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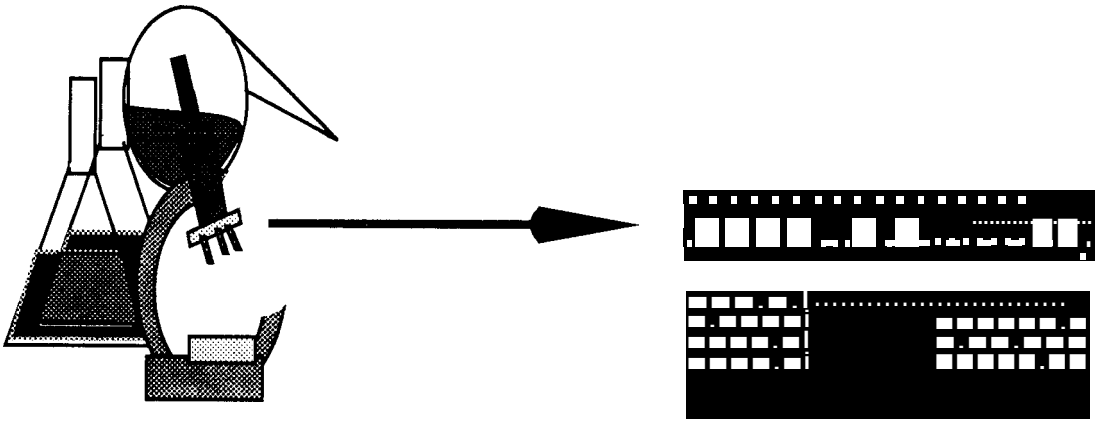
Improving Technology Diffusion For Environmental Protection

Report And Recommendations Of The Technology Innovation And Economics Committee



The National Advisory Council
For Environmental Policy and Technology
NACEPT

CENTER FOR TECHNOLOGY, POLICY AND INDUSTRIAL **DEVELOPMENT** **CAMBRIDGE. MASSACHUSETTS 02139**

1 October 1992

To the Reader:

This report represents the first comprehensive attempt to investigate, in depth, the present and future role of the Environmental Protection Agency (EPA) in the diffusion of environmentally beneficial technologies. Diffusion processes are insufficiently used or encouraged as complements to regulation, permitting and enforcement activities in the environmental management system. This represents an underutilized opportunity to introduce innovative technological solutions into wider use that, in turn, could expand environmental progress in the U.S. and improve economic competitiveness.

In issuing this report, the National Advisory Committee for Environmental Policy and Technology (NACEPT), through the efforts of its Technology Innovation and Economics (TIE) Committee, has adopted a series of recommendations whose implementation is necessary to bring about significant changes in federal regulatory policy. The report strongly recommends that EPA take actions to make innovative technological solutions, especially those that prevent rather than control or treat pollution and waste, more widely disseminated and readily accessible through improved diffusion initiatives.

We would like to thank EPA's Administrator William K. Reilly and Deputy Administrator F. Henry Habicht II for giving the TIE Committee the direction and encouragement to undertake this study, and all those in industry; federal, state and local government; academia; and the environmental community who provided information and perspectives in presentations at Diffusion Focus Group meetings and through other mechanisms. The Focus Group that prepared this document deserves the highest commendations for its contribution of time and effort, its thoughtful deliberations, and its creative and challenging recommendations. In particular its chair, William W. Carpenter and EPA committee management staff David R. Berg and Morris Altschuler should be recognized for their outstanding leadership and support.

Sincerely,

Nicholas A. Ashford
Professor of Technology and Policy
Chair, TIE Committee

NOTICE

The following report and its recommendations have been written in conjunction with the activities of the National Advisory Council for Environmental Policy and Technology (NACEPT), a public advisory committee providing extramural policy information and advice to the Administrator and other officials of the Environmental Protection Agency (EPA). The Council is structured to provide balance, expert assessment of policy matters related to the effectiveness of the environmental programs of the United States. This report has not been reviewed for approval by the EPA. Hence, the contents of this report and recommendations do not necessarily represent the views and policies of the EPA, nor of other agencies in the Executive Branch of the federal government.

ABSTRACT

The United States' potential to improve the environment is directly related to our ability to produce and apply technological solutions. The Technology Innovation and Economics (TIE) Committee, a standing committee of EPA's National Advisory Council for Environmental Policy and Technology (NACEPT), concluded that the environmental regulatory system could expand environmental progress and improve economic competitiveness if processes that diffuse environmentally beneficial technologies are used to effectively complement regulations. Enhanced EPA technology diffusion programs, especially those involving pollution prevention technologies and techniques, are essential to the achievement of EPA's mission. Federal, state and local regulators, technology developers, technology users, the financial community, environmental groups, and academia together identified and assessed potentially practical approaches. In this report, the Committee analyzes several critical policy issues affecting EPA's essential diffusion roles and makes five major policy recommendations, including:

1. Making technology diffusion a major supporting mission for EPA.

2. Building a stronger partnership with technology diffusion providers and users.

3. Making diffusion and incentives the emphases of EPA's pollution prevention programs.

4. Expanding support for the international diffusion of environmental technologies to help meet U.S. environmental and competitiveness objectives.

5. Increasing the support of diffusion provided by EPA's environmental technology research programs.

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EXECUTIVE SUMMARY

Background The mission of the U.S. Environmental Protection Agency (EPA) is to preserve and improve the quality of the environment and to protect human health. EPA has made a commitment to ensure that "U.S. policy, both foreign and domestic, fosters the integration of economic development and environmental protection so that economic growth can be sustained over the long term" *(Strategic Direction for* ***the*** *U.S. Environmental Protection Agency: EPA . . . Preserving Our Future Today*. 1991). The Agency indicates that it will develop and apply incentives that "stimulate . . . firms and consumers to take actions that serve their economic interests while spurring progress towards environmental goals." To this end, EPA has announced that it is:

- Initiating programs for promoting incentives and technology.
- Developing a role as a catalyst for technological innovation.
- Expanding efforts to seek technological cooperation and trade promotion.
- Supporting the use of cross-media and cross-jurisdictionally coordinated approaches to environmental management.
- Undertaking interagency cooperation at the federal level.
- Ensuring a level playing field through strong enforcement.

