



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
WASHINGTON, D.C. 20460

August 21, 2001

OFFICE OF THE ADMINISTRATOR  
SCIENCE ADVISORY BOARD

EPA-SAB-EEC-COM-01-005

Honorable Christine Todd Whitman  
Administrator  
U.S. Environmental Protection Agency  
1200 Pennsylvania Avenue, NW  
Washington, DC 20460

Subject: Measures of Environmental Technology Performance: a  
Commentary by the EPA Science Advisory Board

Dear Governor Whitman:

At its November 1997 retreat, the EPA Science Advisory Board's Executive Committee encouraged its standing committees to undertake more self-initiated efforts. This commentary is one of several Environmental Engineering Committee (EEC) initiatives undertaken in response to that guidance.

Briefly, the EEC recommends that the Agency build on existing strengths in technology evaluation and quality management to provide easy access to reliable information about a *wider* suite of measures of environmental technology performance. It does so because access to such information is increasingly important for evaluating the effectiveness of risk reduction programs and projects.

Three trends cause the Committee to call your attention to the need for an expanded suite of measures of environmental technology performance. These are:

- a) the expanding use of non-regulatory approaches to environmental protection;
- b) the increasing demand from the international community for effective environmental technology; and
- c) the growing desire for sustainable environments.

Determining progress towards some of these goals means addressing metrics that have not traditionally been considered. Some examples of metrics which have been considered in the past include: capital costs, operating costs, removal rates, concentrations in discharges or emissions, and reliability. Some examples of additional metrics which could be considered are:

life cycle costs, the nature and quantities of waste generated, energy use, and some measure of social acceptability.

Collecting the information is one thing, making it easily available to decision-makers is another. The need to widely disseminate relevant information criteria for evaluating environmental technology performance has been recognized by other organizations. For example, the Federal Remediation Technologies Roundtable is an interagency working group which exchanges information on the use and development of innovative hazardous waste characterization, monitoring and treatment technologies. The exchange synthesizes the technical knowledge that Federal Agencies have compiled and provides a more comprehensive record of performance and cost. Because technology cost and performance are affected by waste characteristics and operating conditions, the relevant factors are technology specific and the Roundtable has identified the most important parameters for various technologies.

Public and private decision-makers in the United States and abroad use evaluations of environmental technology performance to determine whether a given technology can potentially address a given problem. If information on relevant measures of technology performance is not available to decision-makers, sub-optimum decisions could be made in technology selection: and sub-optimum decisions may result in increased risks to human health and the environment. Because of its demonstrated strengths in technology evaluation and quality management, EPA has the opportunity to contribute to such information-based decision-making by collecting and disseminating additional information on environmental technology performance.

The more widely accepted evaluations tend to be government sponsored and the EPA is the major, although not sole, provider of such evaluations. EPA evaluates the performance of environmental technologies and reports the results to decision-makers and, within the limits the Agency has established, it does so with skill and credibility. Already a world leader in applying the concepts and practices of quality assurance to data collection and analysis, EPA has pioneered the extension of these concepts to evaluating technology performance. Because of the trends mentioned above and the resulting opportunities for environmental protection, the Committee now recommends that the Agency develop a more comprehensive suite of measures for evaluating environmental technology performance. These measures can be used by the Agency and others to develop the necessary information for decision-makers charged with selecting technologies for use.

In preparing this commentary, the Committee has used the expertise of individual members and consultants; experience gained since 1995 in four reviews relating to environmental technology evaluation; reviews of the Agency's quality management system and its implementation; the participation of two EEC members in the November 1999 EPA-sponsored Industrial Ecology Workshop; the March 2000 review of the Environmental Technology Verification Program; and interactions with EPA staff and managers of other relevant national programs.

Although the Attachment A provides the background, supporting details, and related recommendations, the Subcommittee would like to highlight the following two recommendations here:

- a) The EPA should identify, with stakeholders, the technology areas most in need of shared information on technology performance and, begin developing measures and information systems which would allow that sharing to occur in a meaningful way.
- b) The EPA should re-consider, at regular intervals, whether to permit technology evaluation programs, such as the SITE program, to make cross-cutting analyses of technologies.

We look forward to your written response to the Committee's recommendations to make environmental technology performance measures more comprehensive and useful. Please contact us if we may be of further assistance.

