

October 23, 1996

EPA-SAB-COUNCIL-LTR-97-001

Honorable Carol M. Browner
Administrator
U.S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460

SUBJECT: Council Review of the Clean Air Act Section 812 Retrospective Study entitled "The Benefits and Costs of the Clean Air Act, 1970 to 1990"

Dear Ms. Browner:

On June 5-6, 1996, the Advisory Council on Clean Air Compliance Analysis (the "Council") met to review the May 3, 1996 draft of the EPA document, *The Benefits and Costs of the Clean Air Act, 1970-1990: Report to Congress* (EPA, 1996; Also referred to as the "study," the "Retrospective Study," and the "draft document"). EPA intends to submit the final version of this Retrospective Study as a Report to Congress pursuant to Section 812 of the Clean Air Act Amendments(CAAA) of 1990 (CAA, 1990).

In general, the Council was favorably impressed with this draft. It is based on an extraordinarily rich set of data and models, and it reflects an enormous amount of hard, careful, and effective work by Agency staff and contractors. This draft document is a significant advance over what we have seen in the past; as a result, the final document as an Agency Report to Congress has the potential to be a landmark study. That document should make significant contributions to our understanding of the overall costs and benefits of the Clean Air Act (CAA, see CAA, 1970 and CAA,1990). (We recognize that it was impossible to disaggregate the pre-1990 analysis by programs and look forward to such a disaggregation in the prospective cost-benefit study of the CAA now in preparation.) The final version of this draft document should advance the state of the art and science of cost-benefit analysis. In addition,

difficulties encountered during this study have important implications for research priorities, which can be selected to create a basis for improving future reports.

The Council's task was, of course, not to praise this draft document but to help improve the final document as an Agency Report to Congress. To that end, individual Council members have provided detailed editorial suggestions to involved Agency staff via the SAB staff. More importantly, the Council agreed that unless the issues raised in the remainder of this letter are addressed effectively, the final version of this study will be open to serious criticism. We believe the Agency can address them all effectively with relative ease.

General Issues

The tone of the current draft document is unnecessarily argumentative and defensive at points. As several members observed, by sometimes seeming to cross the line from analysis to advocacy, the authors of this draft document weaken the strong case made by their analytical work. In particular, this draft document seems to deal with the inevitable imperfections of cost-benefit analysis very reluctantly; the idea that any estimate in this draft document might be at all uncertain does not appear until p. xvi of the executive summary¹. (The use of "roughly 20 dollars" in the headline sentence is misleading in this regard.) The Council believes that an accurate and complete treatment of the uncertainties and gaps in knowledge encountered in this study should be included and will, on balance, strengthen the final document as an Agency Report to Congress.

Similarly, this draft document is weakened by almost always using a single discount rate. Because choice of a discount rate is inevitably controversial, the next draft document should include more complete analyses of sensitivity to that choice (in Appendices) as well as clear statements in the text of when that choice has a material impact on an important category of benefits or costs.

A second set of problems seems to have arisen primarily because of hasty writing. It is sometimes difficult, particularly in the Appendices, for even a diligent reader to understand exactly how the analysis was performed. It would be impossible for a diligent reader to reproduce the results of some steps in that analysis based on the information provided in this draft document, and that is not acceptable in a technical document. Similarly, obviously relevant literature is sometimes not cited, even when it is supportive of the proposition being advanced, and controversial

¹ The reference to page numbers, Chapters, Tables and Appendices refers to text being reviewed by the Council specifically related to the EPA draft document (EPA, 1996).

issues are often passed over quickly in the text without citing more extensive treatments in the Appendices. Additionally, the Agency should be sure to cite the primary references, not just secondary references.

