FINAL REPORT ON THE FEBRUARY 13, 2013 ADVISORY COUNCIL MEETING ON THE CONCEPTS AND ISSUES SURROUNDING BLACK CARBON POLLUTION

PRESENTATIONS DELIVERED

The following presentations were made at the February 13, 2013 Advisory Council meeting on Black Carbon:

Black Carbon: Concepts and Issues from a National Perspective
Presenter: Sarah Rizk, Environmental Scientist, Clean Energy and Climate Change Office, US Environmental Protection Agency (US EPA), Region 9, who works with a broad range of partners on reducing greenhouse gases (GHGs) through voluntary action. Her research focuses on the intersection between climate and health benefits. Her recent work quantifies the monetary health impacts of fossil fuel energy and analyzes policy pathways for reducing black carbon from diesel vehicles, drawing from existing regulatory policies. Sarah holds a B.S. and a M.S. in Earth Systems from Stanford University.

Black Carbon: Concepts and Issues from a Statewide Perspective
Presenter: Bart Croes, Division Chief, Research Division, California Air Resources Board (CARB), with responsibility for California's ambient air quality standards; climate change science and mitigation of high global warming potential gases; and health, exposure, and indoor air quality. He was the Public Sector Co-Chair for the NARSTO Executive Assembly, and a former member of the National Research Council (NRC) Committee on Research Pollution in Urban China and the US, a joint collaboration between the National Academy of Engineering, NRC, Chinese Academy of Engineering, and Chinese Academy of Sciences. He has been peer reviewer for the NRC, US EPA, and numerous journals, and has received the Editors' Citation for Excellence in Refereeing from the Journal of Geophysical Research. Bart has published peer-reviewed articles on air quality simulation modeling, emission inventory evaluation, reactivity-based VOC controls, acid deposition, the weekend ozone effect for ozone and PM, PM data analysis and trends, diesel particle traps, and climate change impacts on California. He holds a B.S. in Chemical Engineering from the California Institute of Technology, a M.S. in Chemical Engineering from the University of California at Santa Barbara, and is a registered Professional Chemical Engineer in the State of California.

KEY POINTS BY

Sarah Rizk, US EPA

1. Black Carbon (BC, see glossary for a list of definitions and acronyms) has been studied extensively by the US EPA. A seminal report was presented to the US Congress on BC in March 2012. This report outlines the state of the science on BC and explicitly states that despite remaining uncertainties about the climate impact of BC that require further research, currently available scientific and technical information provides a strong foundation for making mitigation decisions to achieve lasting benefits for public health, environment, and climate change impacts.

2. BC is a climate-forcing pollutant, which heats the atmosphere as the most strongly light-absorbing component of $PM_{2.5}$, which also reduces ice- and snow pack- albedo. Another component of $PM_{2.5}$ is organic carbon (OC), of which Brown Carbon (BrC) is a component; BrC is the most strongly absorbing component of OC. Despite remaining uncertainties on the magnitude of the net climate impact of BC and its co-pollutants, currently available information shows that BC is a net warming agent. Short term climate benefits from a reduction of atmospheric BC may include mitigated impacts from sea level rise and from tipping point events (e.g., ice cap elimination).

3. BC causes significant health impacts worldwide, consistent with those associated with $PM_{2.5}$, e.g., respiratory and cardiovascular effects, as well as premature death. Emissions and ambient concentrations of directly emitted $PM_{2.5}$ are often highest in urban areas, and global BC mitigation measures could thus potentially lead to hundreds of thousands of avoided premature deaths annually.

4. Controls on BC emissions offer an opportunity to quickly reduce its impact on global climate change, as BC particulates settle out of the atmosphere in less than 14 days, rather than over decades (as with major GHGs).

5. Based on short- and long-term climate and health goals, select metrics (e.g., global warming net forcing, cost effectiveness) and time horizons are needed to evaluate and track mitigation strategies and to explore implications from remaining uncertainties.

6. US and California agencies have made progress on reducing BC emissions though a variety of mechanisms, e.g., diesel PM reduction plans. Areas for continued US mitigation include, open biomass burning, mobile sources, and residential heating and cooking. While globally heating and cooking are significant sources, they contribute only 4% of total US BC emissions.

