforts have health co-benefits, and many health-focused efforts also have climate co-benefits:
    a. GHG reduction measures as outlined in California's Assembly Bill 32 Scoping Plan are expected to result in measurable health co-benefits, including reduction of PM and oxides of nitrogen (NOx) emissions. A recent study estimates these reductions by 2030 as 1 and 15%, respectively, when compared to business as usual.

    b. Changing transportation modes to active transportation (i.e., cycling, walking, and transit), not only reduces GHG emissions and other air pollutants, but also provides other health benefits. Maizlish et al., 2011,[4] using ITHIM (an active transportation computer model), predicted that if active transportation in the Bay Area were to increase from the current average of less than 5 minutes a day to 22 minutes (from a 2 to 15% mode share), not only would there be a 14% reduction in GHG emissions, but dramatic health benefits could be expected due to the increase in exercise and physical activity (benefits equal in magnitude to those achieved by California's Tobacco Control Program, which has averted one million excess deaths since implementation 25 years ago). The modeled Bay Area benefits of increased active transportation include a(n):
        - 14% reduction in heart disease, stroke, and diabetes
        - 6-7% reduction in depression and dementia
        - 5% reduction in breast and colon cancers
        - additional 9.5 months of life expectancy per person
        - annual health cost savings of $1.4 to $22 billion.

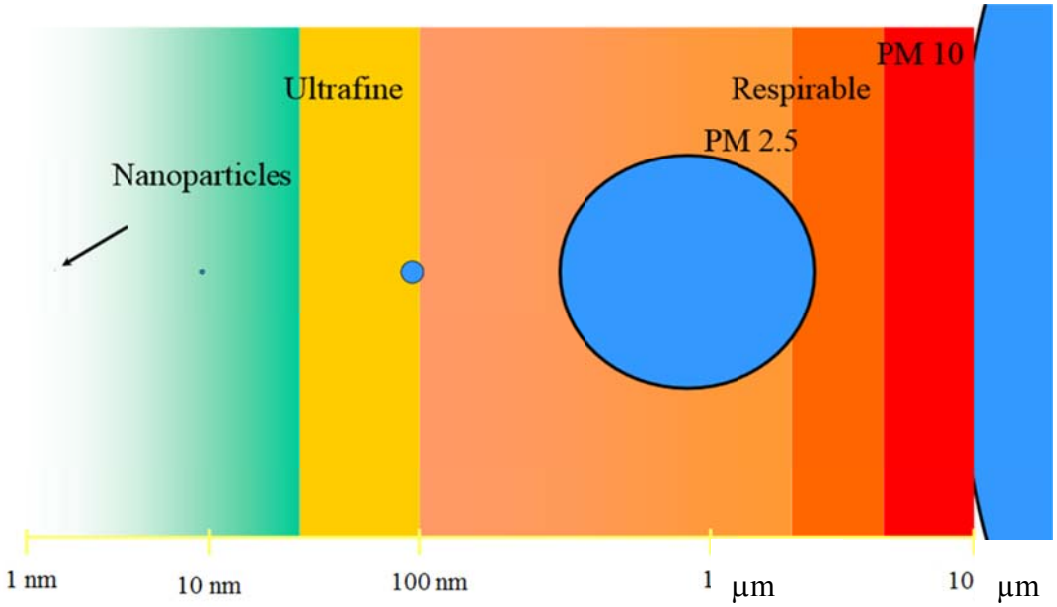
        It is important to note, however, that ITHIM also predicts a 19% increase in avoidable bicycle and pedestrian injuries due to increased potential for conflicts with vehicles. Therefore, in promoting active transportation it is important to identify measures that also address bicycle and pedestrian safety.

[4] Maizlish N, Woodcock J, Co S, Ostro B, Fanai A, Fairley D. Health Cobenefits and Transportation-Related Reductions in Greenhouse Gas Emissions in the San Francisco Bay Area. Am J Public Health. 2013 Apr;103(4): 703-9. doi: 10.2105/AJPH.2012.300939. PMID: 23409903. Technical Report available online at: http://www.cdph.ca.gov/programs/CCDPHP/Documents/ITHIM_Technical_Report11-21-11.pdf. Accessed October 15, 2013.