Several recent reports, including *Permitting and Compliance Policy: Barriers to U.S. Environmental Technology Innovation* (1991, National Advisory Council for Environmental Policy and Technology [NACEPT] [EPA 101/N-91-001]) and "EPA Must Help Lead An Environmental Revolution in Technology" by James Gustave Speth (in *Hazardous Materials Control,* November/December 1991), stress that EPA must play a strong role in fostering the development and use of environmentally beneficial technologies to accomplish its goals. NACEPT noted that "the United States' potential to improve the environment is directly related to the nation's ability to produce and apply technological solutions." NACEPT concluded that "fundamental changes to the environmental regulatory system" are needed "to create incentives encouraging the process of (environmentally beneficial) technology innovation."

Speth stated the challenge: "to reduce pollution while achieving expected economic growth, societies must bring about a wholesale transformation in the technologies that dominate the world economy." He described the implications of this challenge to EPA as "far-reaching. They extend from devising new regulatory approaches to moving beyond regulation and forging new patterns of cooperative interaction among business, government, and environmental experts.... A basic need is for technology transfer and development of assistance policies ... "

The Diffusion Focus Group

In late 1990, EPA Administrator William K. Reilly requested that NACEPT develop advice on two major areas: trade and the environment, and pollution prevention. The Technology Innovation and Economics (TIE) Committee was charged with considering the role of EPA's technology transfer programs in enhancing the effectiveness of the U.S. environmental management system, and to focus particularly on the diffusion of environmentally beneficial technologies in the U.S. economy. Specifically, the Committee was asked to examine "EPA's role in technology transfer, including transfer of products, services, research, and management systems information among EPA and other public and private sector entities." The TIE Committee's eighteen person Diffusion Focus Group of experts was chaired by William W. Carpenter, Vice President for Technology Applications for Martin Marietta Energy Systems, Inc. (see Section IV). The members have a wide range of interests and expertise related to the conduct and management of technology development and commercialization programs, and significant experience on national committees evaluating technology programs and technology transfer activities in the public and private sectors.

Approach

Over a period of sixteen months, the Focus Group held four two-day public meetings and convened through a number of conference calls. It heard the views of more than forty experts, including representatives of EPA; other federal, state, and local agencies; industry; public/private consortia; research institutes; universities; and environmental advocacy groups. The Focus Group visited two EPA laboratories and extended its work through subcommittees.

The Focus Group assessed the role of governmental technology diffusion programs in the environmental management system, which today primarily consists of regulations, permitting and compliance systems, and diffusion mechanisms. The Group examined eight policy topics that are crucial to determining the strategic role of governmental programs for the diffusion of environmentally beneficial technologies:

- The relationship between EPA's roles in technology diffusion and its success in meeting its primary environmental protection objectives.
- The unique quality of barriers to the diffusion of environmental technologies.
- The identity, methods, and motivations of those who diffuse environmental technologies.
- The adequacy of EPA's diffusion organizations and activities.
- The impact of EPA's diffusion strategies on environmental investment decisions by the private sector.
- The need to use unique approaches in EPA's role in the diffusion of technologies that prevent pollution.
- The keys to a successful EPA effort in international technology diffusion.
- The opportunities for EPA to make better use of the Federal Technology Transfer Act.

The Focus Group defined the diffusion of technology as the spread and adaptation of a technical idea following its first successful commercial use. Diffusion activities include technical assistance, information management and transfer, training, publications, licensing policies, marketing, education, and technology transfer programs.

Major Findings And Recommendations

The Technology Innovation and Economics (TIE) Committee concluded that enhanced EPA technology diffusion programs are essential to the achievement of EPA's environmental protection mission (see the Findings and Recommendations sections of this report). The lack of strong diffusion programs in the U.S. environmental management system -- and the limited coordination among existing programs within EPA and between EPA's programs and those outside EPA -- hinders the development, evaluation, and use of innovative environmental solutions. This increases

costs and reinforces a tendency in regulatory mechanisms to overspecify technology. Such a pattern is particularly detrimental to the pollution prevention and international environmental goals of the agency. To remedy these problems, the TIE Committee recommends that EPA integrate technology diffusion into the environmental management system. The agency should establish the climate, culture, and incentives necessary to encourage the widespread use of improved technology solutions that enable environmental progress in a sustainable economy.

The TIE Committee's Diffusion Focus Group focused on three key barriers hindering the widespread use of innovative technologies in environmental applications.

1. The way in which best available technology-based regulations are implemented and enforced.
2. Permitting and compliance policies and practices that do not foster technology innovation and pollution prevention.
3. Barriers to information and technology transfer.

EPA and other environmental agencies could gain significantly from increasing their emphasis on strategies that encourage technology diffusion, such as the "Green Lights" and the SARA Title 3 release reporting programs. The benefits of enhanced technology diffusion include:

- Increased domestic and international environmental quality.
- Wider availability of lower cost solutions to environmental problems.
- Gains from the export of technological improvements.
- Increased use of pollution prevention technologies and techniques that co-optimize for productivity and environmental results.
- A less adversarial relationship with regulated organizations.
- A more competitive U.S. economy.

The TIE Committee recommends several specific strategic and structural changes to help EPA to realize its mission by making cost-effective use of technology diffusion mechanisms. The Committee's central findings and recommendations are:

1

FINDING: EPA, which perceives itself as primarily a regulatory agency has a mission to protect human health and the environment.

RECOMMENDATION: Make technology diffusion a major supporting mission for EPA. The agency has moved in the right direction with its focus on themes in the planning process and its increased attention to relative risk. It will need to reinforce its new emphases with enhanced programs for the diffusion of technology. The TIE Committee recommends that EPA take several critical actions:

1. **Establish a high level position to advocate the role of diffusion in accomplishing the agency's mission,** to promote changes in EPA's culture to support diffusion activities, and to coordinate the agency's diffusion programs.

