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OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

Honorable Carol M. Browner
Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Re: Review of the Global Climate Change Engineering Research and Development
(R&D) Program

Dear Ms. Browner:

We are pleased to transmit this letter report containing findings and recommendations of the Global Climate Change Engineering Research Subcommittee (GCCERS, also referred to as "the Subcommittee") of the Science Advisory Board's (SAB's) Environmental Engineering Committee (EEC). This review was conducted on May 26 and 27, 1993 at the U.S. Environmental Protection Agency's (EPA's) Air and Energy Engineering Research Laboratory (AEERL), Office of Research and Development (ORD) at Research Triangle Park, NC. The GCCERS received presentations and briefings and discussed the Agency's draft report entitled *Global Climate Change Engineering R&D Program*, dated April 1993. The draft document reviewed by the SAB's GCCERS was prepared by AEERL's Global Warming Control Branch of the Global Emissions and Control Division.

Summary

The Subcommittee was charged to evaluate AEERL's present and proposed future approach to global climate change engineering research in terms of their rationality, scientific soundness, rigor and practicality.

The Subcommittee found the existing Global Climate Change Engineering R&D Program to be rational, scientifically sound, practical and supportive of EPA's role, and that the individual projects were appropriate to the capabilities of the laboratory and the qualifications of its personnel. The existing focus on increasing point sources of methane emissions, and on sources controllable by engineering solutions is recommended for expanded emphasis and development.



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The Subcommittee also made recommendations for further development of the Global Emissions Data Base (GloED), inventories on methane emissions from natural gas and coal industries, efforts toward coalbed methane recovery, demonstration of fuel cells for control of waste methane emissions, studies on conversion of biomass to energy, production of transportation fuel, and a systematic prioritization of risks in developing research opportunities for any expanded future program.

Finally, the Subcommittee strongly recommends that the engineering thrust of the program be recognized as a necessary element of the overall global change research in ORD and the other global change activities of OPPE and in the Office of Air and Radiation (OAR).

Charge to the Subcommittee:

The review was requested by ORD's Office of Environmental Engineering and Technology Demonstration (OEETD). The charge, provided in a memo from Mr. Frank Princiotta to Dr. K. Jack Kooyoomjian of the SAB Staff, dated April 30, 1993, can be condensed to: 1) Is the EPA/ORD/AEERL present approach to global climate change engineering research rational, scientifically sound, rigorous and practical, and are its projects reasonable and scientifically sound?; and, 2) Are the AEERL proposed expanded program and strategic directions reasonable, scientifically sound, and promising in terms of potential for significant contribution? Specific areas reviewed were; "greenhouse" gas (GHG) emissions, methane mitigation, biomass utilization and strategic directions for future research. We are also providing advice for broad-ranging coordination and leadership roles for the Agency in this admittedly complex and uncertain area of global climate change.

General Comments:

The AEERL staff's exemplary preparation for this review is acknowledged. The AEERL has demonstrated, both in the past and during this Research-in-Progress Review, its ability to select practical research opportunities, to be innovative, and to forge productive partnerships in promoting commercial use of research results.

The Subcommittee found that the existing Global Climate Change Engineering R&D Program is scientifically sound and supportive of EPA's role, and that the individual projects are appropriate in terms of the laboratory capabilities and personnel qualifications. AEERL has established a program with an important niche, which has already made significant contributions to global climate engineering research despite essentially limited financial resources.

Although the current projects are of high quality, the diversity of funding sources and associated constraints have resulted in a less than sufficient framework and decision-making structure to otherwise facilitate integrated management and direction in a more organized and consistent manner. As a consequence, the program has evolved more from a series of opportunistic projects based upon available funding sources than from an integrated and focussed research agenda. At a minimum, the future program should be structured to systematically define highest priority needs not being addressed by others, and should include integrated projects to responsively address these needs. Such a systematic approach must start with the definition of the users of the results such as atmospheric scientists and policy makers, followed by an evaluation of the needs of those users, and resulting in a program agenda capable of providing the necessary supporting information.