7. To maximize climate benefits from PM health mitigation measures, ambient concentrations of BC and its co-emitted pollutants should be considered in PM attainment strategies.

Bart Croes, CARB

1. BC is an adverse contributor to both global climate change and public health. California has made significant progress towards reduced BC emissions, e.g., thru diesel engine controls, advanced clean-car regulations, and burning restrictions. Due to these actions, BC only contributes 11% of California climate change impacts on a 100-year global warming potential basis, as opposed to 23% globally; short term impacts in California could be higher.

2. Diesel engines are the primary BC source in California. A 2010 Caldecott Tunnel study indicated that the dirtiest 10% of trucks in the study produced half of all measured BC emissions. Over the last 40 years a factor of three reductions in BC emissions has resulted from changes in diesel combustion, while concurrent diesel usage has increased from

about 10 to 70 million barrels per year. By 2020, California is expected to have reduced diesel PM emissions by 85% below its 2000 levels. Additional emission reductions by 2020 are planned through a combination of new vehicle emissions standards, fuel rules, and fleet rules.

3. Agricultural and residential burning controls also have resulted in reduced emissions of both BC and BrC, a class of particulates that includes both elemental and organic carbon compounds that absorb both ultraviolet and visible solar radiation.

EMERGING ISSUES AND RECOMMENDATIONS

Increasing information shows that BC emissions have significant roles in global climate change and public health impacts. Not all BC emissions sources have the same effect, however, due to variations in magnitude, location, and types of co-emitted pollutants. While some BC emissions produce climate atmospheric cooling and others produce warming, on balance the accepted scientific view is that BC emissions have a net warming effect, although exact magnitudes remain uncertain. BC emissions also have significant adverse public health impacts, consistent with those associated with $PM_{2.5}$ exposure. BAAQMD staff included many of the above concepts in their November 2012 report: Understanding Particulate Matter.

Brown carbon (BrC), a common co-emitted pollutant with BC, was identified as a potentially important climate forcer, but it is not fully understood if it has a warming or cooling impact. The Advisory Council will further address BrC in a future report.

The Advisory Council has thus identified the following emerging issues and recommendations, which could lead the Air District to increased activities in the following action areas:

Research

1. **Research:** Ongoing research continues to increase understanding of BC and BrC impacts on climate change and public health. Public policy choices should utilize this new information in the evaluation of benefits from individual mitigation options. Although residential, agricultural, and open burning are known major sources of BrC, refinement concerning its health and climate impacts need further study.

   Recommendation: The Air District should continue to review the research on health and climate impacts from both BC and BrC, as well as the research on mitigation strategies.

Source-Specific Reduction Strategies

2. **Biomass Burning:** Biomass combustion contributes 35% of US BC emissions, and resulting health impacts are well documented.

   Recommendation: In addition to ongoing Air District $PM_{2.5}$ emission-reduction programs (e.g., for wild fire hazard reduction, residential wood burning, smoke

management, chipping, and composting), the Air District should also develop new (regulatory and incentive) programs for safer and more efficient biomass combustion in areas such as improved open burning, equipment upgrades, and wood combustion rules.

3. **Diesel Engines**: Transport contributes 52% of US BC emissions, and diesel accounts for 93% of that amount. Diesel engines are also the primary source of regional BC emissions, even though this sector has had great reductions. Mobile source rules, technology improvements, and declining equipment costs will result in continued turnover of the on- and off-road diesel fleets and in decreasing ambient BC concentrations, but more can be done to accelerate these trends. BC mitigation strategies (e.g., diesel retrofits) offer cost-effective mitigation of near-term climate effects.

   Recommendation: The Air District and CARB should accelerate adoption of cleaner engines in the Bay Area through revision of grant criteria and incentives, especially for off road diesel engines.

Information Development

4. **Inventory:** Development of a BC emissions inventory would support multiple air quality and climate change goals and contributes to understanding the magnitude and complexity of these inter-related problems, e.g., by understanding co-emitted pollutant emissions rates and relative contributions by sector.

   Recommendation: The Air District should develop an inventory of BC and (where relevant and possible) co-emitted pollutants.

