UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

EPA-COUNCIL-10-xxx

The Honorable Lisa P. Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: Advisory on a Preliminary Draft of the Second Section 812 Prospective Study of the Benefits and Costs of the Clean Air Act Amendments

Dear Administrator Jackson:

The Advisory Council on Clean Air Compliance Analysis (Council) met on May 4-5, 2010 to provide advice on the Agency's preliminary draft report on benefits and costs of the Clean Air Air Amendments (CAAA) of 1990. The second prospective study of benefits and costs from the CAAA covers the period 1990 to 2020. In accordance with Section 812 of the CAAA, the EPA Project Team has undertaken a series of technical analyses to evaluate air quality scenarios for futures with and without the CAAA, and to estimate the costs of compliance with CAAA provisions and the benefits associated with projected improvements in air quality. Section 812 also established the Council to review the data, methodologies, and validity and utility of the benefit-cost studies prepared under the section. At the meeting, the Council reviewed the preliminary draft report (dated April 2010) for the Second Prospective Study and supporting reports on costs and benefits of compliance with the CAAA. The Council also considered the advice and recommendations of its subcommittees regarding stand-alone technical documents prepared by the EPA Project Team to support the Second Section 812 Prospective Study.

The Charge to the Committee requested the Council's advice on the Project Team's choice of data and methodologies, as well as on the overall utility of the preliminary draft integrated report. The detailed recommendations on data and methods used in the development of the air quality scenarios, and in estimation of health and ecological effects under those scenarios, are contained in the Council subcommittee reports, being provided to the Agency under separate cover (EPA-COUNCIL-10-001, 002, and 003). Attention to these suggested improvements to data and analyses will enhance the validity of the final benefit estimates. In addition, the Council has asked its Air Quality Modeling Subcommittee (AQMS) to review the final adjusted PM emissions inventories and details of the application of the Modeled Attainment

Test Software, or MATS) for adjusting CMAQ outputs when these are available from the Project Team. The focus of this advisory letter, therefore, is on the preliminary integrated report for the Second Section 812 Prospective Study, with some additional comments on the benefits valuation and direct cost analyses that support the integrated report.

The Council commends the EPA Project Team for its preparation of the second prospective analysis. This project is ambitious in scope, incorporates advances in analysis of the benefits and costs of environmental regulation, and should have significant impact on public understanding of the role that the 1990 Clean Air Act Amendments (CAAA) have played in improving our environment and quality of life.

The second prospective analysis is intended to provide an overall perspective on the benefits and costs of the 1990 CAAA for the period 1990 through 2020. This is an ambitious undertaking that confronts many challenges due to limitations in scientific understanding, modeling, and relevant data. We offer comments and suggestions for improving the analysis and presentation of the work.

Framing and Interpretation

The Council suggests that the framing and interpretation of the second prospective study should be clarified. The draft report could be misinterpreted as estimating the actual benefits and costs for the world as it exists (or will exist) in 2000, 2010, and 2020 compared with the world as it would have existed in those years had the 1990 CAAA not been adopted. In fact, the analysis is more circumscribed. First, it is concerned with decadal trends in pollution, health, and compliance costs, not with shorter-term variations that may result from variations in weather, economic growth, and other factors. Second, it takes many factors as fixed, even if they have or are likely to change over the 1990-2020 period, including climate and atmospheric emissions from Mexico and Canada. Third, it treats many factors as exogenously determined, neglecting any effects of the adoption of the CAAA. Examples include the growth, geographic distribution, and composition of population and economic activity, prices of oil and other resources, as well as climate and emissions from other countries. Fourth, the economic methodology applies estimates of marginal willingness to pay for small changes in risk to large infra-marginal changes in a dissimilar type of risk.

Understanding the framing and boundary conditions of the analysis is important to interpretation of the report. First, because the analysis assumes constant (2002) meteorology, it is inappropriate to compare simulated and measured patterns of pollution in modeled years such as 2000 and 2010 without accounting for differences between simulated and realized meteorology. Similarly, it is inappropriate to compare the levels, distribution, and composition of population, economic activity, and emissions in specific years with actual values without accounting for economic and other fluctuations. It may be useful for the Project Team to include additional analyses characterizing uncertainty about the overall benefits and costs of the CAAA or at least sensitivity to variation in the boundary conditions.