A unifying theme already established by the current AEERL program that needs better emphasis and development includes a focus on the increasing point sources of methane emissions, and on other sources controllable by engineering solutions. If emissions mitigation proves to be an important strategy, the role of EPA as a catalyst for application of engineering solutions (e.g., mitigation) is very important and should be sustained. Such a focus may lead to new discoveries, and may enable the Agency to beneficially expand its expertise for evaluation and analysis of advanced concepts. However, to realize this potential more fully, the AEERL will require substantially enhanced resources, including some which may have to be acquired by nurturing strategic alliances with other agencies and with industrial collaborations.

Development of Greenhouse Gas (GHG) Data Base:

Recent trends in atmospheric methane may be influenced by relative decreases of emissions from agricultural sources and increasing emissions from energy generation and waste disposal. This change in the nature of anthropogenic sources may uncouple causes of past increases of methane accumulation during the last century from causes of future increases. If this premise is correct, it is conceivable that the slowing of the current atmospheric concentration trend may reverse as energy generation and waste disposal sources continue to expand. Therefore, the Subcommittee endorses the AEERL focus on the identification and characterization of key anthropogenic sources of methane, such as coal mines, landfills, and other waste disposal and natural gas sources, since these sources may control future concentrations of atmospheric methane. Moreover, economic considerations aside, these anthropogenic sources are in principle controllable and can provide energy as a bonus, whereas the management of agricultural sources is more difficult. The effort

on determining global emissions, preparing inventories and developing mitigation methods should be continued.

Global Emissions Data Base (GloED) Framework:

Further development of the GloED data base framework is encouraged by the Subcommittee, since it provides a potentially useful foundation for developing an emission data storage and presentation tool for global pollutants that may affect climate. However, the GloED framework is currently structured to attempt to satisfy an extremely broad audience, and there is a consequent diffusion of utility. Two distinct GloED user groups are likely; policy analysts and scientists. They have quite different needs and expectations from a centralized data base. The AEERL should attempt to define the specific needs of these user groups. The present version of GloED seems most appropriate as a tool for policy analysts (once the procedures for accounting and displaying data uncertainties and quality assurance procedures have been applied as discussed below.) For usage of a GloED data base by scientists, such as to provide inputs for use in atmospheric chemistry modeling, the data base will need to have much finer spatial resolution, a temporal component, a much greater ability to perform statistical manipulations, and other functions. The specific requirement for these user groups must be defined after consultation with these groups.

The Subcommittee also recommends that the GloED project needs to be reinforced with a formal Quality Assurance (QA) Plan that carefully documents the data sources and methodology used to derive the estimates of data values (e.g., when multiple references or multiple values are used, the methodology for evaluating the quality and reliability of the data, the procedures for checking data entry, etc.), and how data are selected and used in the data base. A relational database management system should also be associated with this product, and should not only be portable to other PC platforms, but possibly also extended to work stations as well. While the Subcommittee agrees that the existing GloED system can be brought to completion as an initial release, the explicit incorporation of information on uncertainties and data quality prior to the release of GloED is essential. The central objective is to represent existing information at a level of certainty and reliability commensurate with the inherent quality of the data, and not to provide a false sense of high precision or accuracy. Another task that should be completed before release is systematic data examination and verification (i.e., ensure that the numbers obtained from the literature accurately reflect the numbers from the source).

Methane Emissions from Natural Gas and Coal Industries and Coalbed Methane Recovery:

The Subcommittee supports the examination of methane emissions from the coal and natural gas industries, and commends the AEERL staff for its interactions with other agencies, organizations, and private industry, such as the Department of Energy (DOE), the Gas Research Institute, and Amoco Production Company. The proposal to expand the study of emissions from underground and surface coal mines to efforts to measuring emissions from abandoned, underground coal mines for an improved global methane emissions estimation may be important and should be encouraged.

The emissions data now being collected from operating, open-pit and underground coal mines, and from natural gas production, transmission, and distribution systems, appear to be reliable. The Subcommittee believes that the scientific approach for this data-gathering effort is reasonable and sound, and agrees with the current focus of collecting these data, given present estimates of the apparent magnitude of methane emissions from these sources. Therefore, this effort is an appropriate initiative for the Agency and one that could be enhanced by a closer collaboration with the U.S. Bureau of Mines, DOE, and private industry, thereby taking advantage of an opportunity to correlate methane emissions according to coal rank and type of deposit.

