

**U.S. Environmental Protection Agency  
Advisory Council on Clean Air Compliance Analysis (Council)  
Augmented for Review of Black Carbon**

April 18-19, 2011

Omni Shoreham, 2500 Calvert St., NW, Washington, DC 20008

**Purpose:** To review EPA's draft document, *Report to Congress on Black Carbon* (external review draft, March 18, 2011)

**Attendees:**

**Panel Members:** Arden Pope (Chair), Alberto Ayala, Michelle Bell, Kevin Boyle, Sylvia Brandt, Linda Bui, James Corbett, Ivan Fernandez, Christopher Frey, Jan Fuglestvedt, Alan Hansen, Joseph Helble, Mark Jacobson, Denise Mauzerall, Surabi Menon, Richard Poirot, Armistead (Ted) Russell, Michael Walsh, and John Watson (see roster, Attachment A)

**SAB Staff Office:** Stephanie Sanzone (Designated Federal Officer), Vanessa Vu

**Other Attendees:** see Attachment B

**Meeting Materials:**

All materials discussed at the meeting are available on the Council website, <http://www.epa.gov/advisorycouncilcaa>, at the [April 18-19, 2011 Council Meeting](#) page.

**Summary of Discussions:**

**A. Welcome**

The meeting was announced in the Federal Register<sup>1</sup> and proceeded according to the meeting agenda<sup>2</sup>, as revised. **Ms. Stephanie Sanzone**, Designated Federal Officer for the Panel, convened the meeting and noted that the Council and its panels operate in accordance with the Federal Advisory Committee Act. This means that meetings are announced and open to the public, meeting minutes are prepared, and all materials prepared for or by the Council are available to the public. Ms. Sanzone noted that Dr. Ted Russell would participate the first day by telephone, and that several EPA staff would be participating by telephone. **Dr. Vanessa Vu**, Director of the SAB Staff Office, extended her welcome and thanks to Dr. Pope and the other members for their participation on the panel, and she thanked the Agency technical staff for traveling to Washington, DC for the meeting. She also welcomed the registered public speakers and asked the panel members to consider the public comments. Following brief introductions by panel members, **Dr. Pope** thanked the members for preparing preliminary comments.<sup>3</sup> He then welcomed Ms. Lydia Wegman, Director of the Division of Health and Environmental Impacts in EPA's Office of Air Quality Planning & Standards (OAQPS), for her opening remarks.

The following is a summary of the issues discussed and conclusions reached during the meeting.

## **B. EPA Introductory Remarks**

**Ms. Lydia Wegman**, Director of the Environmental Health and Impacts Division of the Office of Air Quality Planning and Standards (OAQPS) (participating by phone) thanked the Council for its important review work. She noted that the Agency had been working on the report since last year and was on a tight timeline. The report was to have been provided to Congress by April 2011, but the Agency will miss that deadline. However, she emphasized that EPA wants to move forward as quickly as possible to finalize the report and that the Council's review is critical. She noted that the report is intended to summarize available scientific information on black carbon, and to serve as a foundation for Congress to use in making decisions on black carbon. A large team of EPA authors, from the Office of Research and Development and the Office of Air and Radiation, has been working on the report, led by Erika Sasser and James Hemby. She noted that the review draft includes input from other federal agencies, and that dialogue will continue as EPA revises the draft report based on the Council's review and formal review of other agencies.

## **C. EPA Technical Overview**

**Dr. Erika Sasser**, OAQPS, presented an overview of the draft *Report to Congress on Black Carbon* (Presentation Slides<sup>4</sup>). She noted that she and the project team were already reviewing the preliminary panel comments and look forward to hearing the Council's perspectives on the draft report. She summarized the events in Congress leading up to the charge from Congress for EPA to develop the report on black carbon. She emphasized that the report draws upon recent literature on black carbon (BC) over the last ten years, and is a foundation report not intended to prescribe policy on BC. Because of time constraints (the Agency was given 18 months to complete the report), she indicated that the report authors had not attempted to do integrative modeling of the effectiveness of a set of BC reduction strategies. She welcomed feedback on the organization of the report, including whether some material should be in the body of the report or the appendices.

Dr. Sasser summarized the report's key conclusions, including that BC and other light-absorbing particles exert a strong influence on regional climate and that BC mitigation strategies are likely to provide health benefits in excess of climate benefits. She acknowledged the need for more quantitative analysis of integrated health and climate benefits, but noted that the agency was not in a position to do that analysis for this report. She briefly noted the key points in each of the report chapters, including climate and health effects, sources and ambient measures of BC, sector-specific mitigation options, metrics for comparing BC to long-lived greenhouse gases, and future research priorities.

In closing, Dr. Sasser described the timeline for completing the report. She stated her hope that the Council's final peer review comments would be available in June or July, followed by federal interagency review in August, and a final report submitted to Congress in the fall.