2. **Redeploy EPA's diffusion resources** to increase their effectiveness and efficiency.

3. **Develop the diffusion support tools that Agency employees require,** including career enhancements, training, performance standards, information, and rotational assignments.

4. **Include in EPA's approach to regulation incentives that encourage innovation and emphasize diffusion as a major contributing element of the environmental management system.**

Among the key specific actions recommended by the Committee are:

Modifying the agency's culture and incentives to support the concept that the diffusion of technology can catalyze environmental improvement.

- Adopting a requirement that all agency program plans contain a technology diffusion component.

- Expanding agency resources to support increased programs for technology diffusion.

- Creating new partnership relationships and strengthening existing ones to enhance the effectiveness of agency diffusion programs.

- Learning from other agencies' diffusion programs.

- Broadening the sources of information contained in EPA's diffusion programs.

2

FINDING: Coordination is lacking between EPA and its potential partners in planning and conducting activities to diffuse technological information.

RECOMMENDATION: Build a stronger partnership with technology diffusion providers and users. The "command and control" based environmental management system increases the adversarial, non-supportive nature of relationships between groups whose cooperation is needed to accelerate environmental improvement. Increased cooperation is critical to the success of EPA in its mission and is particularly essential in the diffusion of environmental information. Although a wide variety of organizations fill one or more roles in the diffusion of technology, EPA could work more systematically with many of these potential partners to make the system to diffuse information work effectively and efficiently. The potential partners include regulated organizations, state and local governments, entrepreneurs, research consortia, consulting engineers, universities, information providers, and other federal agencies. EPA should:

1. **Work more effectively with the full range of diffusion partners,** including information developers, diffusion providers, and diffusers, to actively promote the increased use of innovative environmental solutions.

2. **Increase its collection and generation of credible information about environmentally beneficial technologies.**

3. **Take advantage of the full range of diffusion mechanisms,** including its own and others' research, information systems, technical assistance programs, publications, training, trade shows, professional conferences, and cooperative research and licensing programs.

4. **Define, collect, and analyze environmental business data to** understand diffusion partners and information users.

5. **Support university curriculum development** to increase literacy in environmentally beneficial technology.

Among the key specific actions recommended by the Committee are:

- Leveraging EPA's limited diffusion resources by actively seeking out diffusion partners and promoting others' diffusion activities.
- Expanding efforts to understand the needs of information users.
- Working with state and local governments as critical channels of technology diffusion.
- Establishing a bureau of environmental statistics.

3

FINDING: EPA has not recognized that success in pollution prevention depends on the success of diffusion and incentive-based approaches.

RECOMMENDATION: Make diffusion and incentives the emphases of EPA's pollution prevention programs. The unique factors that motivate pollution prevention are particularly responsive to diffusion and incentive approaches. Pollution prevention requires a continuing commitment that is proactive, internally maintained, and culturally different in nature. If a "level playing field" is created by applying underlying requirements and enforcing them against all polluters, pollution prevention can be driven by information and incentives. The agency should:

1. **Preferentially increase its use of data-based, non-regulatory drivers, including diffusion programs, as a feature of EPA's pollution prevention strategy.**

2. **Create incentives, including multi-media approaches, that favor the choice of pollution prevention by regulated and non-regulated organizations.** Improved regulatory, permitting, and compliance practices can place emphasis on the increased availability of information about pollution prevention methods brought about by stronger diffusion programs. A combination of regulatory and non-regulatory incentives can best influence the development and application of pollution prevention approaches, and information sharing about them.

3. **Introduce new steps to diffuse the pollution prevention ethic within EPA and to establish a system of incentives and support for diffusion efforts by EPA personnel.** Such support includes agency policy direction and an increased use of incentives, rewards, training, and information.

4. **Increase resources for EPA's own technology R&D efforts focusing on pollution prevention.**

Among the key specific actions recommended by the Committee are:

- Strengthening and expanding the use of such successful data-based drivers of pollution prevention as Section 313 of SARA, the 33 - 50 program, and the Green Lights program.

- Strengthening programs to diffuse pollution prevention research and development results, operating experience, and accounting methods to regulated organizations.

- Designing regulations and regulatory processes to encourage the use of the widest possible range of solutions, including pollution prevention techniques.

4

FINDING: EPA's international diffusion activities are focused almost exclusively on developing and Eastern European nations; a much stronger and broader role is needed to enhance U.S. competitiveness.

RECOMMENDATION: Expand support for the international diffusion of environmental technologies to help meet U.S. environmental and competitiveness objectives. EPA has made important progress in expanding international diffusion activities (working in conjunction with traditional federal lead agencies), particularly in its new pilot efforts in Eastern Europe, Latin America, and Southeast Asia. Working with these partners, EPA should significantly increase support for the diffusion of environmentally beneficial technologies] h into and out of the U.S. within the overall goal of environmental improvement. This direction is extremely important to the pursuit of both sustainability and competitiveness. EPA should:

1. **Increase support for the diffusion of environmental technologies out of the U.S.** This step may lead to greater environmental improvements overseas, especially in developing countries where little pollution reduction has occurred.

2. **Strengthen support for U.S. exports of environmentally beneficial technologies to the major world markets in the industrialized nations.**

3. **Enhance EPA's technology diffusion efforts aimed at expanding the range of environmental technology solutions available domestically.** An increased effort to gather information on state-of-the-art environmentally beneficial technologies developed abroad is needed. There is insufficient cooperation to this end between industry and government and among governmental agencies.

Among the key specific actions recommended by the Committee are:

- Encouraging the harmonization of international environmental awareness and standards.

- Supporting business development centers overseas for U.S. environmental firms.

- Collecting information on international environmental markets and environmental regulations, and making that information generally available.

5

FINDING: EPA's research programs do not adequately support the agency's diffusion mission.