The Subcommittee understands that the AEERL intends to continue with the demonstration of Amoco's technology for methane mitigation and utilization, although it is unclear whether Amoco really needs or wants such assistance. Therefore, the Subcommittee questions whether participating in this demonstration is a particularly fruitful approach, since Amoco may be intending to separately demonstrate the technology for commercial reasons. Accordingly, the following recommendations are provided relative to methane mitigation and utilization:

- a) The Agency (through the AEERL and other ORD researchers), should focus on a systematic program to gather information on existing and potential technologies available throughout the world for recovery and use of methane from coal mines;
- b) these technologies should be reviewed for technical and economic efficacy in order to allow them to be incorporated later into the planned Global Technology Database (GloTECH);

- c) the Agency should view itself as a catalyst to stimulate other agencies, organizations and private industry to perform supportive R&D; and
- e) the Agency's role should be one of environmental conscience advocate for such R&D, as well as for potential future applications of the resultant technology. This role should encourage development of actual technology, rather than simply providing a technology information transfer function.

The Subcommittee also understands that the AEERL intends to continue measuring methane emissions from the natural gas industry, with special efforts to develop better methodology for measuring steady and unsteady conditions. Such efforts can facilitate estimation of both domestic and global methane emissions from the natural gas industry, and could be supportive of a new initiative on mitigation and utilization of methane leaks from the production, transmission, and distribution of natural gas. In this regard, the Subcommittee also encourages the Agency to examine the findings of the chemical industry relative to fugitive emission control.

Development of "Greenhouse" Gas (GHG) Data Base for Waste Management Facilities:

The initial focus of the GHG emissions data base on methane from landfills, waste treatment, and livestock waste is appropriate and has been productive. It is rationally addressing an existing and growing issue in waste management areas that is amenable to engineering analysis and control. Hence, it presents potential opportunities for early delivery of a tangible product useful on both local and possibly global horizons. Moreover, continued linkages to other initiatives elsewhere within the international community [e.g., the Intergovernmental Panel on Climate Change (IPCC), the International Solid Waste Association (ISWA), the International Energy Agency (IEA)] can be complementary and enhance development of reliable data and information.

The credibility of individual sources of information, the causative agents and factors influencing spatial and temporal characteristics of emissions, as well as precision and accuracy of data, must be established before transfer to the user community can be accomplished. Simple development of generic emission and activity factors may not suffice if dynamical causative agents and influencing factors are not appropriately addressed and taken into account for either predictive or policy purposes. Some current emission estimate (e.g., landfill gas) may be in need of

further refinement and qualification before being delivered for use in policy, scientific, or engineering decisions.

Demonstration of Fuel Cells for Recovery of Energy and Control of Waste Methane Emissions:

The fuel cell mitigation program is intended to demonstrate the feasibility of using this technology on a commercial scale to produce electricity from landfill and anaerobic digester gas. A major research issue is gas cleaning before fuel cell use. With regard to this research program, the Subcommittee concludes that:

- a) The research focus is reasonable in terms of opportunity to affect reductions in methane emissions;
- b) the stated objective to reduce methane emissions and to recover energy in an environmentally acceptable manner is technically achievable;
- c) emphasis on clean-up of the waste gases is reasonable, although more attention should be given to means and costs of managing byproducts, system design, sequencing of unit processes and operations, and considering the effect of waste gas quantity and quality on the utilization system and the implications of the presumed worst-case waste gas scenario; and
- d) options considered for utilization of gas should not be limited to fuel cells, and other methods should be conceived for comparison in terms of implementation and associated cost-effectiveness.