In response to Dr. Sasser's comments, panelists made the following points:

- Many of the referenced papers were published in the mid-1990's when fossil fuel consumption was on the rise in developing countries. Will EPA try to project forward?
- The report is an impressive summary of the literature, but it could do more to summarize priorities for the U.S. going forward (e.g., describe a system for assigning relative benefits of various mitigation options).
- The open biomass burning category vs. anthropogenic category may be confusing to readers.
- Clarify what is meant by the term "contained combustion."

- The report should include more explicit evaluation of the various mitigation approaches, without making specific policy recommendations, and differentiate between U.S. and international policy options.

#### **D. Public Comment**

**Mr. Joseph Suchecki** provided comments on behalf of the Engine Manufacturers Association (ESA), a trade association for manufacturers of internal combustion engines (on and off road, marine, stationary). He noted that his organization supported the legislative request for the report and the cooperative work to reduce emissions from diesel engines. He referred to significant reductions in PM from diesel exhaust because of technology such as wall-flow diesel particulate filters (DPFs). Mr. Suchecki noted that the draft report overemphasizes diesel engines as a source of BC and gives the impression that diesel is the only source of BC from mobile sources. Regarding co-benefits of BC reduction, he cautioned against double-counting of health benefits by including health benefits from existing controls that already were justified on the basis of those benefits.

Several panelists noted that DPF is a game-changing technology, but that manufacturers in the nonroad sector are planning to meet new regulations without the use of that technology.

#### **E. Panel Discussion of Charge Questions**

##### BC Effects on Climate (Question 3):

**Drs. Watson** and **Mauzerall** led the discussion of Charge Question 3, regarding identifying and characterizing light-absorbing particulate matter (PM). Dr. Watson referred to the distinction between organic carbon (OC), brown carbon (BrC), BC and soot, but noted that what is observed is soot, which is a mixture. He noted that Figure 2-4 is slightly misleading, and although the discussion of flaming versus smoldering is good, not all BrC is brown. He also recommended some clarification of the OC/BC ratio. Dr. Mauzerall added that soot is more than BC and so it is important to define soot and to be consistent throughout the report.

Panel members made the following additional points:

- The report should include a more thorough discussion of absorbing properties of particles in multiple wavelengths, and discuss absorbing and scattering in mixtures and consider these as occurring in a plume, not an either/or.
- The term BrC has been applied differently over time (e.g., older use was for near-UV low absorber and new BrC in East Asia is higher absorbing than BC), and the report should point out that there has been an improved understanding of how BrC absorbs.
- Additional discussion is needed on the influence of mixing state on optical properties of BC.
- Fig A-1-1 should be included in the body of the report as a helpful way to simplify the various definitions of particles for readers.
- A glossary of key terms would help readers because of the interdisciplinary content of the report.
- Chapter 2 is the first discussion of the models, so it would be useful for the text to assess how well the models perform.

##### BC vs Long-Lived GHG (Question 4):

**Drs. Fernandez** and **Hansen** led the discussion of Charge Question 4, regarding the comparison of BC to long-lived greenhouse gases (GHG) such as carbon dioxide. Dr. Fernandez concluded that the chapter

provided a good treatment of the differences between BC and long-lived GHG and appropriately highlighted the contrast in atmospheric residence time and the policy implications. He noted that the report lacks any treatment of ozone and water vapor and interactions, and recommended that the report be clear that there are additional indirect ecosystem impacts that are not included in the discussion. Dr. Hansen noted that the chapter nicely describes regional and global differences, and the vertical distribution of the effects. He noted that the chapter had a lot of overlap with Chapter 11 on metrics.

Panel members made the following additional points:

- The discussion of metrics (Chapter 11) could be split into two parts, with an explanation of the utility of backward-looking (for understanding system response) and forward-looking (for policy design) perspectives.
- Graphics should include a time scale to explain the temporal dynamics of the components.
- Over the long term, a warming climate and changes to wind patterns may affect the deposition, mixing and transport of BC.
- Since carbon dioxide stays in the atmosphere longer than BC, reductions in CO<sub>2</sub> emissions won't product a climate response as quickly as reductions in BC. However, the report focuses on radiative forcing, not climate response.
- The report should discuss the implications of reducing short-lived forcing agents, for example in reducing impacts on sea ice and to avoid tipping points.