A third set of problems involves careless wording on some sensitive points. This is particularly troublesome when it occurs in the executive summary, which is likely to be by far the most widely-read part of the final document as an Agency Report to Congress. The misleading description of economic valuation on p. xv is a case in point. The costs used in this study are called "Clean Air Act compliance costs" at several points, though in principle at least, they clearly include costs of complying with environmental regulations that were in place before 1970. Contrary to the assertion on p. xviii, as a matter of pure logic, total benefits well above total costs in 1990 does not necessarily imply "that substantial additional cost-beneficial protection remained to be achieved" because it implies nothing about marginal costs or marginal benefits. While it may be the case that further "cost-beneficial protection" can be achieved for some pollutants, the present analysis does not shed any light on this question. It is not the case (ch. 1, p. 7) that the direct costs of the CAA are "readily obtained"; the cost estimates here rest on a number of judgments regarding the evolution of technology in the absence of the CAA. The draft document regularly (e.g., p. xvii) refers to unmonetized benefits, which are present, and ignores the possibility of unmonetized costs. Such costs may arise, for instance, because this analysis (sensibly) does not attempt to quantify possible adverse impacts of regulation on the rate of technical change -- effects that would continue long after 1990. A number of additional issues of this sort are raised in the separate memoranda of individual Council members.

Costs

In general, this draft document devotes too little attention to the significant uncertainties that affect the estimated control costs. Moreover, it is not possible, as it should be, for a diligent reader to reconstruct the process by which the cost estimates were derived. In addition to these general problems, several specific questions require attention.

First, the cost numbers are said to be based primarily on *The Cost of Clean* (EPA, 1990). In some cases, however, those numbers appear to be inconsistent with (and below) the data underlying the annual articles published by the Department of Commerce's (DOC) Environmental Economics Division in DOC's *The Survey of Current Business* (U.S. DOC, various issues). Because it is likely to become a standard reference, the Agency's Retrospective Study should explain the

discrepancies. Moreover, the adjustments performed on *The Cost of Clean* (EPA, 1990) numbers are not well-explained. In principle, they should be reproducible so that other researchers can understand how the numbers used in the Retrospective Study were derived and can test alternative assumptions.

Second, the most important source of cost uncertainty (and potential underestimation) relates to the potential “chilling” effect of environmental regulation on innovation, which represents some cost to society. Four significant issues in the following subparagraphs (a to d) deserve attention; all point to omissions that tend to underestimate costs:

- a) The draft document presents annualized total direct compliance costs (about \$25 billion in 1990; see Table 28). It also presents the Jorgenson-Wilcoxon (J-W) estimates of the reduction in real Gross National Product (GNP) in percentage terms (1% in 1990; see Table 29). This presentation is consistent with our earlier advice to de-emphasize changes in GNP because it is an inferior measure of changes in economic welfare (SAB, 1996b). However, as the draft document itself acknowledges (p. 57), the direct compliance costs are also an imperfect measure because of their failure to capture a variety of indirect effects of regulation on economic welfare. We recommend that the draft document include a presentation of the annual reduction in real GNP (about \$55 billion in 1990, or 1% of the 5,524 billion GNP of that year) to give the reader an indication of the potential importance on indirect effects as contributions to the total cost of the 1970 CAA.
- b) The draft document as a Retrospective study used as its macroeconomic benchmark the J-W model. One of the features of this model is its effort to incorporate Endogenous Technological Change (ETC). In our June 1996 report (SAB, 1996b), we had recommended against making ETC the base case of the analysis. This draft document presents only the results without ETC. We understand that the estimated reductions in GNP are substantially larger when the model is run with ETC. We recommend that the results of both model runs be presented so that the reader can understand the importance of the assumptions about ETC for estimates of total costs.
- c) The annualization of all stock data adds a further complication to this problem. The J-W estimates are for the “flow” of services from technology rather than the stock of technology. The estimate of the loss

in output should include not only the annual technological losses but also the technological losses that continue past 1990. This is a complicated technical and computational problem, but it is unavoidable if we wish to get an accurate estimate of the costs of regulation. Sample calculations by one of the Council members suggest that taking account of future losses due to reductions in innovation and technological change could increase estimated costs substantially, perhaps by almost a factor of two. This issue should be addressed in the draft document.