Development of Global Emissions Inventories for Tropospheric Ozone Precursors:

Since the research on tropospheric ozone precursors has just begun and no results were presented, it is not possible to evaluate current progress. If this program is to continue, the Subcommittee recommends that the potential users of the generated data should be identified and their data needs defined first, since they are likely to be different than the principal users of the data bases on methane. In addition, the Subcommittee believes that the effects of biomass burning and resultant aerosols could be an additional element for this program. However, because of its breadth and potential implications, the Subcommittee also recommends that this program be scheduled for review in any overall evaluation of EPA's global climate

change program, and receive further evaluation after one or two years to assess actual progress and relevance.

Conversion of Biomass to Energy:

The initial focus of the AEERL biomass utilization program has been the selection and evaluation of promising approaches for the high efficiency production of electricity in small-scale systems (i.e., 0.5 to 5.0 MW). Specific systems that have been investigated include an integrated gasifier/gas turbine system (Cratech and Vermont/GE) and a combustion system (ENERGEO) integrated with a gas turbine. In addition, an innovative energy conversion technology project will be initiated with the Strategic Environmental Research and Development Program (SERDP) to convert or replace an existing energy system at a Department of Defense (DOD) installation to utilize biomass, although a technology has not yet been identified for this project.

The Subcommittee believes that targeting small-scale high efficiency systems is a reasonable program for AEERL to undertake. With the increased restrictions on landfilling of certain biomass materials, these systems may be more marketable for generation of electricity than larger-scale systems. Based on information provided to the Subcommittee, the projects undertaken have enjoyed extensive partnerships, and support for FY 93 will largely be as a result of the SERDP/DOD funding and resources. This search for complementary support from other agencies is commendable and should be continued.

Present research should result in findings that enable decisions to be made regarding broad deployment of the selected approaches to generate electricity from biomass. The Subcommittee suggests that AEERL undertake a more systematic evaluation of the available technologies. This evaluation should determine the technical barriers and challenges associated with various system components, the consequences of system design process variations, the requisites for high pressures (up to 20 atm), the relative advantages and disadvantages of the operation, maintenance and safety requirements of these systems compared to other types of systems, and the fundamental issue of whether gasifiers actually represent a viable process replacement option.

AEERL should also investigate and evaluate the likelihood of converting existing energy generating systems in order to utilize biomass as fuel and associated technical challenges involved. The SERDP project will clearly involve some of this evaluation, but the Subcommittee would like to encourage the implementation of this process prior to the selection of further demonstration projects. In addition, for the

selected DOD technology, an evaluation of available technologies may enable better identification and understanding of the comparative limitations and applicability of the selected technology at other sites.

Production of Transportation Fuel:

The major emphasis of the transportation fuel project has been on the Hydrocarb process, originally conceptualized by the Brookhaven National Laboratory. Preliminary economic assessment and process optimization analysis are considered an appropriate first step in the evaluation of this process, and have been used to demonstrate the favorable economics of an ideal process. However, the AEERL should also consider the economic and ecological perspectives within which the process will be used. For example, the Subcommittee suggests a more thorough examination of water use, biomass and fuel transportation, and other ecological impacts associated with the implementation of large-scale utilization systems and biomass plantations which may make the economics and intended global climate benefits less attractive.

The development of this technology is a high risk program, despite potentially high payoffs for (GHG) mitigation. The technology is complex. It involves integration of state-of-the-art chemical processes for a heterogeneous feedstock. Many of the necessary process components have either not been developed or have never been used or integrated in this manner. For example, there are uncertainties regarding performance of such items as high temperature heat exchangers, high temperature filters, high pressure hydrogasification, catalyst performance, etc. Therefore, the Subcommittee strongly suggests a systematic examination of the performance limitations of process components in light of the practicality of utilizing a relatively heterogeneous feed stock, and the potential technical challenges and implementation barriers also identified in previous peer reviews. Moreover, since the program required for development will be extensive and resource intensive, additional funding and support will be required, and the Subcommittee recommends active solicitation of a collaborative effort with SERDP, DOE and, in particular, NREL (National Renewable Energy Laboratory in Golden, CO), since development of utilization technologies for renewable fuels such as biomass is part of its mission.