#### Mechanisms and effects on climate (Question 5):

**Drs. Jacobson and Menon** led the discussion of Charge Question 5, regarding the mechanisms whereby BC affects climate. Dr. Jacobson noted that the discussion is missing the effects of BC absorption within clouds (cloud absorption effect). The report should discuss the competing effects from the semi-direct effect and cloud burn-off. The report also should discuss the feedback to water vapor (warming air increases evaporation, creating a positive feedback). These changes are missed if the focus is exclusively on radiative forcing rather than using modern simulation models to look at climate response. Dr. Menon recommended that the report better convey that BC is mixed, comes in different shapes and sizes, and that radiative forcing is affected by physical and chemical transformations of BC. She noted that models treat BC differently, so it would be helpful to list the properties treated in the different models to help readers understand why the results vary from model to model.

Panel members made the following additional points:

- Additional papers are available on climate response, including on short vs. longer term BC impacts on precipitation and research on the influence of soot on clouds.
- The economic analyses lack the rigor given to the natural science portions of the report. The report mentions the social cost of carbon, but does not reference the large economic literature on this topic. Additional references are suggested on the impacts of climate and temperature change on agricultural.
- The report would be more meaningful to Congressional audiences if it discussed effects endpoints (e.g., health and welfare impacts) rather than changes in forcing as Watts per meter.
- The Executive Summary should be more clear about why BC and BC mitigation is important (e.g., effects on the Arctic). Although the purpose of the report is not to explain why climate change is important, the report could further emphasize the co-benefits to health and environment.

- The vague reference to social carbon should be taken out of the document, unless a more thorough discussion is presented. The report should be clear that benefits and costs are not just for BC, but for PM as a whole. Where literature is available, the report could discuss relevant impacts (e.g., impacts on agriculture) and present the state of practice on valuing these impacts.
- A separate chapter could discuss issues surrounding valuing benefits and costs, rather than having dollar values sprinkled throughout the report. This chapter also should discuss uncertainties in the analyses and how these uncertainties could be carried through to the economic analyses.

#### Health Effects of BC (Question 6):

**Drs. Bell and Levy** led the discussion of Charge Question 6, regarding the available scientific evidence for public health effects of BC. Dr. Bell recommended that the discussion of health issues be expanded, although she recognized that the section would not be as detailed as the agency’s Integrated Science Assessment (ISA) for PM. She noted that the document discusses uncertainty about toxicity of different components of PM, but should not give the impression that the uncertainty is greater for health effects of BC than other components. BC is a major contributor to PM total mass, and more could be included on apportionment studies, including traffic studies. She also recommended that more attention be given to climate co-benefits of policies to reduce PM and that the discussion of economics issues be enhanced. Dr. Levy also recommended that the chapter be expanded to provide a better synthesis of the evidence and to provide more explanation of the basis of the dollar-per-ton values given in the chapter. He agreed that more detail should be provided on valuation (e.g., discussion of issues surrounding Value of a Statistical Life, or VSL, estimates).

Panel members made the following additional points:

- The report seems to emphasize that we can’t distinguish BC from PM in general. The EPA Clean Air Scientific Advisory Committee (CASAC) agreed there was not enough evidence to regulate BC differently than PM, but there are studies that demonstrate differences and these could be discussed. For example, there are many indicative studies that associate BC with impacts in children.
- In contrast to ozone (which negatively impacts yields), the effects of BC on agricultural yields are not clear.
- The chapter could include a table summarizing health effects from the ISA, with a column that gives the relevance of BC on the topic.
- Be consistent in the health effects being discussed and the emissions being controlled (i.e., when reducing biofuel burning, that will reduce pollutants other than BC)
- The report tries to use the term BC consistently, but older literature says “carbon black” and other terms. When BC-specific literature is cited, the report should specify what was being measured (black smoke, BC, etc.).

#### Non-Climate Environmental Effects (Question 7):

**Dr. Brandt and Mr. Poirot** led the discussion of Charge Question 7, regarding the evidence for non-climate environmental effects from BC. Dr. Brandt noted that the report did not assess the robustness or applicability of the studies (e.g., are the ecological endpoints related to a welfare change?). For agricultural impacts, do the measured crop changes translate into price/welfare impacts? Can the studies be extrapolated to crops important in the U.S.? She recommended that the document be more precise and consistent in its use of economic terms (e.g., “cost-effectiveness” is a relative concept; the terms

“use” and “nonuse” values are used incorrectly). Issues associated with VSL are not presented. The report needs a coherent story about what information is needed and what is known to allow examination of the cost-effectiveness of a range of mitigation options. The report should draw upon existing efforts, including the ISA and the recent Section 812 Study on the Benefits and Costs of the Clean Air Act. Mr. Poirot noted that there is little evidence linking BC to crop effects, since many effects come from scattering and BC is not a major source of scattering. In contrast, visibility effects of BC are very quantifiable and this topic is well covered in the report.