Prof. Michael Kleinman

1. Brown Carbon (BrC) and Black Carbon (BC) aerosols are present in the nanoparticle size range. Figure 1 illustrates the size of nanoparticles compared to larger particles. The 10 micron (μm) particle shown in the blue area on the right of Figure 1 is approximately one-sixth the diameter of a human hair.

Figure 1. Particle Size scale.



Source: Professor Michael Kleinman

2. Combustion processes result in formation of nanoparticles. Studies of roadways in Southern California show that the majority of particles measured were < 1 micron in diameter, and that those closest to the source were even smaller and ranged between 70 and 80 nanometer (nm).

3. More recently, nanoparticles manufactured for use in electronics, grinding during finishing processes, and research, including medical research can have a similar structure to diesel exhaust particles and can be inflammatory in the human body.

4. The surface area per unit mass of nanoparticles is greater than that of larger particles. This allows for a greater number of potentially toxic particles to attach to nanoparticle surfaces, and be subsequently inhaled.

5. Due to the small size of nanoparticles, they can be deposited deep in the lung, can penetrate across cell membranes, and can be transported via the bloodstream to distal organs, potentially resulting in a wide range of adverse health effects. These health effects can include impacts on cardiovascular and pulmonary function, as well as cellular and DNA damage. While some toxic materials present on BrC and BC aerosol particles are fairly insoluble, evidence exists that some nanoparticles and/or partially soluble particle components may be transported to other organs, affecting the lungs, liver, brain, and heart.

6. Both BrC and BC contain organic carbon. Prof. Kleinman conducted a study on mice that evaluated health effects from the organic components of BrC and BC. He exposed mice over an eight week period to particles containing organic components and to particles stripped of semi-volatile organics, including highly toxic organic compounds, such as Polycyclic Aromatic Hydrocarbons (PAHs). The following results were observed:

    a. Mice exposed to particles without semi-volatile organic components showed increased cholesterol, as well as arterial wall thickening.

    b. Mice exposed to particles with semi-volatile organic components also showed increased cholesterol and arterial wall thickening, but further showed increased arterial plaque, and decreased heart rate variability (an adverse health effect).

7. Prof. Kleinman 's studies concluded:

    a. While adverse health effects from nanoparticles stripped of organics still remain important, it appears that the semi-volatile fraction of particulates may be the key contributor in leading to inflammation and development of atherosclerosis and heart disease

    b. Thermal-emission control technologies that remove semi-volatile organics not only reduce PM pollution, but may also reduce the toxicity of residual particles (e.g., by removing PAHs, oxygenated hydrocarbons, and free radicals)

    c. Exposure to laboratory-concentrated ambient particles (CAPs) increases inflammatory responses in the brain and is associated with damage to dopamine producing brain cells (same as in degenerative nerve diseases, such as Parkinson's).[5]

EMERGING ISSUES

1. Global climate change is happening faster than expected and at the upper end of IPCC scenario projections. Aggressive measures are needed to address climate change.

2. The recent Yosemite Rim Fire may provide an opportunity to further examine health impacts from large wildfires, anticipated to increase with climate change.

3. Air quality has and will continue to improve, but these improvements may be partially offset by effects from climate change (a climate penalty). In the Bay Area, the potential

[5] This information appeared in Dr. Kleinman's presentation materials, but was not orally presented to the Advisory Council.

for this climate penalty may be mitigated by summer daytime coastal cooling, an expected reverse-reaction result of climate change.[6]

4. Preparation for public health implications from climate change requires:

    a. Identification of vulnerable populations and development of policies to protect them, such as strengthening social support networks

    b. Designing communities that:

        i. enhance walking, cycling, and public transit
        ii. improve energy efficiency
        iii. adapt to, and recover from, impacts from heat, drought, floods, and sea level rise.