A related point concerns assumptions about compliance or “rule effectiveness” that can vary across domains. For local sources, the analysis includes assumptions about the costs of unidentified control measures that are needed to ensure compliance with the CAAA. It would be useful to state explicitly what assumptions are made about compliance, and how these affect estimated benefits and costs.

The second prospective report serves multiple purposes. One goal is to estimate the magnitude of total benefits and costs of the CAAA over the study period (1990 – 2020). A second is to provide a comprehensive assessment of the benefits and costs of the CAAA, including effects that may be small relative to the total, but may be important to some stakeholders. A third is to develop methods for better quantifying benefits and costs that are not well estimated in previous Section 812 reports or other reports assessing the benefits and costs of air quality regulations. A fourth is to identify high-priority areas for research.

The tension among these goals has implications for the analysis and presentation of results. For example, the quantified benefits are dominated by the reduction in mortality risk associated with lower concentrations of fine particulate matter ($PM_{2.5}$). The total quantified benefits and uncertainty about their magnitude is determined almost entirely by the components of the analysis that estimate changes in annual $PM_{2.5}$ concentrations, the slope of the concentration-response function for mortality, and the monetary valuation of mortality risk. For the first goal, most of the emphasis in the report should be on these factors.

For the second goal, it is important to consider other benefits of the CAAA, including effects of other pollutants (e.g., ozone and hazardous air pollutants) and consequences other than mortality, including reductions in morbidity and a range of effects on agriculture, forestry, unmanaged ecosystems, visibility, and on construction and other materials. This aspect of the report is spotty in its coverage, reflecting limitations of scientific knowledge, data, and analytic choices about which effects to include. Some effects are treated comprehensively (e.g., the relationship between ozone exposure and mortality) but others are treated only in the form of case studies that represent a tiny share of the total effect in some domain. For example, quantified effects of the CAAA on agriculture and forestry are limited to effects of ozone and exclude acidification. Quantified effects on lake ecosystems are for selected effects (acidification impacts on recreational fishing) in or near the Adirondacks. The only quantification of the effects of hazardous air pollutants (HAPs) is a case study of the health effects of benzene emissions in the Houston metropolitan area. Many of the non-fatal health effects are valued using cost-of-illness methods that do not fully capture the gain in well-being from improved health.There appears to be no adequate basis to extrapolate from these selected effects to the larger domains of which they are examples.

The incomplete coverage is largely justified by the absence of comprehensive data and estimates of concentration-response functions for various pollutants and endpoints, but it is difficult for the reader to have a sense of what share of benefits (and perhaps costs) of the CAAA are included in the quantified components. To a large extent, the report describes what can be seen under a modest number of lamp-posts, without attending to other existing lamp-posts (e.g., other case studies that could have been performed) or attempting to characterize what may be concealed in the territory not illuminated by lamp-posts. The Council recommends that the report should be written to help readers understand what effects are, and are not, quantified, and to explain why it is not possible to generalize from the limited case studies.

A third purpose of the report is to develop and illustrate improved methods for quantifying the benefits and costs of air-quality regulations. One improvement on the first prospective analysis is the adoption of a “one-atmosphere” approach using a single model (CMAQ) to simulate (virtually) all of the air quality parameters needed for the project. In addition to the case studies (e.g., ecosystem effects in the Adirondacks, benzene in Houston), the report includes supplementary analyses using a computable general equilibrium (CGE) model and a dynamic population-simulation model. Each of these analyses demonstrates a theoretically superior method for quantifying selected effects of the CAAA, but these methods have not been sufficiently well-developed to provide the levels of geographic and other detail that are of interest and can be provided using the primary analytic tools. The Council supports the development of these improved methods and encourages EPA to continue to improve them so that they may be used in future analyses.