Panel members made the following additional points:

- In the discussion of ecological effects, most of the references given are for effects of trace metals, not carbon. The report should clarify that the effects are from the associated chemistry, not the carbon itself.
- BC and surface dimming would have effects, but need different references to support that.
- The discussion of valuation is too brief and should discuss double-counting issues. For example, the Chestnut and Rowe study on visibility may be double-counting other mortality/morbidity impacts. The report needs to provide the context for the valuation numbers, and integrate the discussion in one place in the document so the reader can understand what has been done.

#### BC Emissions (Question 8)

**Drs. Corbett and Fuglestedt** led the discussion of Charge Question 8, regarding available information on historical and current BC emissions in the U.S. and globally. Dr. Corbett summarized issues from the member pre-meeting comments, including source characterization, OC/BC ratios and speciation, accuracy and uncertainties, and geographic characterization (Presentation Slides<sup>5</sup>). He noted that some terms (e.g., contained combustion, domestic sources) required clarification, and recommended that uncertainties be presented consistently throughout the chapter. Sources impacting the Arctic were hard to characterize from the inventory categories, and the rationale was not presented for focusing on emissions north of 40 degrees North latitude.

Panel members made the following additional points:

- Future emissions are not discussed in the chapter.
- Some of the figures show intra-source variability (differences among speciation profiles) rather than uncertainty.
- The amount of OM from a source or source type can vary greatly, even with an OC/BC ratio that is approximately the same.
- As with EC, there is a need for an operational definition of BC (measurement methods measure different things and that affects the uncertainty). This is less critical for an inventory, but may be very important when looking at atmospheric behavior, etc.
- The report makes definitive statements about global BC emissions, but these are based on 10-yr old data and energy consumption has changed over that time. The global distribution of emissions may be different now.
- Data will be scarce for inventories in developing countries, so uncertainties will be even greater when extrapolating from regulation/technologies in other countries.

## Transport of BC Emissions (Question 9)

**Dr. Jacobson** led the discussion of Charge Question 9, regarding the transport of BC emissions. (Dr. Russell was unable to attend the first day of the meeting because of a schedule conflict). Dr. Jacobson offered two major comments: (1) the report should note the role of aircraft emissions as a direct source of BC, especially over the Arctic, and (2) the report should discuss the changes in optical properties of BC as it ages (e.g., gets more internally mixed and aggregate particles become more coated and more absorbing).

Panel members made the following additional points:

- Figure 4-14 points out differences in marginal benefits of reducing BC from different countries.
- Differential contributions to the Arctic, and consequences for marginal abatement costs, should be discussed. However, don't exclude other areas (e.g., the Himalayas).
- Abatement for the Arctic produces a global benefit. Other areas with large effects and emissions will get health co-benefits from emission reductions.
- Mention studies on health impacts of intercontinental transport of BC.

## BC Ambient Concentrations (Question 10):

**Drs. Hansen and Watson** led the discussion of Charge Question 10, regarding information on BC from the observational record. Dr. Hansen noted that the references appear to be thorough and up-to-date, although the study authors have chosen to characterize only a portion of the observational data. He noted a few errors in translation of findings from a few of the studies. Dr. Watson also noted the value of the trends information in North America, which seems to demonstrate that concentrations increased during industrialization and are now coming down as a result of regulation. He noted that some of the data tables needed clarification (e.g., regarding averaging period) and Figure 5-4 had some puzzling results (e.g., high sulfates in the Los Angeles area) and needed a clarifying footnote about whether OM or OC was used. Dr. Watson recommended that some of the detail on measurement methods be moved to an appendix. He also noted that the report should have more discussion on absorption at different wavelengths, which also relates to the effect of BrC on radiation transfer.

Panel members made the following additional points:

- The New York City example is a good illustration of regional variation and the reasons for this, but additional references should be included to show that NYC is not a unique case.
- The discussion about conflicting and overlapping definitions of categories of particles may be more detailed than policymakers need. The discussion might refer back to more detailed descriptions elsewhere in the document, then note what is usually included when the term "black carbon" is used.

Following the panel discussion, Dr. Sasser requested advice from the panel on how to address the complex relationships among categories of particles since definitions were not included in the Congressional request. Members suggested that BC or OC could be considered an indicator for light-absorbing fraction that effects climate, and reiterated the suggestion that a glossary of terms be included in the EPA report and that more detailed discussion of this issue be included in an appendix to avoid interfering with the flow of the report.

## Mitigation Technologies and Control Strategies (Question 11):

**Drs. Ayala, Frey and Helble** led the discussion of Charge Question 11, regarding available technologies and control strategies for BC from various sectors.

**Mobile Sources:** Dr. Ayala complimented the agency for producing a synthesis of information that will be valuable for states who are taking action on BC emissions. He emphasized the importance of converging on an operational definition of BC in terms of what will be measured in the field. He agreed with the public commenter (EMA) that the report could include information on gasoline engine emissions to balance the discussion of diesel, particularly in light of the transition to new diesel technology (i.e., future emissions profiles for diesel and gasoline engines will look very similar).