5. Public Health climate strategies should take full advantage of both climate and health strategies that provide co-benefits. Metrics can assess relative health benefits of climate policies. Some strategies may reduce both GHGs and other pollutants, but may present potential conflicts and may need further policy development, including:

    a. Spare the Air Day alerts that recommend that the public bicycle and walk on days when air quality is poor, potentially expose sensitive groups to higher levels of air pollution.

    b. Building high density development in high traffic areas may result in greater pedestrian and cycling injuries and may increase risks from higher levels of air pollutants.

6. Removal of highly toxic organics, including PAHs, from particles before inhalation can have substantial health benefits by reducing build-up of arterial plaque and its resulting adverse effects on the cardiovascular system. Processes for removing organic toxins are similar to engine afterburner technologies, which not only reduce pollution, but may also reduce the toxicity of residual particles.

7. Nanoparticles use in products (i.e., engineered nanomaterial) and manufacturing has increased with little safety research and regulation. The unique properties of some engineered nanotubes (see glossary), which may have a similar structure as diesel particles, pose special challenges, ranging from the effects of occupational exposures to the final disposition of discarded products. The National Institute of Occupational Safety and Health (NIOSH) is recommending concentration levels to the Occupational Safety and Health Administration (OSHA) to address workplace safety issues resulting from the use of carbon nanotubes. Such regulations present challenges, because the current proposal regulates nanotubes and nanofibers at one 1 $\mu g/m^3$, the quantification limit in air samples.

[6] Lebassi, B., J. Gonzalez, D. Fabris, E. Maurer, N. Miller, C. Milesi, P. Switzer, and R. Bornstein, 2009: Observed 1970-2005 cooling of summer daytime temperatures in coastal California. Journal of Climate. 22, 3558-73.

RECOMMENDATIONS

The following recommendations are based on the presentations given at the September 11, 2013 meeting of the Advisory Council, as well as from Advisory Council input:

1. The Air District should continue, and consider additional, climate protection strategies to reduce GHG and short-lived climate pollutant (SLCP) emissions and to provide guidance to protect vulnerable populations and promote building of resilient communities. The Air District should consider the following strategies:

    a. Compile and supplement specific research[7] and analyses to understand the effects of spatial and temporal variations of climate change (including potential beneficial air quality effects from summer daytime coastal cooling), air pollution, and health impacts in the Bay Area and for vulnerable populations.

    b. Develop an outreach program that includes education of the public to understand climate change impacts on local health and air quality.

    c. Develop a regional GHG emission reduction plan to demonstrate reasonable progress toward meeting targets in California's Executive Order S-3-05 to reduce GHG emissions by 80% below 1990 levels by 2050. This plan should also include SLCPs and strategies to address them.

    d. Develop health metrics to evaluate relative co-benefits from climate and air quality strategies.

    e. Identify climate protection and adaptation strategies, and work with applicable agencies and municipalities to incorporate applicable policies as part of land use planning.

[7] There are at least two existing reports that have explored the vulnerability of the Bay Area to climate events. These reports are referenced below:

1. Jerrett, Michael, Jason G. Su, Colleen E. Reid, Bill Jesdale, Alberto M. Ortega Hinojosa, Seth B.Shonkoff, Edmund Seto, Rachel Morello-Frosch (University of California, Berkeley). 2012. Mapping Climate Change Exposures, Vulnerabilities, and Adaptation to Public Health Risks in the San Francisco Bay and Fresno Regions. California Energy Commission. Publication number: CEC-500-2012-041. Available online at: http://www.energy.ca.gov/2012publications/CEC-500-2012-041/CEC-500-2012-041.pdf. Accessed October 16, 2013.
2. Cooley, H., E. Moore, M. Heberger, and L.Allen (Pacific Institute). 2012. Social Vulnerability to Climate Change in California. California Energy Commission. Publication Number: CEC-500-2012-013. Available online at: http://www.pacinst.org/wp-content/uploads/2013/02/full_report31.pdf. Accessed October 16, 2013.