Sincerely,

*/ Signed /*

Dr. William Glaze, Chair  
EPA Science Advisory Board

*/ Signed /*

Dr. Hilary Inyang, Chair  
Environmental Engineering Committee  
EPA Science Advisory Board

*/ Signed /*

Dr. Edgar Berkey, Chair  
Subcommittee on Measures of Technology Performance  
Environmental Engineering Committee  
EPA Science Advisory Board

**U.S. ENVIRONMENTAL PROTECTION AGENCY**  
**EPA Science Advisory Board**  
**Environmental Engineering Committee**

**CHAIR**

**Dr. Hilary I. Inyang**, Duke Energy Distinguished Professor and Director, Global Institute for Energy and Environmental Systems, University of North Carolina, Charlotte, NC<sup>1</sup>

**MEMBERS**

**Dr. Edgar Berkey**, Vice President and Chief Science Officer, Concurrent Technologies Corporation, Pittsburgh, PA

**Dr. Calvin C. Chien**, Senior Environmental Fellow, E. I. DuPont Company, Wilmington, DE

**Dr. Barry Dellinger**, Patrick F. Taylor Chair and Professor of Chemistry, Louisiana State University, Baton Rouge, LA

**Mr. Terry Foecke**, President, Waste Reduction Institute, St. Paul, MN

**Dr. Nina B. French**, President, SKY+ Ltd., Napa, CA

**Dr. Domenico Grasso**, Rosemary Bradford Hewlett Professor and Chair, Picker Engineering Program, Smith College, Northampton, MA

**Dr. Byung Kim**, Staff Technical Specialist, Ford Motor Company, Scientific Research Laboratories, Dearborn, MI

**Dr. Gordon Kingsley**, Assistant Professor, Georgia Tech, School of Public Policy, Atlanta, GA

**Dr. John P. Maney**, President, Environmental Measurement Assessment, Gloucester, MA

**Dr. Michael J. McFarland**, Associate Professor, Utah State University, River Heights, UT

**SCIENCE ADVISORY BOARD STAFF**

**Kathleen W. Conway**, Designated Federal Official, U.S. EPA Science Advisory Board (1400A), 1200 Pennsylvania Avenue, NW, Washington, DC 20460

**Mary L. Winston**, Management Assistant, U.S. EPA Science Advisory Board (1400A), 1200 Pennsylvania Avenue, NW, Washington, DC 20460

---

<sup>1</sup> At the time of the review, University Professor and Director, Center for Environmental Engineering Science and Technology (CEEST), University of Massachusetts, Lowell, MA

## NOTICE

This report has been written as part of the activities of the EPA 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.

**Distribution and Availability:** This EPA Science Advisory Board report is provided to the EPA Administrator, senior Agency management, appropriate program staff, interested members of the public, and is posted on the SAB website ([www.epa.gov/sab](http://www.epa.gov/sab)). Information on its availability is also provided in the SAB's monthly newsletter (*Happenings at the Science Advisory Board*). Additional copies and further information are available from the SAB Staff [US EPA Science Advisory Board (1400A), 1200 Pennsylvania Avenue, NW, Washington, DC 20460-0001; 202-564-4533].

# **Attachment A**

## **Measures of Environmental Technology Performance**

### **1. Existing EPA Programs and Policies**

**EPA evaluates technologies** -- Since its formation, the EPA has evaluated and reported on the performance of environmental technologies. Most Agency evaluations are conducted to meet a specific regulatory need. Additionally, two specialized programs exist to conduct formal and independent evaluations – the Superfund Innovative Technology Evaluation (SITE) Program and the Environmental Technology Verification (ETV) Program.

Because the Agency is likely to continue to evaluate environmental technologies, it will be advantageous for the Agency to consider how its evaluation program can be changed to better serve the needs of decision makers. To make technology selection decisions, decision-makers will need answers to questions such as these:

- a) Are measures of environmental technology performance being adequately addressed and integrated into the Agency's role?
- b) Are site, environmental and operating conditions being considered in testing protocols?
- c) Are procedures in place for assuring that performance measures are realistic and adequate for decision-makers?
- d) Do descriptions of performance in final Agency reports convey all the essential measures and pertinent information?
- e) What are the installation, operation and maintenance life cycle costs?
- f) How can the desired information be obtained cost effectively?

**EPA has important and useful policies on quality** - Providing environmental technology performance data of known and usable quality is a significant challenge, especially because the environmental technologies of concern to EPA vary significantly in size, complexity, intended use, and the media in which they operate. The technologies range from relatively simple monitoring or sensing instruments to more complex treatment systems for wastewater, solid and hazardous waste, and air pollution control.