Concomitant to the attempts to provide a comprehensive description of the benefits and costs of the CAAA and the development of methods for better quantifying these effects, the report helps to highlight areas in which new research would be valuable for quantifying (or better quantifying) certain effects. The Council suggests that implications for research priorities be described directly in the report and that the Project Team consider the merits of conducting an explicit value-of-information study to help rank research priorities.

A characteristic of the analysis is that it attempts to base estimates of particular effects on specific papers in the peer-reviewed scientific literature and refrains from making estimates when no specific papers are available. This feature is commendable and consistent with broader EPA policy regarding peer review of all scientific input to analyses, in that it seeks to ensure that results are based on solid evidence. However this approach has the drawbacks of producing spotty coverage, treating similar effects using inconsistent methods, limiting the analysis to incomplete models, and perhaps providing too much weight to idiosyncratic error in a particular study. It might be preferable to adopt a smoother approach in which estimates of similar effects are treated more similarly, drawing on a synthesis of the broader literature, rather than tying each estimate to a specific paper.

The tension between these approaches is analogous to a common question in statistical estimation: to what extent does the quality of an estimate improve or worsen as one moves from a very small but relevant sample to a broader but more diverse sample? As an example, in estimating direct costs, estimates of learning-curve effects in some industries are based on a single paper studying that industry, whereas it might be more credible to assume similar learning curves across a set of industries and use a common estimate for all industries in that larger set. In valuing changes in visibility, values for national parks are restricted to the parks included in a particular study while values for residential visibility in metropolitan areas without direct estimates are assumed to be similar to values estimated for comparable areas with direct estimates. (Moreover, visibility is measured using different concepts – visual range and deciviews – in the two contexts, because those were the measures used by the original studies.) Exposure-response functions for materials damage appear inconsistent and incomplete as they differ substantially in form by the affected material and do not incorporate humidity or acidity.

Presentation

The Council supports the Project Team's plan to report the results of the 812 analyses using several documents (and possibly websites) rather than as a single volume. The primary integrated report should be accessible to knowledgeable readers and provide a clear explanation of the framing, primary analytic methods, and interpretation of the study results. Many of the technical details should be provided in subsidiary reports, with clear linkages to them in the integrated report.

The Council suggests it is important to provide sufficient context for understanding the primary results. The estimated benefits of the CAAA are on the order of $2 trillion per year in 2020, on the order of $5,000 per capita or 10 percent of income. To put these benefits in context, it would be useful to summarize the extent to which they reflect improvements in air quality subsequent to 1990 and to what extent they represent preventing deterioration of air quality that is assumed would have occurred in the absence of the CAAA. The report could discuss the possibility that, had the 1990 CAAA not been adopted, other federal or state regulations or voluntary actions might have prevented some of the degradation that is modeled in the without-CAAA scenario, and so some of the benefits of the CAAA would have been achieved and some costs would have been incurred. The Council concurs with the EPA Project Team that it would be too speculative to specify any alternative to the without-CAAA scenario other than the assumption that no further control measures would have been implemented.

It would also provide helpful context to include a graphic comparing the simulated air quality with and without the CAAA with actual air quality in prior years (e.g., 1960, 1970, 1980, 1990 and 2000) for example locations.

The report should provide some interpretation of the distribution of benefits and costs across components, both endpoints and control measures. It is striking that direct control costs are dominated by mobile sources of pollution (NO_x, CO, and VOC emissions) while the bulk of the benefits are derived from reductions in PM 2.5 releases from controls on electricity generating units (EGU).

In presenting an overall summary, the Project Team may wish to include the benefits (and costs) of aspects of the CAAA that have not been analyzed as part of the second prospective report, but are available from the first prospective or retrospective reports. These include regulations on lead and on CFCs and other stratospheric-ozone depleters.

Comparisons of the results of the second prospective report with those of the first are helpful for understanding the implications of the new analysis, but these are likely to be of more interest to technically oriented readers, and might better appear in an appendix or subsidiary report rather than in the primary integrated report.

Characterization of Uncertainty

The second prospective report characterizes uncertainty about the estimates using a variety of approaches, including probabilistic uncertainty analysis, sensitivity analysis, tables reporting qualitative evaluation, and alternative analyses. Some sources of uncertainty are ignored (e.g., climate change and economic recession).