- d) A final question involves the work of Gray and Shadbegian (1993; 1995) on the "technological chilling effect" of regulation. They estimate that the indirect costs of regulation are significantly larger than the direct costs estimated by the Census Department. This work was reviewed by Industrial Economics, Inc. (IEc) in a memorandum (Peterson and Unsworth, 1995) that is quite misleading and flawed in a number of respects.² We are not suggesting that this study should accept the Gray-Shadbegian conclusions without qualification, but it should certainly include sensitivity analyses that allow for these costs (as with the J-W costs), recognizing that important elements of costs are uncertain. In addition, the questions of future technology discussed in connection with the J-W estimates are equally relevant for the chilling effect of regulation on productivity.

Emissions and Air Quality

Numerous assumptions were required to create the emission inventories used in this study, and this has resulted in significant uncertainties, especially for the no-control scenario and for volatile organic compounds (VOCs). Although these uncertainties are unlikely to have a significant impact on the outcome of this study, they need to be more thoroughly articulated (Table 6 should be discussed) in the chapter and appendix.

³This is not the place for a detailed review of the IEC memorandum (Peterson and Unsworth, 1995), but a few points are worth making. The IEC memorandum is incorrect in stating that the authors in the 1995 study "correct an important methodological problem." Based on a conversation with Dr. Gray, who was not given a chance to review the IEC memorandum, the Gray-Shadbegian work in 1995 (Gray and Shadbegian, 1995) includes fixed effects in the regression. Dr. Gray stated (conversation on June 12, 1996 with Dr. William D. Nordhaus) that he is somewhat suspicious of the fixed-effects approach because of timing and other measurement issues; while this approach provides alternative information, it does not supersede the 1993 estimates (Gray and Shadbegian, 1993). In addition, the IEC study argues that the Gray-Shadbegian studies "omit certain factors" such as the impact on worker productivity. These impacts are in principle included in the benefits and are not an appropriate reason to omit an analysis of the impact on productivity.

Similarly, numerous assumptions have resulted in significant uncertainties in the predicted no-control scenario air quality measures. This was especially true for those pollutants and measures not linearly related to emissions: ozone, visibility, acid deposition, and, to a lesser extent, particulate matter (PM). As with emissions, the Clean Air Scientific Advisory Committee (CASAC) Air Quality Models Subcommittee (CASAC/AQMS) concluded that these uncertainties were unlikely to affect the study's outcome significantly, but they need to be explicitly stated. (In particular, Table 7 should be discussed in the text, and the more extensive discussions in Appendix C should be referenced.) The present chapter conveys a degree of precision that is not justified. [For the sake of completeness, it should be noted that after discussing the CASAC/AQMS letter report (SAB, 1996a), dated May 31, 1996 with that group's Chairman (Dr. George Wolff), the Council endorsed the CASAC/AQMS report and conclusions.]

Physical Effects

The Council's Physical Effects Review Subcommittee (PERS) met on June 4, 1996. The Council met on June 5 and 6, 1996. The PERS Chair (Dr. Morton Lippmann) and Vice-Chair (Dr. A. Myrick Freeman) attended the Council meeting, and their deliberations were reviewed at some length. The Council is comfortable with their main conclusions as we understand them. Their work raises important, but corrigible, problems of both substance (choice and use of studies) and presentation (the "low-mid-high" approach, also discussed below). The Council has approved the PERS (EPA, 1996c) letter report and has recommended that it be submitted to the Administrator of the Agency. This Council report endorsed the findings and recommendations of the PERS report, to which the reader is referred for the complete presentation of details (SAB, 1996c).

Valuation

We believe that the values applied to statistical lives saved by the CAA should, in principle, reflect the health status of those saved and their remaining life expectancy. We also believe that the value currently applied to a statistical life, \$4.8 million (1990 U.S. dollars), significantly overstates the value most people would attach to the average number of life years saved (per person) by the CAA. One must recognize that this number is based on a set of labor market wage/risk tradeoff studies of working age adults with a lower average age and high life expectancy than the age groups with the higher risks of death due to air pollution considered in this study.

We recommend that the premature mortality avoided by the CAA be stated in terms of the expected number of life years saved, and that life years be valued instead of statistical lives. At the very least, something must be said about the age of the statistical lives saved. This can be done in the case of episodic mortality studies by applying the age-specific coefficients in those studies to the U.S. population. If the \$4.8 million (1990 U.S. dollars) figure is retained, it should be made clear that this was derived as the value of saving the statistical life of a 40-year-old. Another approach is to value the changes in the mortality risks based on estimates in the literature of how this value varies with age. We discussed this approach in some detail and provided relevant references on page 8 of our June 1996 report (SAB, 1996a).