RECOMMENDATION: Increase support for the diffusion of technology provided by EPA's research programs on environmentally beneficial technologies. Because the resources invested by EPA in research, development, demonstration, and evaluation (R&D) on environmentally beneficial technologies comprise a small fraction of the total U.S. R&D investment, EPA will have to focus its limited efforts on the most important technology opportunities emphasize other major roles for its environmental technology research programs. EPA's current technology research activities should be refocused to take on a major role in the diffusion of information about credible environmentally beneficial technologies. To accomplish this, EPA should:

1. **Adopt a leadership position in environmental innovation throughout the R&D life cycle.** The R&D life cycle includes R&D planning, the conduct of R&D (including research, development, demonstration, testing, and evaluation), and the dissemination of the results of these activities among all participants in the environmental management system (including industry, other federal agencies, state and local governments, universities, and research consortia).

2. **Build and expand EPA coordination efforts in environmental R&D programs across the public and private sectors.**

3. **Use EPA's technology R&D programs to improve the quality of environmentally beneficial technology data generated by others.**

4. **Emphasize the commercialization endpoint in environmental technology R&D programs --** whether they are EPA's or those that EPA influences in its leadership role.

Among the key specific actions recommended by the Committee include:

- Taking a leadership position to increase interagency cooperation in environmental technology R&D.

- Involving industry, consortia, state and local governments, and other important players in planning EPA's technology R&D.

- Requiring EPA to attract private sector co-funding for a portion of its own technology R&D.

- Expanding the new program to encourage testing of environmentally beneficial technologies at federal facilities.

5 (continued)

FINDING: EPA's research programs do not adequately support the agency's diffusion mission.

RECOMMENDATION: Increase support for the diffusion of technology provided by EPA's research programs on environmentally beneficial technologies.

Additional key specific actions recommended by the Committee are:

Increasing EPA's cooperative research and testing efforts.

Instituting an industrial user facility program at EPA to enable outside parties to make use of unique EPA facilities.

Establishing programs for the use of EPA laboratories to test and evaluate technologies developed outside the agency.

Strengthening EPA's FTTA effort, which is already growing rapidly.

Increasing ORD's efforts, working with EPA's diffusion partners, to disseminate information about environmentally beneficial technologies.

Promoting the harmonization of technology testing and reporting, so that performance data are useful to a broader range of users.

- Building EPA's expertise in economics, marketing, and commercialization. (Expanding these areas of expertise would also be valuable in other EPA programs.)

II. PREFACE

The U.S. environmental management system was developed to protect human health and the environment. The environmental management system includes all legislative authorities, regulatory processes and regulations, regulatory administrative systems (permitting, compliance, and certification), technology transfer and other support programs, and federal, state, and local environmental research programs. This system has achieved significant progress toward these goals, but much greater progress is needed to meet remaining objectives and the new needs that will surely arise. A particular challenge for the future is to combine further environmental progress with sustainable economic growth.

The National Advisory Council for Environmental Policy and Technology (NACEPT) was formed in 1988 as a source of outside policy advice to the Administrator of the U.S. Environmental Protection Agency (EPA) on improving U.S. environmental management, with a special focus on technology. NACEPT's mission is "bridging the gap from problem identification to environmental solutions through successful program implementation, cooperation, and consensus-building by business, government, educational institutions, and private organizations."

NACEPT has established five standing committees. One is the Technology Innovation and Economics (TIE) Committee, which advises on ways to encourage the development, commercialization, and use of optimal environmentally beneficial technologies. Such technologies, include those that reduce the cost of performance, improve overall performance, reduce waste, or increase productivity. They include source reduction, waste minimization, and other pollution prevention measures, recycling technologies, environmental control technologies, cleanup technologies, monitoring and measurement technologies, analytical techniques, and information management systems. The TIE Committee recognizes a hierarchy of technology approaches to environmental improvement, with pollution prevention in general being the preferred option. It also believes that EPA is unlikely to accomplish its goals unless the nation's ability to produce and apply environmentally beneficial technologies is improved.

Technology diffusion is one critical element of the environmental management system. Diffusion includes technology transfer, technical assistance, training, education, and

information management and transfer. Through diffusion, environmentally beneficial technologies become more accessible and more responsive to the needs of users and government at all levels.

NACEPTs January 1990 TIE Committee report observed that simultaneously improving environmental protection and economic competitiveness requires the development and use of innovative technologies. Citing, lagging investment in technology innovation, NACEPT pointed out that further study was needed of how regulation, tax policy, and corporate decision making affect the development and commercialization of environmentally beneficial technologies. NACEPT recommended that EPA assume leadership in fostering environmentally beneficial technology innovation and that the Administrator take three key steps:

> Evaluate the degree to which U.S. environmental programs stimulate technology innovation.
>
> Issue a policy statement expanding the Agency's mission to include the fostering of technology innovation.
>
> Develop and implement a strategy for fostering technology innovation.

NACEPT's 1991 report on the effects of permitting and compliance policies on environmentally beneficial technology innovation argued that the current environmental regulatory system does not systematically address the creation and diffusion of technology. The report identified five general areas of needed improvements:

- Modifying permitting systems to aid the development and testing of innovative environmental technologies.
- Implementing permit processes to aid the commercial introduction of innovative technologies.
- Encouraging the use of innovative environmental technologies in compliance programs
- Maximizing the effectiveness of permitting and compliance improvements by supporting stakeholders.
- Identifying and removing regulatory obstacles to the use of innovative environmental technologies.

Deliberate encouragement of all three processes of the technology R&D life cycle -- innovation, invention and diffusion -- is crucial to governmental success in promoting optimal environmental solutions. To help the Agency learn how to be most successful in encouraging technology diffusion, the TIE Committee formed the Diffusion Focus Group and charged it with answering the following questions:

- What should EPA's role be in a market-dominated diffusion system?
- How can technology and other information be diffused more effectively by EPA and industry?

The Focus Group organized its 16-month investigation to address the following eight specific issues:

- Should there be a policy defining the relationship between EPA's role in the diffusion of environmentally beneficial technologies and the achievement of EPA's major objective of protecting human health and the environment?
- Are there unique barriers to the diffusion of technology for environmental purposes?
- Who diffuses technology for environmental purposes, why, and how?
- Should the organizations and activities of EPA and others be improved with respect to environmentally beneficial technology diffusion?
- What are the influences of EPA diffusion strategies on private sector environmental investment decisions?
- What are the differences and/or similarities between EPA's role in the diffusion of pollution prevention technologies and its role in the diffusion of other technologies for environmental purposes (notably, for pollution control and remediation)?