2. The Air District should support all necessary strategies that promote active transportation, including:

    a. Increased funding for transit operations and alternative (to solo driving) transportation choices (e.g., transit, vanpools, carpools, car sharing, bicycle sharing), including use of funds from cap and trade, toll increases, high occupancy toll lane revenues, and tax measures.

    b. Increased funding and promotion of improved roadway designs for safer walking- and cycling-infrastructure (i.e., complete streets; see Glossary) to maximize health co-benefits from reduced air pollution and increased physical activity (see the National Association of City Transportation Official's Urban Bikeway Design Guide at: http://nacto.org/cities-for-cycling/design-guide/).

    c. Expanded funding for bicycle infrastructure, with a focus on secure bicycle parking near transit, workplaces, and schools. Incentive funding for bicycle purchases and/or subsidized bicycle sharing, especially for low income populations.

    d. Ensuring that the 2016 Regional Transportation Plan maximizes health benefits from active transportation.

3. The Air District should evaluate both the relative climate and health benefits and risks from infill development (e.g., exposure to air pollutants, pedestrian/cycling injuries) and identify appropriate policies to address them.

4. The Air District should continue to work with other agencies to address indoor air quality in both new development and existing buildings, particularly near air pollution sources. While tighter building envelopes improve energy efficiency and reduce infiltration of external pollutants, those generated indoors become increasingly important and require adequate filtration and ventilation.

5. The Air District should further investigate the relative health risks and benefits from recommending walking and cycling on high air pollution days, particularly with respect to sensitive populations (e.g., asthmatics). Spare the Air recommendations may require reformulation, with a goal of promoting active transportation, while providing appropriately protective recommendations for such sensitive populations.

6. The Air District should monitor and support research on processes that reduce emissions of the semi-volatile organic fraction of UFPs generated in a wide range of combustion engines.

7. The Air District should continue to monitor and support research and regulations related to nanoparticles use in industrial and consumer products, e.g., toxicological testing, biomonitoring, and product labeling.

In addition throughout 2010, the Advisory Council investigated strategies for aggressively reducing GHG emissions to meet California's 2050 GHG target of an 80% reduction in emissions below 1990 levels. Specifically, the recommendations from its October 2010 meeting should be reviewed by the Air District for inclusion, as appropriate, to its plans to meet its long-term GHG reduction goals (see Attachment A for those recommendations).

ACRONYMS

BC: black carbon

BrC: brown carbon

CAP: concentrated ambient particles

EPA: (United States) Environmental Protection Agency

GHG: greenhouse gases

HEPA: high efficiency particulate air

IPCC: Intergovernmental Panel on Climate Change

ITHIM: Integrated Transport and Health Impact Model. For more information see: http://www.cdph.ca.gov/programs/CCDPHP/Documents/ITHIM_Technical_Report11-21-11.pdf

Micrometer (μm): one millionth of a meter or 1,000 nm

Nanometer (nm): one billionth of a meter

NIOSH: National Institute of Occupational Safety and Health

NOx: oxides of nitrogen

OSHA: Occupational Safety and Health Administration

PAH: polycyclic aromatic hydrocarbon

PM: particulate matter

SLCP: Short-lived climate pollutant

UFP: ultrafine particles

GLOSSARY

Complete Streets: Transportation policy and design approach that requires streets to be planned, designed, operated, and maintained to enable safe, convenient, and comfortable travel, and to provide access for users of all ages and abilities, regardless of their mode of transportation. Focus should be on separating pedestrians and cyclists from motor traffic and slowing traffic to safe speeds. Complete Streets is intended to allow for safe travel by those walking, bicycling, driving automobiles, riding public transportation, or delivering goods.

Food Insecurity: Limited or uncertain availability of nutritionally adequate and safe foods, or limited or uncertain ability to acquire acceptable foods in socially acceptable ways.