An alternative approach to presenting the mortality benefits of the CAA that avoids having to explicitly value either life years or statistical lives is to compute the cost per life or per life year saved implied by the Act. For example, one would divide the \$25.1 billion in compliance costs for 1990 by the estimated 79,000 lives saved to arrive at a cost per life saved of \$318,000. This, of course, ignores the benefits of air pollution control other than reduced mortality. It also begs the question "Is \$318,000 greater or less than the value of saving a statistical life?" The computation does, however, permit a comparison of the cost per life saved of the CAA with the cost per life (or life year) saved of other health and safety regulations. We believe that efficient regulation requires that such comparisons be made.

The study currently values heart attacks and strokes avoided by the CAA by the value of preventing a severe case of chronic bronchitis. In view of obvious differences among the three illnesses, it is essential that this benefits transfer be justified. This could be accomplished by comparing the medical costs and foregone earnings associated with each of the three diseases. To the extent that they are similar, one could argue that the three diseases place similar limitations on at least some aspects of performance and that willingness-to-pay to avoid them should therefore be similar.

The estimates of the value of reducing lead emissions contains estimates of the value of Intelligence Quotient (IQ) points lost. Our most recent report indicated that including induced effects in this calculation represents an error (see SAB, 1996a, point 4.9, page 12). This error persists in the current draft document.

The choice of a discount rate is not adequately discussed in the current draft document. A 3 percent per year real discount rate is used almost exclusively, though this is not warranted either by Administration policy (which mandates a 7 percent real

discount rate), by agency practice (which, the Council was told, is generally to use a 5 percent real discount rate), or by documented reasoning. As we have indicated in earlier reports, we believe that a range of rates should be employed, though differences in results should be presented only when they are substantial. As a general matter, it is not clear how much the choice of discount rate would affect the conclusions of the Retrospective Study. One clear point is in the estimates of the value of IQ points lost because of lead in the no-control scenario. One Agency official in attendance at our Council meeting indicated that the IQ benefits (in dollars) in lead would be reduced by 2/3 if a 7 percent discount rate were used. If true, this should be made clear.

Finally, the Council discussed two important issues of presentation of valuation analysis. First, more disaggregated information on benefits should be given in the text and executive summary. At present, the executive summary contains information on a variety of estimated physical effects in Table 1 and information on a variety of estimated values in Table 3, and these are reprinted as Tables 11 and 14, respectively, in the text. However, only total benefits (computed by multiplying physical effects times values and summing) are presented -- in Figures 3, 21, and 22. The Council believes that a table of benefit values, disaggregated at roughly the level of Tables 1 and 3, should be presented in both the text and the executive summary. Second, because reduced mortality is such an important source of dollar benefits, both physical effects (Tables 1 and 11) and dollar benefits, the new Tables just discussed should show the effects of changes in lead separately from the effects of changes in other pollutants. (The Council recognizes the conceptual difficulty of further disaggregation.)

Uncertainty

The analysis of uncertainty given in Chapter 7 of this draft document focuses on developing a plausible probability distribution for aggregate benefits. This distribution is determined by probability distributions for individual physical effects and valuation parameters. Unfortunately, while the latter distributions are presented in appropriate detail in the Appendices, the reader is given no justifications for the assumptions on which those distributions rest. Some distributions used seem to be anchored on the highest and lowest credible estimates of physical effects within the literature base. This is inappropriate, if only because the range between the high and low can be expected to increase as the number of studies included increases, while the true uncertainty would be decreasing with the inclusion of more studies (other things being equal). Rather, the distributions used in the analysis of Chapter 7 should reflect reasoned judgments regarding the implications of the literature. In turn, the

ranges of physical effects presented in the text and executive summary -- and the ranges of values that should be presented in both places -- should represent confidence intervals of the distributions used in the analysis of Chapter 7.