5. **Modeling**: Modeling of BC emissions and ambient-concentrations, as well as of the morphology and fate of BC, OC, and co-emitted pollutants, will help evaluate their health and climate impacts.

   Recommendation: Evaluate the capabilities of existing models and identify needed improvements.

6. **Monitoring**: Limited ambient BC monitoring is carried out for public-health and regulatory reasons, but additional measurements are needed to provide more detailed information on BC concentrations and to update and verify emission inventories. This may require new stations and perhaps new equipment.

   Recommendation: The Air District should develop an enhanced BC monitoring plan to determine spatial and temporal concentration variations.

Regional and Ongoing Reduction-Strategies

7. **Inter-agency cooperation:** BC is an important short-term climate forcer, whose emissions if controlled would result in reduced atmospheric concentrations. Other agencies, e.g., CARB, BAR, and MTC, also are involved in such successful local reduction strategies.

   Recommendation: The Air District should consult with local, regional, and state agencies to ensure synergy with its PM and multi-pollutant planning processes.

8. **Control-Strategy Metrics**: Metrics should align with jurisdictional health and/or climate goals. Selected goals will influence metrics for evaluating BC control strategies. Metrics should accurately reflect progress toward those goals and be capable of measuring the overall effectiveness of mitigating both climate-change and public-health impacts**.**

   Recommendation: The Air District should incorporate BC, co-emitted pollutants**,** climate change, and health cost-benefit data into future planning processes and regulations.

9. **Compliance:** Compliance with existing regulations to reduce BC emissions can be achieved through educational outreach, incentives, and regulatory efforts, each an important component of a successful air quality and climate protection program.

   Recommendation: The Air District should continue to measure the success of, and to improve as necessary, existing incentives, educational efforts, grant programs, and compliance strategies to reduce BC emissions from all sources. This could include public education of emission impacts, benefits from diesel-engine regulations, and advocating for increased enforcement of state and federal diesel engine regulations.

   Recommendation: The Air District should interact with BAR with respect to lube oil burning vehicles

GLOSSARY: Many definitions are condensed from the March 2012 US EPA Report to Congress on Black Carbon

BAR: Bureau of Automotive Repair.

Biomass: Organic materials, such as wood and agricultural wastes, which can be burned to produce energy or converted into a gas for use as a fuel.

Black Carbon (BC): Solid form of mostly pure carbon, produced by incomplete combustion; the most effective form of PM (by mass) at absorbing all wavelengths of solar radiation.

Brown Carbon (BrC): Class of particulate OC that absorb ultraviolet and visible solar radiation. Can be directly emitted during incomplete combustion, or it can form as atmospheric pollutants age.

Climate Change: Significant change in climate (e.g., temperature, precipitation) lasting for extended periods (i.e., decades or longer). May result from natural factors (e.g., changes in solar intensity), natural processes (e.g., changes in ocean circulation); and/or human activities that change atmospheric composition (e.g., fossil fuel consumption) and/or land surfaces (e.g., deforestation, urbanization).

Co-Emitted Pollutants Gases and particles emitted with BC, e.g., OC, sulfates, nitrates, sulfur dioxide, nitrogen oxides.

Greenhouse Gas (GHG): Gas that absorbs infrared atmospheric radiation, e.g., water vapor, carbon dioxide, methane, and nitrous oxide.

Hazardous Air Pollutant (HAP): Pollutants known or suspected to cause cancer or other serious health issues (e.g., reproductive effects or birth defects).

Open Biomass Burning: Burning of vegetative material, e.g., agricultural burning, prescribed burning, and wildfires.

Organic Carbon (OC): Compounds containing carbon (bound with other elements, e.g., hydrogen and oxygen). May be a product of incomplete combustion or formed through the oxidation of atmospheric VOCs.

Particulate Matter (PM): Complex mixture of small particles and liquid droplets suspended in atmosphere in various size ranges, i.e., PM_{10}, $PM_{2.5}$, and ultrafine.

$PM_{2.5}$: Particles with diameters $\leq$ 2.5 micrometers.

Volatile Organic Compounds (VOCs): Organic carbon in vapor phase.

Wildfire: Unplanned ignition from lightning, volcanoes, human actions, or escaped prescribed fires.