  What are the differences and/or similarities between EPA's domestic and international roles in diffusion?

  What is needed to make better use of the Federal Technology Transfer Act of 1986?

The Focus Group held four two-day meetings and convened through a number of conference calls between January 1991 and April 1992. It heard the views of a wide range of interested parties, including representatives of EPA and other federal, state, and local agencies, industry, public/private consortia, research institutes, universities, and

environmental advocacy groups (see Appendix 1). The group solicited and received comments on the report from every involved office at EPA.

The Diffusion Focus Group unanimously approved the report on April 15, 1992 and forwarded it to the TIE Committee for review and approval. Approval was granted by the TIE Committee in May, 1992. The report was then forwarded to NACEPT for concurrence and submission to the Administrator of EPA.

This report may contain unintended omissions due to the limited time and resources available to the Diffusion Focus Group for the preparation of this report. As stated previously, the Group made every attempt to include all of the relevant EPA offices and outside stakeholders in the process of gathering facts and conducting analysis. Beyond the limits of time and resources, it should be noted that other omissions may be examples of failures in the diffusion system. When a significant diffusion resource was not found and studied by the Group, that omission may be may be representative of a failure in the diffusion process.

III. INTRODUCTION

Although great environmental progress has been made in recent decades, there are still significant shortcomings in the quality of America's environment today. The U.S. environmental management system, in which EPA is a key player, has reached a point where it has become unlikely that in their traditional adversarial roles, polluters and regulators can work together to efficiently solve the county's current environmental problems. A new, more cooperative approach to environmental management must be adopted in order to simultaneously improve, i.e., co-optimize, environmental quality, economic productivity, and international competitiveness. How can EPA adopt such a program and still accomplish its mission of protecting human health and the environment?

One method the agency should use more of is the diffusion of environmental technologies throughout the world. In a world of rising populations and economic expectations, the widespread application of new and innovative technologies would seem to be the natural answer. For example, rather than reducing the amount of light available, we could apply new lighting methods. Rather than eliminating plastics, we might look at new ways of recycling them into their component parts and find more environmentally benign plastics. Rather than shutting down a refinery, we could apply advanced pollution prevention techniques that not only reduce pollution, but also produce economic value for the refinery owner.

The diffusion of environmental technologies world-wide is a relatively low cost way to make global environmental improvements. Sharing an environmental technology with the rest of the world multiplies its value. For example, if a foreign polluter can adopt an environmental technology that is ten million dollars less expensive than the current technology he is considering, we have in effect given that polluter a ten million dollar subsidy to reduce pollution. Such incentives can have a powerful effect on regulated organizations in third world countries where economic concerns often outweigh environmental concerns.

The global diffusion of environmental technologies has two additional benefits. First, it makes available foreign technologies to U.S. regulated organizations, potentially lowering costs and/or reducing pollution. Second, because the U.S. is the world's leading environmental product and service producer, global diffusion may lead to increased U.S. exports of environmentally beneficial technologies. This may, in turn, lower the unit costs

of U.S. environmental product and service providers and attract more capital to field. This increased capital should result in additional environmental R&D in the U.S.

The same benefits that are received from international diffusion can be obtained on the domestic front. Making more environmentally beneficial technologies available to regulated organizations may reduce their costs and/or reduce pollution. Shortening the time it takes for a new environmentally beneficial technology to get to market and be broadly adopted may attract new capital to the field. Any time there is a lack of reliable, credible information there is a barrier to employing a new technology, environmental or otherwise. Diffusion reduces the barriers and encourages the use of new and innovative technologies because it helps create and spread information about the technology.

One of the best things about diffusion is that it is relatively inexpensive for EPA. There are no large costs for additional R&D facilities, no direct subsidies needed for users, no restrictive regulations or long legal battles. In fact, the agency has a wide variety of diffusion programs underway right now, some of them doing exactly what is needed. This is the good news.

However, EPA's diffusion efforts need to be coordinated. They need to be a higher priority for agency personnel and to be supported by agency policies and resources. Moreover, the agency should reach out to potential diffusion partners to share the message and the burden. There are a great many ways for EPA to get more value out of its current diffusion programs and resources, not to mention the serious need for additional resources in certain areas.

The remainder of the Introduction discusses what technology diffusion is and who the diffusion "stakeholders" are: those who are in some way involved in or impacted by diffusion. The rest of the report examines in detail the policy instruments that EPA can use to increase the pace and probability of any environmentally beneficial technology gaining widespread use and the findings which led to these recommendations.

What is Technology Diffusion?

"Diffusion" is the spread and adoption of an idea following its first successful commercial use. When environmentally beneficial technologies are put into widespread use, all environmental stakeholders gain -- technology developers, technology users, the public, the environmental management agencies, and the investment community. Making more effective use of diffusion as an element of the environmental management system is necessary if EPA is to achieve its goal of protecting human health and the environment.

The development, innovation, and diffusion of environmentally beneficial technologies are critical to improving environmental protection and to simultaneously promoting environmental and productivity efficiency. Technology innovation refers to the first commercial use of a new technical idea. Technology diffusion is the spread and adoption of a technical idea following its first successful commercial use. Clearly, the use of innovative environmental solutions (notably technologies and approaches that achieve greater environmental protection or lower costs) depends on their adequate diffusion. Diffusion can also be the most cost-effective approach to environmental protection, since it allows the full exploitation of the best technologies already available.

The TIE Committee chose the term "diffusion" (rather than technology transfer) for two reasons:

- Throughout the 20-year history of the federal environmental program, technology transfer has been regarded by many people as a stepchild program, in which the federal role held a lower priority when compared to other elements of the environmental management system. Federal technology transfer efforts were viewed by many to be of secondary value and competitive with commercial technology transfer efforts and were often criticized as jeopardizing the federal government's objectivity when compliance failures occurred. The TIE Committee believes that this view fails to recognize the critical role of diffusion programs in the environmental management system.