Monte Carlo analysis should also be used to provide information regarding the relative importance of the many sources of uncertainty that underlie the aggregate distributions currently summarized in Chapter 7. The first step in this procedure is to single out one variable, to set all others equal to the corresponding best estimates, and to compute the distribution of aggregate benefits implied by the uncertainty in the singled-out variable alone. Applying this procedure to all variables treated as uncertain in the computations summarized in Chapter 7 yields a set of distributions, the variances of which can be readily compared. Chapter 7 should include a short table giving the benefit distribution variances implied by the largest few sources of uncertainty, compared to (or divided by) the variance of the aggregate distribution. This one-variable-at-a-time analysis is important because it shows where reduction in uncertainty would most improve the precision of aggregate benefit estimation.

Research Issues

Appendix J represents a unique opportunity to use the lessons from the analytical process created by this study as a foundation for establishing air pollution research priorities in the future. The current version of Appendix J misses this opportunity by presenting views which are largely independent of the analysis rather than flowing logically from it.

During the research process a number of gaps in available information were uncovered. Some suspected physical effects (such as ecological and health effects associated with air toxics) could not be quantified. Other quantified physical effects (such as nonmarketed forest services) could not be reliably valued. Many others could be quantified and valued, but either the corresponding uncertainty could not be well-described or the literature implied very wide confidence intervals. Collecting and characterizing these information gaps would provide a useful menu of needs and opportunities for future research.

Setting priorities among these gaps would require some comparison of the value of additional information with its cost. For those effects where estimates were possible, but only within wide confidence intervals, it should be possible to gain some insight about the value of additional information. The one-variable-at-a-time Monte Carlo studies (described above) could be used to identify those specific relationships where greater precision (resulting in smaller confidence intervals) could have the

greatest impact on the aggregate estimates. Combining these results with some information on the cost of filling individual research gaps would allow some inferences about research priorities to be drawn.

Our review has identified significant uncertainties and gaps in data and support information. Since it appears that cost/benefit analyses will become a continuing method for evaluating the CAA, a strategic plan for research must be developed in order to identify, validate, prioritize, and employ the most appropriate variables and indicators for these types of analyses.

Some of the necessary variables already exist, but there are major gaps (e.g., ecological metrics) which can only be addressed through a focused, well-designed, strategic plan of research and development. Such a plan can be used to establish priorities that will effectively direct resources to reduce exposure and adverse health or environmental responses by controlling sources of concern.

Appendix J also discusses the "Prospective Study" of post-1990 CAA costs and benefits that is in preparation. Two issues seem to us particularly important in this context. The first concerns the treatment of mortality as discussed in the Valuation section above. A recurring issue in the Retrospective Study has been the life-lengthening impact of reduced air pollution. The Council inquired on this point on a number of occasions, and the question is still unresolved. The Prospective Study could be improved if EPA were to increase the research effort devoted to this important question. One approach would be to estimate empirical survival curves as a function of concentrations. In fact, it would appear to be both prudent and possible to conduct such an analysis of existing data (e.g., Pope et al., 1995) as a part of the retrospective study.

A second issue concerns the utility of this work for improving regulatory design. One of the shortcomings of the current Retrospective Study is the inability to disaggregate beneath the totality of all regulations. As a result, we cannot use the current Retrospective Study to determine in a rigorous way which air pollution controls are cost-beneficial and which are not, or which ones are highly cost-beneficial and which ones are less so.

A major task for the CAA Section 812 Prospective Study, then, is to ensure that the future CAA Section 812 Study design allows such a disaggregation. In the discussion of the prospective work, it would be useful to emphasize that the problem of deploying the enormous machinery used in the Retrospective Study for actual

program and regulatory policies is critical and should be absolutely central as the CAA Section 812 Study team moves on to the prospective studies.

Once again, it has been a pleasure for the Council members to work with able and dedicated Agency staff on this important project. We expect that you and everyone involved will be proud of the quality of the final product, and we look forward to your response to our findings and recommendations.

Sincerely,

A handwritten signature in black ink, appearing to read 'R. Schmalensee', written in a cursive style.

Dr. Richard Schmalensee, Chair
Advisory Council on Clean Air
Compliance Analysis

NOTICE

This report has been written as part of the activities of the Science Advisory Board, a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The Board 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 or commercial products constitute a recommendation for use.