Research Opportunities for an Expanded Future Program:

The Subcommittee commends the AEERL staff and management for an excellent job in identifying targets of opportunity and in leveraging the EPA initiatives with activities supported by other government, as well as private, sources. However,

before embarking on an expansion of the existing program, the Subcommittee believes there should first be a systematic strategic planning exercise for this gas emissions mitigation research. The central focus must be risk reduction - performing a systematic assessment of sources of greatest uncertainties; it is here that EPA can make the greatest contribution to reduction of risks of potential global change within the context of mitigation activities. This review should explicitly consider the approaches to identifying and comparing options used in previous systematic assessments. (Two noteworthy sources are the National Academy of Sciences (NAS) report on "Policy Implications of Greenhouse Warming" and the Office of Technology Assessment (OTA) report entitled "Changing by Degrees.") Consideration of options should extend beyond the technical potential and engineering aspects of a technology to an examination of practicality.

In this strategic planning activity, careful attention should be given to identifying mitigation possibilities under different conditions, especially in the international arena. This would be responsive to the often-stated priorities of the Agency's Office of Policy, Planning and Evaluation (OPPE), and can position the Agency in a proactive role of identifying and developing or facilitating technologies that can be transferred to other countries for mitigation of their contribution to the global climate change problem. A key consideration here are issues of economy and practical implications of scale. For example, a biomass energy facility might be practical and feasible for deployment at one scale in a developing country, and be totally impractical in another. The EPA uniquely can contribute to these issues, and toward greater understanding of the environmental constraints and costs of these gas emission mitigation technologies.

The Subcommittee recommends extensive use of systematic sensitivity analysis. The systematic examination of uncertainties, discussed previously, should incorporate sensitivity analyses in both the planning and implementation phases of the research activities. Extensive use of sensitivity analyses can highlight areas of greatest uncertainty, consequent research needs, and the relative importance of various methodologies or policy options.

The Subcommittee is concerned that an active inter-agency coordinating group on gas emissions mitigation research was not in existence. The EPA has taken on the mission of being the lead agency for the gas emissions mitigation aspects of potential global climate change. There is an opportunity for EPA to take the lead role in ensuring that its programs are compatible and complementary with activities in other agencies. This is likely to gain growing importance as DOE and DOD activities focusing on gas emissions mitigation and global climate change issues accelerate,

and do so with the advantage of much greater resources than are currently available to the EPA program.

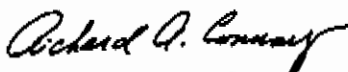
The Subcommittee believes that, contingent on the outcome of a systematic risk reduction assessment, if additional resources are provided to support the gas emission mitigation program, they should be directed toward enhancement of existing activities in data base development, methane utilization, and biomass energy, rather than initiating new activities. An exception, in regard to additional funding commitments, is the development of the GloTECH data base, i.e., extending GloED to a system that allows greater examination of the utility of various technologies for mitigating "greenhouse" gas emissions. The Subcommittee generally recommends that AEERL not embark on new projects until an adequate review of needs is completed and a global climate mitigation engineering research strategy has been developed. Until then, the Subcommittee favors more fully developing the program already initiated.

The comments and recommendations included in this SAB letter report are meant to improve and refine an already productive research program. We appreciate the opportunity to conduct this review, and look forward to your response.

Sincerely,



Dr. Raymond C. Loehr, Chair
Executive Committee
Science Advisory Board



Mr. Richard A. Conway, Chair
Environmental Engineering Committee
Science Advisory Board



Dr. Frederick G. Pohland, Chair
Global Climate Change Engineering Research
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ABSTRACT

The Global Climate Change Engineering Research Subcommittee of the Environmental Engineering Committee of the Science Advisory Board has prepared this letter report on its May 26 and 27, 1993 discussions and review of the draft document entitled "Global Climate Change Engineering Research and Development (R&D) Program," dated April 1993.

The Subcommittee was charged to evaluate the U.S. Environmental Protection Agency (EPA) Office of Research and Development (ORD), Air and Energy Engineering Research Laboratory (AEERL) present and proposed future approach to global climate change engineering research in terms of their rationality, scientific soundness, rigor and practicality.

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Key Words: Global Climate, Global Climate Change, Global Climate Mitigation, Global Climate Change Engineering Research

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