Comprehensive uncertainty characterization is a huge challenge, and the Council commends the Project Team for its attention to this issue. It suggests providing a more comprehensive discussion of the strategy for characterizing uncertainty, explaining when different approaches are adopted, and how the approaches should be interpreted. For example, probability distributions associated with Monte Carlo analysis account for uncertainty in the factors for which input distributions are provided (e.g., slope of the concentration-response function for $PM_{2.5}$ and mortality) but are conditional on other factors treated as fixed (e.g., the difference in $PM_{2.5}$ concentrations between with-CAAA and without-CAAA cases in 2020).

The attempt to qualitatively characterize uncertainties with respect to the likely sign and magnitude of their effects (in the tables concluding each chapter) is laudable, although the Council suggests the Project Team may be able to better explain the magnitude (e.g., a 5 percent of net benefit cutoff for major effect may be too small given the scale of some of the uncertainties).

Lessons Learned

The Council is impressed with the scale of effort the EPA Project Team has devoted to the series of Section 812 reports. It encourages the team to reflect on these efforts and to document lessons learned regarding allocation of effort, types of analytic tools, and other choices from which subsequent efforts would benefit.

Health Benefits

Overall, the Council notes that the studies relied on to value changes in health risk are dated and that improvements in valuation methods and estimates are not incorporated. For mortality risk, the estimates of value per statistical life (VSL) continue to be drawn from the 26 studies originally identified for the retrospective analysis, most of which rely on data from the 1980s or earlier. For morbidity risk, many of the studies are similarly dated and some endpoints are valued using cost-of-illness methods. Particularly for mortality risk, there are questions about the extent to which VSL varies by age, health status, and characteristics of the risk (such as whether the exposure is voluntary or controllable and whether it causes traumatic injury or disease), and a number of newer studies address these issues. Given the importance of VSL for total benefits, the Council suggests that the report discuss the extent to which there is evidence supporting variation in VSL by these factors and how much effect that could have on the total benefits (see, e.g., the symposium on age-dependence of VSL in the Review of Environmental Economics and Policy[1]).

In addition, when the difference in risk between the with-CAAA and without-CAAA scenarios is large, it may be inappropriate to use unadjusted marginal estimates of the rate of substitution between wealth and mortality risk. As noted above, the average per capita benefit is

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[1] Symposium: Mortality-risk Valuation and Age. 2007. Review of Environmental Economics and Policy 1(2):228-282.

on the order of 10 percent of income in 2020. This value is large enough that the difference between willingness to pay to reduce exposure from the without-CAAA scenario (compensating variation) and willingness to accept compensation to forgo the exposure reduction (equivalent variation) may be substantial.

Estimates of the slope of the concentration-response function for PM and mortality are based on two well-studied epidemiological cohorts and an expert-elicitation study. The Council agrees with its Health Effects Subcommittee[2] that these studies are a good foundation for the health benefit estimate for PM. The evidence concerning this parameter could be bolstered by discussion of several additional epidemiological studies (e.g., the Medicare cohort[3] and the Nurses' Health Study[4]).

Although the possibility of differential toxicity among PM components could be an important issue, the Council did not feel that the state of knowledge is sufficient to conduct a sensitivity analysis at this point. However, the Project Team might discuss the extent to which there are large differences in the CAAA-related reductions for different PM components and to indicate whether differential toxicity could have a major effect on estimated benefits

The dynamic population model is a significant advance over conventional static methods for estimating consequences of changes in mortality risk, especially when they are as large as those estimated for the CAAA. The Council encourages further development of this approach.

Welfare Benefits

A subset of "welfare" (i.e., non-health) benefits was selected for analysis and inclusion in the primary estimate of benefits of the CAAA, namely improvements to visibility, ozone-related benefits for agricultural crops and commercial timber, and benefits from reduced materials damage. Additional, limited estimates were developed for recreational fishing benefits in Adirondack lakes (discussed by the Council's Ecological Effects Subcommittee[5]).