Panel members made the following additional points:

- As with Chapter 4, the BC global trends presented in Chapter 6 are a snapshot in the past, and global energy consumption has changed.
- Table 6-2 discussion of benefit/cost ratio is a snapshot. It would be helpful to see cumulative costs and cumulative benefits.
- The discussion of control strategies is overly optimistic regarding potential for adoption of new cook stove technologies over a several decade timeframe.
- The discussion would be more effective if the endpoint of global mean temperature could be linked to other endpoints of interest to readers.
- In Figure 6-4, show the increment that is due to BC alone.
- The chapter should clarify whether targets to be achieved are short-term, long-term or both.
- The chapter does not discuss biodiesels. Is biodiesel use (or mixing biodiesel with diesel) a possible mitigation strategy?
- The report also should discuss mitigation strategies involving development of new, low-carbon fuels, moving to electric vehicles, land use change, and other factors that would decrease demand.
- Given movement among engine manufacturers to meet the PM standards for nonroad diesel engines without using particulate filters, it may be important to emphasize the regulation of the nonroad sector for BC.
- Voluntary programs to address the legacy fleet (e.g., trade-in programs) have had funding cuts, so the discussion may be overly optimistic and mandatory measures may be required.
- Countries where low-sulfur fuels are not available can take short-term measures (e.g., switching vehicles to CNG).

**Stationary Sources:** Dr. Frey noted that as economies develop they tend to electrify, and many developing countries don't have PM controls. The chapter on stationary sources gives cursory treatment of emissions from stationary furnaces for steam generation for electricity generation. The chapter should describe what is captured by electrostatic precipitators, and what is released without these technologies. This would set the stage for discussion of international emissions and possible reductions from those sources. The text confuses the terms "combustion efficiency" and "boiler efficiency." Discussion of fuel switching could be clarified, e.g., to discuss implications for BC of switching from high-sulfur to low-sulfur coal, effects of shifting to hydrofracking sources of natural gas. The chapter could compare a "business as usual" case and a "new technologies" case as bounding analysis.

**Heat/Cooking and Biomass:** Dr. Helble noted that the chapters provide a good overview of the challenges and mitigation options for these largely uncontrolled sources. Given the challenges in

implementing the fire control options and the issues surrounding wide-spread adoption of new cook stove technology, he noted that the mitigation estimates for these sources may be overly optimistic.

Panel members made the following additional points:

- Natural fires are not the reason that BC is a concern, so it does not make sense to try to remedy the situation using fire suppression or prescribed burns to address previous fire suppression. Agricultural burning is different and could be addressed separately as a category that may be more influenced by mitigation options.
- The report could include additional anecdotal information on cook stove adoption to justify the optimism about this as a source of BC mitigation.
- Prescribed burning can be a tool in forest management to prevent further carbon loss. This relates to feedback of climate warming impacts (e.g., increased pest damage, increased lightning strikes), and should be highlighted in the EPA executive summary.

#### Costs of Reducing BC Emissions (Question 12):

**Dr. Boyle** led the discussion of Charge Question 12, regarding costs of reducing BC emissions. Dr. Boyle noted that the panel had more concerns with the economic discussion than with other parts of the document. He noted the uncertainty that is associated with transferring costs and benefits from one study to another, and urged that the report document what is being measured in each monetary estimate. Further, he noted that the term “cost-effectiveness” is misused in the report and should only be applied when multiple approaches or technologies are being compared. When cost figures are presented, the report should define relevant categories of costs (e.g., capital costs, operation and maintenance, institutional costs) and indicate which costs are included. A summary table of available numbers, and how the underlying inputs match the desired categories, would be helpful. All dollars should be converted to the same year to allow comparison. Dr. Boyle also noted that from an economic perspective, the various particles probably are co-reduced, so technology costs are probably associated with benefits from multiple categories of particles and the report should acknowledge that there may be double-counting of benefits under multiple policies. He noted that there is no reason to assume that costs or benefits are linear on a per-ton basis over time, although this assumption is made throughout the report.

Panel members made the following additional points:

- The report does not identify the most cost-effective approaches to mitigate BC (e.g., what are the major mitigation options by source, and how do they rank in terms of cost-effectiveness).
- A summary table could assemble mitigation cost estimates across technologies by source category to help Congress identify opportunities.
- It would be helpful to discuss the feasibility of the mitigation strategies for other countries.
- Present a range of costs, average or marginal costs from the literature to convey the uncertainties.

#### **Recess and Reconvene**

The panel recessed for the day at 4:45 p.m. on April 18, 2011, and reconvened at 8:30 a.m. on April 19, 2011.