Nanoparticles: Particle having one or more dimensions of the order of 100 nanometers or less.

Nanotubes: A hollow cylindrical carbon structure used in nanotechnology

Attachment A

Recommendations from the Advisory Council Report from the October 13, 2010 Meeting

Strategies and Technologies for the Transportation Sector

The Air District should:

1. Work with MTC and ABAG to condition transportation and development investments and grants upon implementation of parking reform. The Air District should also include parking reform policies in development of an indirect source rule.
2. Work with MTC to analyze induced demand impacts from MTC's HOT Lane network expansion (study being done by MTC consultant Parsons Brinkerhoff). Modeling does not currently, but should, include a range of impacts of induced demand or increased housing at suburban fringe. The Air District should specify that net revenues from HOT lanes be used for expanded non-highway transit and transit choices, rather than expansion of the highway system.
3. Work with MTC to consider adoption of a quantification tool that evaluates a broad range of public health impacts and benefits from transportation and land use policies and decisions. The Air District should also encourage MTC to conduct a performance-based analysis of transportation projects to ensure investments are cost effective.
4. Through the Air District's role in the Joint Policy Committee, encourage MTC to evaluate all transportation projects, including projects in previous Regional Transportation Plans (RTP), for impacts on VMT and potential to induce growth. The air district should encourage MTC to only include SCS/ RTP projects that do not increase personal VMT and do not induce sprawl. Additionally, the air district should implement the relevant Transportation Control Measures and Leadership Platform* in the 2010 Clean Air Plan to address those issues.
5. Develop a social marketing campaign to increase walking, cycling, and transit, based on latest research of proven strategies that affect behavior change, including comparison-with-neighbor policies.
6. Seek state legislation requiring CMAs to expand their mission statement from primarily "congestion management" to include a major emphasis on reducing GHG and to enable a focus on: health; increasing mode share of walking, cycling, and transit; and on reducing VMT, rather than managing congestion.
7. Develop a toolkit for planners, local agencies, and CMAs for land use and transportation policies that have the greatest public health, air quality, and GHG reduction benefits.

8. Require use of cool paving materials, such as high albedo materials, for future outdoor surfaces, such as parking lots, median barriers, and roadway improvements to reduce urban heat island effects and to save energy.
9. Use MTC's SB 375 implementation planning funds for local community planning processes.
10. Build upon SB 535 (Yee) to support development of a strong statewide ZEV mandate and incentives to help the state reach aggressive GHG reduction goals.
11. Continue to work with other agencies in regional efforts to fund and accelerate EV charging infrastructure and streamline residential charging station installation and permitting, including incentives to promote solar EV charging installations. In addition, work with cities, counties, and utility districts to assist property owners in funding charging stations through Property Assessed Clean Energy (PACE) bonds, pursuant to SB 1340 (Kehoe).
12. Promote expansion of congestion toll pricing to all other regional bridges. Revenues raised should be used to improve public transit service in those corridors.
13. Develop and promote policies and programs, including securing necessary legislative authority, to achieve significant reductions in employer-related vehicle miles traveled, including mandating employer transportation demand management plans, such as have been adopted by Oakland (GreenTRIP) and San Francisco. Additionally, the air district should implement the relevant Transportation Control Measures and Leadership Platform* in the 2010 Clean Air Plan to support these policies.
14. Support establishment of a VMT fee or gasoline tax in the Bay Area to achieve GHG, criteria pollutant, and air toxics reductions goals, and implement the relevant Transportation Control Measures and Leadership Platform in the 2010 Clean Air Plan to support this recommendation.

* Leadership Platform: Some of the most potentially beneficial measures in the Bay Area 2010 Clean Air Plan (CAP) to improve air quality will require action by other agencies, such as CARB or US EPA, or adoption of new legislation. The CAP also thus includes a Leadership Platform, summarized in its Volume I, Table 4-7, which identifies policies and actions by other entities to complement the CAP control strategy.