Visibility. As noted above, residential and recreational visibility benefits were valued using different approaches (e.g., recreational WTP took into account household income, whereas residential WTP did not) because those approaches were used in what the Council understands to be the only relevant studies. This inconsistency suggests a need for additional research to improve methods and estimates. In addition, the use of annual average visibility for valuation

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[2] Health Effects Subcommittee of the Council. Review of EPA's Draft Health Benefits of the Second Section 812 Prospective Study of the Clean Air Act. (EPA-COUNCIL-10-001).
[3] Eftim SE, Samet JM, Janes H, McDermott A, Dominici F. 2008. Fine particulate matter and mortality: a comparison of the six cities and American Cancer Society cohorts with a medicare cohort. *Epidemiology* 19(2):209-216.
Zeger SL, Dominici F, McDermott A, Samet JM. 2008. Mortality in the Medicare population and chronic exposure to fine particulate air pollution in urban centers (2000-2005). *Environ Health Perspect* 116(12):1614-1619.
[4] Puett RC, Schwartz J, Hart JE, Yanosky JD, Speizer FE, Suh H, Paciorek CJ, Neas LM, Laden F. 2008. Chronic particulate exposure, mortality, and coronary heart disease in the nurses' health study. *Am J Epidemiol.* 168(10):1161-1168.
[5] Ecological Effects Subcommittee of the Council. Review of Ecological Efects for the Second Section 812 Prospective Study of Benefits and Costs of the Clean Air Act (EPA-COUNCIL-10-003).

includes nighttime hours (when visibility is less relevant) and does not capture large visibility improvements on extreme days with the most severely impaired visibility. For future analyses, the Agency should consider supplementing the present approach with an estimate of the value of improving daytime visibility on days with severely impaired visibility.

Agricultural and Forest Yield. The benefits of decreased ozone exposures are based on fairly well-understood concentration-response relationships that indicate improved yields in specific agricultural crops and commercial timber species (see the EES report[6]). The draft prospective report indicates that these changes in yield will be valued using the Forest and Agricultural Sector Optimization Model (FASOM), which allows optimization across crops and between agricultural and timber land uses. However, FASOM results were not available for the Council's May meeting. The Council expects that a more detailed description of the model, and the model results, will be provided in the next version of the integrated report so that the details of the methodology can be evaluated.

Materials Damage. Unlike other air quality effects that are modeled using CMAQ (see the AQMS report[7]), the materials damage effects are modeled using the Air Pollution Emissions Experiments and Policy (APEEP) model (which incorporates results of a source-receptor matrix). The Agency should consider using CMAQ estimates of SO_2 concentrations that were developed for other parts of the 812 study. If APEEP is to be used, it would be useful to report on the consistency between APEEP and CMAQ estimates of SO_2 concentrations. As noted above, the exposure-response functions used for materials damage appear incomplete (they do not depend on humidity and acidity) and vary substantially across materials. As in other areas, the literature is evidently thin, providing little basis for more credible and comprehensive estimates.

Direct costs

Most of the direct cost estimates are based on an engineering approach that may reflect ideal operating conditions and fail to capture input-substitution possibilities. For some components (e.g., EGUs), econometric estimates of the cost of compliance with at least part of the CAAA (Title IV) are available and could be usefully compared with the simulated results.

As discussed above, the learning-curve estimates (i.e., estimates of reduced costs as affected persons and industries learn how to respond to new constraints) are partly based on different studies and there is limited evidence for overall magnitude or extent of variation by industry. The justification for using different learning curves across different industries comes from estimates found in the empirical literature. The literature, however, is based on technologies that are more than 20 years old, and may not be relevant for the purposes of this study. Furthermore, there is some question as to what, exactly, is captured by the "learning curve" effect. A more straightforward approach would be to call this effect "technological

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[6] Ecological Effects Subcommittee of the Council. Review of Ecological Efects for the Second Section 812 Prospective Study of Benefits and Costs of the Clean Air Act (EPA-COUNCIL-10-003).
[7] Air Quality Modeling Subcommittee of the Council. Review of Air Quality Modeling for the Second Section 812 Prospective Study of Benefits and Costs of the Clean Air Act (EPA-COUNCIL-10-002).

change," and to use a single rate for all industries as there may not be enough evidence to justify different rates across different industries.