### Benefits of Reducing BC Emissions (Question 13):

**Dr. Bui** led the discussion of Charge Question 13, regarding the range of climate and health benefits from reducing BC emissions. She noted that a table of benefit numbers could be used to convey a sense of the relative uncertainty (e.g., high, medium, low uncertainty) associated with different numbers. She also noted that the report should emphasize the sizable health benefits, in addition to the large potential for climate benefits. Given the difference in benefit opportunities for the U.S. relative to other countries, she recommended that the discussion not switch back and forth between the U.S. and other countries. She noted that VSL is typically used in the U.S., but that this approach would not transfer well to other countries. In addition, she recommended that the report discuss short-term vs. long-term benefits, and the spatial and temporal (seasonal) distribution of benefits.

Panel members raised the following additional points:

- The report should discuss the spatial distribution of benefits, including benefits to the Arctic and the Himalayas and why those regions are a concern.
- When describing costs and benefits, use a table to illustrate how economists think about categories of costs/benefits (e.g., avoided costs, direct costs of morbidity, nonmarket costs, etc)
- BC has an almost a unique role in the epidemiology literature (e.g., London literature, coke oven worker literature, markers of exposure to diesel /traffic) and these studies implicate BC as much as any other constituent of PM. Given the global burden of disease, the air pollution-related numbers will be associated with very large benefits.
- Discuss how control technologies not designed primarily to control BC could be optimized for most effective BC removal (e.g., optimize the boiler to avoid too much carbon in the fly ash, enlarge the electrostatic precipitator).
- Assumptions of linearity may be acceptable for exposures in the U.S., but not for indoor exposure to solid-fuel cooking.

### Metrics for comparing BC and Other Climate Forcers (Question 14):

**Drs. Fuglestedt** and **Russell** led the discussion of Charge Question 14, regarding the range and limitations of available metrics for comparing the impacts from BC to impacts from other climate forcers. Dr. Fuglestedt noted that the adequacy of metrics depends on what is to be achieved, and the report does not clearly define the climate goals (e.g., slowing the rate of warming, reducing the level of short-term or long-term climate change). He recommended that additional metrics be evaluated, and that graphics be included to illustrate the uncertainties associated with metric values, to illustrate forward-looking scenarios relevant to policy, and to show how different groups of mitigation approaches would play out over time (Presentation Slides<sup>6</sup>). Dr. Russell agreed that the chapter was comprehensive but did lack some focus and could be improved by additional references and graphics. He also recommended a summary table listing metrics, a range of values for each, and pros and cons associated with each metric.

Panel members made the following additional points:

- It is important to consider both BC and CO<sub>2</sub> when designing policies to avoid technologies that reduce CO<sub>2</sub> but increase BC, and to consider the time horizon when evaluating policies.
- The document could do more to recommend metrics to inform different types of policies, and clarify that the policy decisions regarding trade-offs among actions is different than technical comparisons of the climate effects from BC and long-lived GHG.

### Research Recommendations (Question 12):

**Dr. Mauzerall** and **Mr. Poirot** led the discussion of Charge Question 12, regarding priority research needs relating to black carbon. Dr. Mauzerall noted that the research needs identified in the document are appropriate, but recommended the addition of research on which mitigation options would be most cost-effective for different regions and sources. Additional research on BC toxicity would also be useful. Mr. Poirot suggested that the conclusions should be less tentative since that section may be widely quoted. He also noted that some of the supporting discussion could be clarified (e.g., scattering and multiple wavelengths, BC and related pollutants, surface and remote sensed observations, microphysical processes and the characteristics influencing these processes).

Panel members made the following additional points:

- The conclusions section should focus on opportunities for BC reductions, both in the U.S. and globally, and should be more of a cumulative summary of the report's findings.
- Research needs should be listed in the order of importance, rather than the order they appear in the report, and the section should not imply that action cannot be taken on BC without the additional research.
- Research priorities should include research on relative costs and benefits of different mitigation approaches.
- Research needs should include research to characterize the magnitude of open burning as a source of BC, and to understand the feedback loop between increasing wildfire as climate changes (e.g., the contribution of open burning to cooling versus warming).
- Laboratory studies of the optical properties of BC particle mixtures would improve the performance of models relative to measured data.

### Executive Summary (Question 1):

Panel members discussed the following suggested changes to the EPA report's executive summary:

- The executive summary should provide a brief introduction to the issues, the big "take away" messages, reference that the key points are listed in the chapters, and a wrap-up section that notes that the report includes a glossary and other tools to help readers use the document.
- More emphasis on the health benefits, and discussion of the uncertainties associated with different components of the analysis.
- Points should follow the order of the report, and clearly state what is being recommended for BC mitigation as a result of the study.
- Delete Figure C because its message is not clear (information on forcing patterns in  $W/m^2$  is not the same as patterns of response).
- Include a timeline of the opportunities for mitigation and how they might affect environmental outcomes (e.g., precipitation and temperature, health, visibility, agricultural impacts) and costs.
- Discuss policy options and "no regrets" actions from a health perspective.
- Clarify the discussion of co-benefits, to health and climate, of mitigation options. Although the report does not provide cost-effectiveness analysis, the benefits appear to exceed costs and that could be stated.
- Clarify that the report's discussion of "indirect effects" does not include climate-ecological interactions and effects.