Although EPA is a world leader in applying the concepts and practices of quality assurance to obtaining and using environmental data, the application of quality assurance principles and practices to the evaluation of environmental technology performance is a recent development which the Agency needs to fully implement. This is likely to improve technology selection efforts and enhance the transparency of decisions to stakeholders. Also, it is necessary

to include measures of performance that realistically indicate to decision-makers how a technology is likely to perform in real-life situations.

If, as the Committee believes, future decision-makers will typically demand a more comprehensive suite of measures, then technology evaluators would have to consider appropriate ways to determine technology performance within the expanded evaluation program and to make the information easily available to decision-makers. In such instances, EPA policy encourages use of a structured planning process such as the Data Quality Objective process for evaluating environmental technology performance.

Application of a systematic planning process, such as the Agency's Data Quality Objectives process, can ensure that:

- a) measurements are appropriate for achieving project objectives
- b) data quality is known, and appropriate for performing analyses such as life-cycle costing for full-scale technology implementation
- c) data are defensible and reproducible

The systematic planning process would establish clear goals for the evaluations. If the Agency required that all evaluation reports incorporate additional measures of performance, then decision-makers would have a better basis for judging how a technology will perform outside the range of conditions tested; extrapolations of results from one set of circumstances and scenarios to others could then be possible. This is of high utility because resource constraints usually make it impossible to test technologies under the complete set of factorial experiments when they are considered for use beyond the initial set of conditions in which they were tested. This is particularly important because some technologies that perform well in limited-term tests may have excessive life-cycle costs if they are implemented in the field.

## **2. The Need for a Wider Suite of Measures**

Evaluations that provide maximum value to the decision-makers describe the quality of the performance data being measured, including the bias and variability of the data under varying operating conditions and situations. The Agency could require that technology evaluations include sufficient measures of performance to provide decision-makers with information on how a technology will perform under realistic and likely conditions of use.

If the quality of the performance data is not fully addressed, if test conditions are too tightly prescribed (and are consequently unrealistic), or if performance under varying conditions is not determined, then the resulting evaluations of technology performance have limited value as decision aids, especially when conditions for proposed use of a technology are somewhat different from those under which tests were performed. Thus, providing adequate information to decision-makers requires that measures of performance used to describe how a technology

performs are sufficiently comprehensive.

A useful performance description should address, among others, two particularly critical elements. First, there should be explicit treatment of the experimental uncertainties (which are a part of all technical measurements). Second, it must provide the parameters or variables that help describe real-life use of a technology. A successful suite of measures will also meet the following criteria:

- a) The measures are based on a variety of realistic and well documented circumstances under which a technology is to be used – or the limited circumstances of testing are clearly documented and emphasized
- b) The measures identify all key variables that affect the performance and life-cycle costs of a technology
- c) The measures provide an indication of how rugged a technology is with respect to these variables.
- d) The measures include purchase, installation, operation and maintenance costs
- e) The measures convey in practical terms the level of performance that a technology can meet

### **3. Stakeholder Involvement in Determining Performance Measures**

Strong stakeholder involvement in the development of verification protocols and test plans, a key aspect of the DQO planning process, has been a strength of the ETV Program. Stakeholder involvement could improve other evaluations by helping determine the most relevant performance measures for decision-making. To determine better measures of environmental technology performance, it would be useful to include stakeholders such as:

- a) regulators
- b) regulated communities
- c) technology users
- d) technology developers
- e) professional and trade associations
- f) environmental groups
- g) financial investment groups
- h) insurance underwriters.



Each of these groups is concerned with deciding whether environmental technologies can satisfy given requirements. They are in an excellent position to help the Agency define what information is really needed.

#### **4. Doing More with What We Have**

In its 1996 review of the SITE program, the EEC noted that, while there were several cases where competent analyses had been performed on several individual technologies in a single technology family, there were no cross-cutting analyses comparing them to one another and drawing general conclusions. Yet, the staff was clearly capable of such analysis. This logical next step in technology evaluation was not taken.

There were policy reasons why this was the case in addition to the fact that cross-comparisons would, likely, not have been welcomed by all the technology vendors. The vendors have found that participation in the SITE or ETV program has facilitated commercialization of their technologies. However, individual vendors may not find being compared by the government with other similar technologies to be beneficial. Communities, state and local regulatory officials, and consulting engineers, on the other hand, are likely to find that kind of cross-cutting analysis very helpful.

While the Committee favors the cross-cutting analyses and comparisons, it recognizes that this decision involves balancing the needs of different groups. Therefore, the Committee recommends that Agency formally re-visit this issue from time to time.