- The term "technology transfer" does not capture the set of activities that constitute technology diffusion. In popular parlance, technology transfer means moving a technology from government labs to industry, or from one community to another. Diffusion is the process of getting technologies that are ready for commercial use into widespread practice, within and between different industries and institutions. Diffusion is the third phase of the technology life cycle and is preceded by "invention" -- the birth of a technology concept -- and "innovation"

> -- the development of a technology concept into a commercial product and the first uses of that product. During the diffusion phase, a product's use expands and it is adapted to fill other commercial needs. Diffusion activities include at least the following: technical assistance, information management and transfer, training, publications, licensing policies, marketing, education at the college and graduate levels, and technology transfer programs. Technology transfer is only one subset of the activities that are relevant to diffusion.

The diffusion of a technology is supported by a wide range of groups, including those with a proprietary interest, the government (in pursuit of its environmental protection interest), professional groups, trade groups (in the interest of solving common problems), consulting engineers (whose advice is used by regulated organizations), and environmental organizations (who seek to educate the public and polluters, and to influence regulators).

Along with regulation, permitting and compliance programs, certification, grant assistance, and research, diffusion is an important part of the environmental management system. Diffusion receives an inadequate amount of agency attention, resources, and perceived value.

The diffusion process embraces all types of information about environmentally beneficial technologies, including conventional approaches, best practices, innovative technologies, and pollution prevention methods. Strong diffusion efforts are especially critical to the spread of pollution prevention methods, which encompass technologies and techniques that effect changes in production activities and product designs. Diffusion is also vital to the employment of other innovative environmental technologies. The use of The use of both pollution prevention methods and environmental technologies is information-intensive, depending on state-of-the-art technical knowledge, intimate knowledge of industrial processes, and an understanding of regulatory flexibilities.

The Stakeholders

There are several groups of stakeholders involved in the diffusion of environmental information, who benefit from the process in various ways: regulated organizations; new (and possibly not yet regulated) entrants to a manufacturing or production market; federal, state, and local regulators; providers of environmental products and services; investors; and the public. Organizations may fall into more than one stakeholder category. They may be producers or consumers of environmental information, and not infrequently they are both.

All stakeholders stand to gain from the freest flow -- the greatest diffusion -- of information possible, within the constraints of protecting confidential business information.

Regulated organizations. Because they must comply with regulatory requirements, regulated organizations are uniformly concerned with obtaining accurate information to assist their own compliance. All regulated organizations require sufficient information on the environmental requirements, policies, and practices, at federal, state, and local levels, with which they must comply. All are concerned with obtaining credible information about regulatory requirements and processes, and with receiving reliable results from their choice of environmental solutions. Many organizations choose a compliance strategy that entails minimal risks and disrupts production the least-- often an end-of-pipe solution. Others are willing to consider a broader range of options to co-optimize productivity and environmental results. These organizations especially require ready access to full information about all available options.

The diffusion of information about environmentally beneficial technologies and technical assistance are particularly important for industries dominated by small to medium-sized firms. Such firms are less likely to be technically self-sufficient or to possess the resources needed to access the best technical advice. Firms in these industries may prefer to rely on "good services" third parties.

Actually, firms in all industries often choose to rely on "good services" third parties, as well as (or instead of) government, to learn of their options. Such sources of information include other similar firms, state commerce departments, trade and professional associations, and university-based consortia.

Regulated organizations are both generators and diffusers of information. While firms are naturally concerned with protecting information that provides them with a competitive advantage (such as that embodied in special production processes), they are often willing to share information when the result may be of mutual benefit. In some notable cases, they have even shared information on environmentally beneficial technologies to avoid regulators' imposition of more stringent measures, whether immediately or in the future. In some cases, firms may establish a new profit center by selling their specialized environmental expertise.

The lack of adequate information on environmentally beneficial technologies clearly adversely affects regulated firms. Aspects of diffusion systems of particular concern for these stakeholders include: communication and cooperation with regulators about environmental technology information; understanding regulatory, permitting, and compliance processes and requirements; and accessibility of state-of-the-art environmentally beneficial technology information, with concern for confidentiality.

New entrants to the areas of manufacturing or production also need accurate information similar to that required by regulated organizations. These new entrants typically manufacture products that are environmentally benign, but can also compete with environmentally harmful products (e.g., carbon dioxide charging systems for aerosol cans, silicones that substitute for PCBs in transformers). They need information about environmental trends regarding competing products and how the competition is to be regulated. These new entrants' products are usually unregulated by EPA because of their benign nature.

Regulators (federal, state, and local government). **Regulators, including** rulemakers, permit writers, and compliance personnel, require access to information and also provide mechanisms to disseminate information. To fulfill their role as regulators, they must understand and be able to communicate regulatory requirements and processes. They must also be technically competent and understand the perspectives of regulated communities. The latter expertise can be gained through academic training and, more critically, from appropriate contacts within regulated organizations and their representatives, such as trade and industry organizations. Rulemakers need ready access to information on state-of-the-art technologies and their performance, cost, and reliability characteristics to write regulations. Similarly, permitting and compliance personnel need such information to perform their functions, although their ability to share it is sometimes compromised by the regulatory nature of their contact with users.

Through regulations, permits, and compliance actions, regulators announce to all stakeholders the availability of approved technologies and techniques. They can also encourage the use of advanced technologies, such as pollution prevention techniques and innovative technologies, and therefore future development and investment in new technologies through direct and indirect means. By providing predictability, consistency, and cross jurisdictional coordination through regulations, permit approval processes, and compliance actions, regulators can create a powerful incentive to search for improved

solutions. This, in turn, fuels the need for diffusion services and makes more information available to include in them.

Through their research programs, government agencies are also important developers, collectors, evaluators, standardizers, compilers, and diffusers of environmentally beneficial information. These roles make government research agencies critical players whose credibility and neutrality are essential foundations for information and technology transfer.