The document implies that the specific sequence of controls is important to the estimates of costs. If the sequence is imposed only to avoid double-counting of emissions controls, however, that should be made explicit in the document. In addition, the document should more clearly describe how the $15K figure was developed for the cost of unidentified local controls.

The direct cost methodology employed assumes very specific optimizing behavior by polluters. This assumption should be addressed in the uncertainty section. If polluters do not optimize in the manner assumed (which very well may be the case), the direct costs may under-estimate the true costs of compliance.

CGE modeling

The Council endorses the use of CGE modeling in the second prospective analysis. The effects of the CAAA on firm and consumer behavior are large enough that general-equilibrium effects are likely to be important. In the past, CGE models have been employed to identify some of the “hidden costs” associated with environmental regulation. The Project Team has done this, and also provided an estimate of some of the “hidden benefits” that result from reduced mortality and morbidity risk: increasing time available for labor and leisure and decreasing some medical costs.

While the Council endorses the use of CGE modeling, it has concerns about the particular model and its implementation, at least as described in the materials provided[8]. The model seems to require that consumers purchase greater quantities of market goods to maintain their utility, as opposed to paying higher prices for the same quantities (e.g., requirements for cleaner gasoline are modeled by requiring households to buy more gallons of gasoline rather than by having households pay a higher price per gallon). One symptom that this implementation may be misleading is the result that oil consumption is higher in the with-CAAA case. In addition, the modeling assumes separability of labor supply and environmental quality in the utility function; this separability does not always hold (e.g., cleaner air may encourage leisure activities such as birding and fishing, making air quality a complement to leisure). Assuming separability may misrepresent benefits by up to 30 percent in some cases[9].

It is important that the integrated report explain how to appropriately compare the CGE estimates with the primary estimates of benefits and costs. The CGE model represents flows of products and factors of production (e.g., labor and capital) between producers and consumers. It excludes improvements in well-being due to enhanced longevity and health, except to the extent that these increase time available for labor and leisure and reduce some medical costs. As a result, the estimated benefits in the CGE section of the report are quite small (tens of billions of dollars) compared with the primary estimate of benefits based on willingness to pay (in the

[8] 812 Economic Analyses Using the EMPAX-CGE Modeling System: Revised Draft Report (April 2010). Prepared for ICF Incorporated LLC by TRI International (RTI Project Number 0212224.000.004).
[9] For example, see: Carbone, J.C. and V.K. Smith. 2008. Evaluating policy interventions with general equilibrium externalities. *J. Public Econ.* 92:1254-1274.

hundreds of billions of dollars). The Council strongly encourages the Project Team to clarify how the CGE modeling results fit within the larger framework so that these seemingly inconsistent results can be better understood by readers. A specific suggestion is to replace the term "benefits-adjusted" (which may be easily misinterpreted) with "labor-force adjusted" or some other alternative.

In addition, it would be useful to provide more comparison between the cost estimates from the CGE model and the direct cost estimates, including discussion of the various factors that account for the differences (e.g., labor/leisure tradeoff, tax interaction effects, changes in investment). This comparison would elucidate the types of adjustment that are incorporated in the CGE but not the direct cost estimates, and clarify which are the most important.

Conclusion

In sum, the Council commends the EPA Project Team for its work on the second prospective analysis and looks forward to reviewing an improved integrated report.

Sincerely,

Dr. James K. Hammitt, Chair
Advisory Council on Clean Air
Compliance Analysis

NOTICE

This report has been written as part of the activities of the EPA Advisory Council on Clean Air Compliance Analysis (the Council), a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The Council is structured to provide balanced, expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency and, hence, the contents of this report do not necessarily represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names of commercial products constitute a recommendation for use. Reports of the Council are posted on the EPA Web site at http://www.epa.gov/advisorycouncilcaa.

U.S. Environmental Protection Agency
Advisory Council on Clean Air Compliance Analysis

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