## Overview Comments (Questions 1, 2 and 16)

**Dr. Brandt** and **Mr. Walsh** led the discussion of Charge Question 1 regarding the overall accuracy and clarity of the report. Dr. Brandt reiterated her desire to see more information on the process used to come up with the dollar figures (e.g., Table 6-2 has dollars in different years) and that the economic discussion be better supported. She noted that clarity could be improved by: (1) presenting a timeline of existing and potential new policies and technologies and BC reductions associated with each (i.e., show the change in trajectory from “business as usual”), (2) including a table to pull together information on effects of concern, how those effects are assessed, and measures used to value those effects, and (3) differentiate between mitigation approaches that could be employed (new vs. expansion of existing technologies). Mr. Walsh noted that the report is clearly written, with good summaries at the beginning of each chapter. He recommended an early focus on the fact that health and ecological benefits justify action on BC, including expanding and accelerating BC mitigation efforts. Some of the chapters lack an explicit finding or recommendation for what should be done. Several members noted that the report could do more to summarize mitigation potential, without setting policy priorities.

In response to Charge Question 2, panel members identified additional relevant studies on particles and health effects, comparisons of various land-based monitoring methods, and the UNEP report on BC. In response to Charge Question 16, panelists provided comments on the technical appendices to the report, and suggested that Figure A1-1 be included in the body of the report, that some material from Chapter 7 (discussion of the mobile source inventory, assumptions on VMT and fleet characteristics, etc.) be moved to an appendix, etc.

### **F. Agency Requests for Clarification**

**Dr. Sasser** requested clarification of the Council’s comments on report organization, including how to avoid confusion when discussing U.S. versus global effects and mitigation opportunities and how to present the economic information. Several members indicated that they did not intend to micromanage the organization of the report, but suggested that a separate chapter be added to lay out what endpoints are being measured and how these endpoints could be valued as a way of connecting the natural science and economic analyses. Members also noted that the report should convey the degree of confidence in the different cost and benefit numbers used in the report.

### **G. Points for the Letter to the Administrator**

**Dr. Pope** led the panel in a discussion of key points to include in the letter to the Administrator that would accompany the Council’s report. Panel members noted the importance of including positive messages about the importance of the work, as well as highlighting requests for improvements. Priority points nominated for inclusion in the letter included more focus on health effects and benefits of BC, documenting uncertainties without being timid about what is known, integrating the discussion of costs and benefits into a new chapter, prioritizing the identified research needs, identify mitigation strategies that look most promising, and emphasize the role that EPA could play in helping accelerate BC mitigation actions in developing countries. Members agreed that the letter should state that the evidence strongly suggests that short-term action taken to reduce BC emissions would have beneficial effects for climate, and would “buy time” as longer term strategies to mitigate CO<sub>2</sub> are developed.

## H. Adjournment

There being no further business, the DFO adjourned the meeting at 2:30 p.m. on April 19, 2011.

Respectfully Submitted:

*/signed/*

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Stephanie Sanzone,  
Designated Federal Officer  
EPA SAB Staff Office

Certified as Accurate:

*/signed/*

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Dr. C. Arden Pope, III  
Chairman  
Advisory Council on Clean Air  
Compliance Analysis

NOTE AND DISCLAIMER: The minutes of this public meeting reflect diverse ideas and suggestions offered by Panel members during the course of deliberations at the meeting. Such ideas, suggestions and deliberations do not necessarily reflect consensus advice from the Panel. The reader is cautioned not to rely on the minutes to represent final, approved, consensus advice and recommendations offered to the Agency. Such advice and recommendations may be found in the final advisories, commentaries, letters or reports prepared and transmitted to the EPA Administrator following the public meetings.