It is a major diffusion concern for members of this community are that they be well informed about the regulatory system. They also need to know the characteristics of environmentally beneficial technologies and techniques, including those representing the state-of-the-art. Finally, they require mechanisms to make useful information widely available to those who need it.

Providers of environmentally beneficial products and services. Developers and marketers of environmentally beneficial technologies are major generators and diffusers of information, though they also require access to information to fulfill their roles. They provide technology and associated information to regulators, users, investors and the public, on performance, costs, reliability, and risks. Results of technology development, testing, and demonstration provide the basis for regulations, the actions of investors and users, and the actions of the public, who may, for example, allow the siting of technologies depending on testing and demonstration results. (Trade and professional associations provide a trusted mechanism for the diffusion of such results.)

Technology providers are central to technology diffusion. They have large information needs, because of their need to gauge market risks, and to satisfy regulatory requirements. They need to develop and provide adequate information so that users, regulators, and the public can evaluate the applicability and acceptability of technologies. For their part, developers must anticipate environmental problems, user needs, and public acceptability. These are the major diffusion concerns for this community.

investors. Investors support technology developers and the entire provider community, as well as regulated organizations. They are major stakeholders in the diffusion process, but are minimal direct diffusers of technology. Their own diffusion needs ultimately revolve around their interest in measuring and ultimately reducing risk. The availability of information about environmental regulations, permitting and compliance

policies and practices, and markets is important to their measurement of risks, as is the availability of performance, cost of performance, and reliability data derived from testing and demonstration. Finally, investors are concerned that diffusion systems will help carry the message about technologies they have supported to users, regulators, and the public.

Thepublic. The public and its representatives, the public interest groups, are large consumers of diffusion services. They need access to credible information about the performance, costs, reliability, and risks of innovative environmental solutions and their alternatives, as well as about regulations and regulatory processes, so they can decide whether solutions that are proposed are the best choices (or an acceptable choice) for a local environmental problem. Peoples' fear about what they do not understand is universal, and the public's lack of trust is only reinforced in the absence of information that is not credible. The public interest groups are important providers of information on the acceptability of technologies to the public and to other stakeholders. Public acceptability, which depends on the good functioning of these information channels, is a major determinant of decisions by developers, investors, and users in developing and commercializing technologies. Regulations and permits in significant measure reflect such public acceptance, as do the statutes that underlie them. Thus, elected officials are another important consumer of well functioning information channels.

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Mr. Dag Syrrist, Co-Chair	Technology Funding, Inc.
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V. FINDINGS

The findings in this section are based on an analysis by the TIE Committee of EPA's role in the diffusion of environmentally beneficial technologies. These findings lead directly to the TIE Committee's recommendations for improving EPA's diffusion activities presented in the following section.

Finding 1

EPA, which perceives itself as primarily a regulatory agency, has a mission to protect human health and the environment.

Since its founding, EPA's mission has been to protect human health and the environment. No other department or agency of the federal government has this function as a primary mandate.

The environmental management system, as designed in legislation, regulations, policies, and practices, has a primarily regulatory focus. EPA's organization, activities, budgeting, culture, and external relations have all been defined by its historical and fundamental perception that it is primarily a regulatory agency. EPA's organization is based on media-specific program offices, corresponding to the major pieces of federal environmental legislation determining EPA's functions. Other EPA offices, including its Office of Research and Development (ORD), largely support the regulatory functions of the media-specific program offices. EPA's perception of its role as regulator permeates the Agency's culture and external relations; EPA is deeply concerned with procedure, compliance, documentation, avoidance of conflict of interest, and assurance of equal treatment. Its relationships with regulated organizations can usually be characterized as adversarial, with little or no reliance on incentives to motivate innovation for environmental improvement.

Historically, technology diffusion has played a limited and subordinate role to regulation, permitting, and compliance in the regulation-based environmental management system. The "best available technology" (BAT) approach to regulation optimally offers mixed incentives for the development and use of improved environmental and production

technologies. Technologies must await the uncertain recognition by rulemakers before their niches in the marketplace are assured. After regulatory requirements are imposed, compliance with BAT-based rules requires the quick use (and diffusion) of a technology with the requisite performance. However, this provides no rewards for the subsequent development and use of better performing technologies, regardless of the environmental and public health risk remaining after the use of BAT. The incentive to diffuse is largely restricted to the BAT, and only innovation to achieve lower costs is encouraged. EPA's and regulated organizations' adoption of innovative approaches to environmental improvement are hindered by EPA's inadequate emphasis on supporting technology innovation and technology diffusion.

This is ironic, because EPA determines the stringency, applicability, timing, and longevity of environmental requirements. The environmental marketplace is largely defined by these environmental requirements and their enforcement. Thus, federal decision making provides critical signals for regulated communities and technology developers. Finding regulatory signals that enhance the marketplace is a critical step.

The environmental permitting process is another important impediment to innovation, with confusion about the federal, state, and local permitting processes seen both outside and within EPA. Both permit applicants and regulatory staffs report they are often confused by permitting procedures, by the different permitting requirements of different acts and agencies, and by permitting practices that are inconsistent between media. Testing and evaluation is significantly restricted by current permitting authorities and practices to the point that innovation is being slowed in the U.S. These problems present obstacles to the diffusion of new technologies.

The TIE Committee found in its 1991 report and recommendations (and reiterates this finding here) that the lack of predictable and consistent permitting and compliance programs at all levels of government dampens the expectation of the need to comply with environmental requirements and, therefore, lowers the perceived need to purchase environmental products and services. Similarly, the lack of predictable enforcement discourages permittees from using innovative technologies, which inherently expose them to greater risk. The lack of flexibility in permitting and compliance systems reduces the incentive to innovate and to use innovative (and therefore more risky) solutions. All of these factors, along with the difficulty of predicting future regulatory requirements, increase the long-term development risks associated with environmentally beneficial

technologies, diminishing the relative attractiveness of investment. They therefore discourage entrepreneurs from investing money and effort in the innovation process and dissuade regulated organizations from using the technologies and techniques that result. Thus, the potential for the diffusion of new or newly developed technologies to support national environmental goals is reduced.