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Although a member of the Council, Dr. Dudek was unavailable to participate in this specific review.

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Although a liaison from the EPEC, Dr. Cooper was unavailable to participate in this specific review.

ABSTRACT

The Advisory Council on Clean Air Compliance Analysis (the Council; formerly known as the Clean Air Compliance Analysis Council, CAACAC) of the Science Advisory Board (SAB) has reviewed on June 5 and 6, 1996 the Agency's May 3, 1996 draft Report to Congress entitled "*The Benefits and Costs of the Clean Air Act, 1970-1990*." While the Council was favorably impressed with this draft and noted that it reflects an enormous amount of careful and effective work by the Agency staff, a number of suggestions were offered to improve the final report.

Some of the major issues that the Council stressed include the estimation and valuation of changes in mortality, the treatment of uncertainties and gaps in knowledge, the clear presentation of cost methodology, the exposition of important issues and data, the need to conduct a sensitivity analysis on the discount rate, the need to consider the indirect costs of regulation, and the need to display more disaggregated information on benefits in the text and executive summary.

The Council recognized that this is an unusual opportunity to use the lessons learned from this study to establish sound research priorities. The Council, drawing on the work of its subcommittees, identified significant uncertainties and gaps in data and support information. The Council also noted that research priorities should reflect the continuing important role of cost/benefit analysis in program design and evaluation.

Key Words: Air Pollutants, Clean Air Act, Cost-Benefit Analysis, Economic Valuation, Valuation Methodologies

REFERENCES CITED

- CAA. 1970. Clean Air Act. Public Law 91-604, December 31, 1970
- CAA. 1990. Clean Air Act. Public Law 101-549, Section 812, 104 STAT 2692, November 15, 1990
- EPA. 1990. "Environmental Investments: The Cost of A Clean Environment," U.S. Environmental Protection Agency, Office of Policy Planning and Evaluation (OPPE), EPA-230-11-90-083, November, 1990
- EPA. 1996. "The Benefits and Costs of the Clean Air Act, 1970 to 1990," Prepared for U.S. Congress by U.S. Environmental Protection Agency, draft, May 3, 1996
- Gray and Shadbegian. 1993. Bureau of Census Discussion Paper CES 93-6
- Gray and Shadbegian. 1995. National Bureau of Economic Research (NBER) Working paper 4994, 1995
- Peterson, T.B and R.E. Unsworth. 1995. "The Effect of Environmental Regulations on Productivity," Memorandum from T. B. Peterson and R.E. Unsworth of Industrial Economics, Inc. (IEc), May 12, 1995.
- Pope, C.A. III; Thun, M.J.; Namboodiri, M.; Dockery, D.W.; Evans, J.S.; Speizer, F.E., and Heath, C.W., Jr. 1995. Particulate Air Pollution is a Predictor of Mortality in a Prospective Study of U.S. Adults. *Am. J. Respir. Care Med.*, Vol. 151, March 1995, pp. 669-674
- SAB. 1996a. CASAC Comments on Air Quality Modeling for the Section 812 Retrospective Study, U.S. Environmental Protection Agency, Science Advisory Board (EPA-SAB-CASAC-LTR-96-007), May 31, 1996
- SAB. 1996b. ACCACA Review of the Agency's Retrospective Study of Section 812 Clean Air Act Benefits and Costs from 1970 through 1990, U.S. Environmental Protection Agency, Science Advisory Board (EPA-SAB-ACCACA-96-003), June 3, 1996
- SAB. 1996c. Review of "The Benefits and Costs of the Clean Air Act, 1970 to 1990" by the Physical Effects Review Subcommittee (PERS) of the Advisory Council on Clean Air Compliance Analysis (ACCACA), U.S. Environmental Protection Agency, Science Advisory Board (EPA-SAB-ACCACA-LTR-96-010), September 26, 1996
- U.S. DOC. various issues. *Survey of Current Business*, "Pollution Abatement and Control Expenditures," U.S. Department of Commerce (DOC), Environmental Economics Division, published in various issues beginning twice/year and now once/year for the past several years

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