**Attachment A: Roster**

**U.S. Environmental Protection Agency  
Advisory Council on Clean Air Compliance Analysis  
Augmented for Review of Black Carbon**

**CHAIR**

**Dr. C. Arden Pope, III**, Professor, Department of Economics, Brigham Young University, Provo, UT

**COUNCIL MEMBERS**

**Dr John Bailar\***, Scholar in Residence, The National Academies, Washington, DC

**Dr. Michelle Bell**, Professor, School of Forestry and Environmental Studies, Yale University, New Haven, CT

**Dr. Kevin Boyle**, Professor and Department Head, Agricultural and Applied Economics, Virginia Tech, Blacksburg, VA

**Dr. Sylvia Brandt**, Associate Professor, Department of Resource Economics, University of Massachusetts, Amherst, MA

**Dr. Linda Bui**, Associate Professor, Department of Economics, Brandeis University, Waltham, MA

**Dr. Ivan J. Fernandez**, Professor, Department of Plant, Soil and Environmental Sciences, University of Maine, Orono, ME

**Dr. Shelby Gerking\***, Professor of Economics, Department of Economics, University of Central Florida, Orlando, FL

**Dr. D. Alan Hansen**, Independent Consultant, Fremont, CA

**Dr. Jonathan Levy**, Professor, Department of Environmental Health, Boston University School of Public Health, Boston, MA

**Dr. Denise Mauzerall**, Professor, Woodrow Wilson School of Public and International Affairs, and Civil and Environmental Engineering Department, Princeton University, Princeton, NJ

**Mr. Richard L. Poirot**, Environmental Analyst, Air Pollution Control Division, Department of Environmental Conservation, Vermont Agency of Natural Resources, Waterbury, VT

**Dr. Armistead (Ted) Russell**, Professor, Department of Civil and Environmental Engineering, Georgia Institute of Technology, Atlanta, GA

**Mr. Michael Walsh**, Independent Consultant, Arlington, VA

\*Did not participate in this review

## **INVITED EXPERTS**

**Dr. Alberto Ayala**, Chief, Monitoring and Laboratory Division, Air Resources Board, California Environmental Protection Agency, Sacramento, CA

**Dr. James J. Corbett**, Professor, College of Earth, Ocean, and Environment, University of Delaware, Newark, DE

**Dr. H. Christopher Frey**, Professor, Department of Civil, Construction and Environmental Engineering, College of Engineering, North Carolina State University, Raleigh, NC

**Dr. Jan Fuglestedt**, Research Director, Center for International Climate and Environmental Research-Oslo (CICERO), Oslo, Norway

**Dr. Joseph Helble**, Dean and Professor, Thayer School of Engineering, Dartmouth College, Hanover, NH

**Dr. Mark Jacobson**, Professor, Civil and Environmental Engineering, School of Engineering, Stanford University, Stanford, CA

**Dr. Surabi Menon**, Physicist Staff Scientist, Lawrence Berkeley National Laboratory, Berkeley, CA

**Dr. John Watson**, Research Professor, Division of Atmospheric Sciences, Desert Research Institute, Nevada System of Higher Education, Reno,

## **SCIENCE ADVISORY BOARD STAFF**

**Ms. Stephanie Sanzone**, Designated Federal Officer, U.S. Environmental Protection Agency, Science Advisory Board (1400R), 1200 Pennsylvania Avenue, NW, Washington, DC 20460

## **Attachment B**

### **Advisory Council on Clean Air Compliance Analysis Augmented for Black Carbon, April 18-19, 2011 Meeting Other Attendees (from Sign-in Sheets)**

Bryan Bloomer, U.S. EPA

Nathan Borgford, IGSD

Ranyee Chiang, AAAS/U.S. DOE

Nimmi Damodaran, Stratus Consulting

John Dawson, U.S. EPA

Ben DeAngelo, U.S. EPA

Andrew Eil, U.S. State Department

Neil Frank, U.S. EPA

Nancy Garcia, U.S. EPA

Jack Gehring, Caterpillar

Michael Geller, U.S. EPA

Lesley Jantarasami, U.S. EPA

Nick Juliano, Inside EPA

Terry Keating, U.S. EPA

Joseph Kubsh, MECA

Venkatesh Rao, U.S. EPA

Marcus C. Sarofim, U.S. EPA

Joseph Somers, U.S. EPA

Darrell Sonntag, U.S. EPA

Holly Stallworth, U.S. EPA

Joe Suchecki, EMA

Xiaopu Sun, IGSD

## Materials Cited

The following meeting materials are available on the Council website, <http://www.epa.gov/advisorycouncilcaa> , at the [April 18-19, 2011 Council Meeting](#) page.

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<sup>1</sup> Federal Register Notice announcing the meeting (76 FR 17123-17124)

<sup>2</sup> Meeting Agenda, Advisory Council on Clean Air Compliance Analysis Augmented for Black Carbon, April 18-19, 2011

<sup>3</sup> Black Carbon Review Panel: Individual Pre-Meeting Comments

<sup>4</sup> Presentation by Erika Sasser, OAQPS, on An Overview of the Report to Congress on Black Carbon

<sup>5</sup> Question 8 - Emissions Sources: Pre-synthesis (Presentation Slides from Dr. Corbett)

<sup>6</sup> Chapter 11 Points for Discussion (Presentation Slides from Dr. Fuglestvedt)