The clients of EPA's information transfer efforts have been, by design, mostly internal, although some efforts have been directed to attract external clients. EPA's limited information transfer efforts, whether for internal or external audiences, have emphasized the publication of written reports and computerized data based on the results of its own research, the sponsorship of conferences, training courses, and seminars, and hot lines. The program of the Technology Innovation Office (of EPA's Office of Solid Waste and Emergency Response) is one of the notable exceptions to this rule.

EPA manifests its low priority on the diffusion of environmentally beneficial technologies in a number of ways:

- Having limited collaboration and coordination with other potential partners in the diffusion of information.
- Failing to adequately integrate the objective of the diffusion of information and to sufficiently emphasize diffusion programs in regulatory policies and programs. These include permitting and compliance policies as they relate to tests, evaluations, and use of innovative and pollution preventing technologies and techniques.
- Failing to support the diffusion of information goal adequately in planning and programs.
- Failing to adequately coordinate and lead efforts to diffuse information both within and beyond the agency.

The low priority given to technology diffusion is also seen in inadequate employee incentives to diffuse technology (e.g., financial rewards, recognition, performance evaluation credit); inadequate training of personnel; unspecified, nonexistent, or inadequate budgets for diffusion; a single media character in most diffusion programs; a lack of attention to pollution prevention in diffusion programs; and the lack of internal expertise assigned to deal with diffusion. EPA's organizational structure also appears to discourage accountability and coordination in technology diffusion.

The TIE Committee believes that, while EPA's mission is unchanged, the means for accomplishing this mission must change. An exclusive reliance on regulatory methods is no longer sufficient for EPA to achieve its goals. EPA's failure to fully integrate technology diffusion into the environmental management system hinders the achievement of its mission. EPA must reverse the pattern that technical information often does not get to those who need it.

Finding 2

Coordination is lacking between EPA and its potential partners in planning and conducting activities to diffuse technological information.

EPA is not now working closely with its potential partners to make the information diffusion system work effectively and efficiently. These partners include: (1) those who understand user needs, (2) information developers, (3) information providers, and (4) users or consumers.

Many organizations play one or more of these diffusion roles, and if each did its part effectively, the diffusion system would work more efficiently to expand the availability of credible information to those who need it. Within EPA, for example, there is little coordination of diffusion efforts across the media offices and with the research program. With the exception of the Technology Innovation Office (in the office of Solid Waste and Emergency Response) EPA has not built a diffusion partnership on behalf of the environment. The resulting lack of strength in this system is a significant barrier to innovation and to the environmental improvement that can result from the diffusion into widespread use of innovative solutions.

Importantly, EPA should provide leadership to the diffusion partners, but it now does not, with some exceptions. One of the barriers to working together derives directly from the adversarial nature of regulatory relationships. EPA's credibility, on the other hand, is not being fully exploited as an asset in the information transfer system of environmentally beneficial technologies. Many other developers of information and providers of diffusion services are seen by users as lacking EPA's credibility. Yet, EPA is not taking full advantage of its credibility to improve the volume and availability of credible information,

including information about regulatory systems and processes (e.g., permitting and compliance systems).

EPA plays a relatively small part in any of the four diffusion roles, as it should. Yet, its diffusion services appear to lack wide input in their planning, contain predominantly EPA-generated data, and apply a limited range of diffusion mechanisms. The fact that federal and state agencies account for less than 20 percent of all U.S. investment in environmental technology innovation (and EPA only a few percent) reveals the need for partnering in planning, generating, and disseminating technology information.

There is also no systematic EPA effort to document information about the businesses that provide products and services used for environmental purposes. Without understanding both the purchase and the sale sides of environmental transactions domestically and internationally (i.e., the environmental market), EPA cannot clearly understand the impacts of current environmental policies on the nation's ability to meet environmental goals. Nor can it measure the national capability to innovate and adapt, and to remain competitive internationally.

Finding 3:

EPA has not recognized that success in pollution prevention depends largely on the success of diffusion and incentive-based approaches.

EPA's efforts to encourage pollution prevention have made a good start in the right direction. The tendency in EPA to think first of regulation has already been noted. The Committee is concerned that pollution prevention programs will depend too much on regulations. The encouragement of pollution prevention, however, requires a different approach for success, one that emphasizes diffusion of information and incentives.

The Committee believes it is important to recognize that the motivations which drive pollution prevention are not the same that motivate a compliance-based, end-of-pipe strategy. Pollution prevention requires a continuing commitment that is proactive, internally maintained, and culturally different in nature. In some organizations pollution prevention is closely related to a commitment to total quality management. Pollution

prevention can be information and incentive driven because of this unique culture, but only if there is a "level playing field" created by underlying requirements that apply to all regulated organizations.

The Pollution Prevention Act of 1990 requires EPA to promote pollution prevention. This undertaking is vast, affecting both small and large firms. Thousands of small U.S. businesses could benefit from pollution prevention techniques, but do not have technical staff trained to identify and apply technological opportunities. In the case of large firms that use complex production processes, multiple changes throughout the production system often lead to a pollution prevention result. In small and large firms, a great deal of information is required to carry out such changes -- often far more than required by an end-of-pipe pollution control solution.

Still, even firms seeking low-cost pollution prevention approaches to environmental compliance -- information that EPA may have -- distrust EPA because of its regulatory role, fearing that information about pollution prevention solutions revealed to EPA representatives will be used to expand the regulatory grip. Fear that proprietary information may be revealed also restricts data sharing. It will be necessary to consider the impact of such factors that inhibit the direct flow of pollution prevention technology information between EPA and firms.

The diffusion process for pollution prevention thus differs from the diffusion of other environmental purposes. Pollution prevention technologies and techniques are often information-intensive, requiring extensive knowledge of a plant's processes, feedstocks, and products. Pollution prevention often requires the close collaboration of highly knowledgeable partners and trust that the sources of competitive advantage within industrial processes will not be revealed. Some types of pollution prevention, in the areas of industrial hygiene, general housekeeping, lighting, grounds maintenance, and commuting, are less threatening to competitive advantage and more general across industry groups. These considerations bear directly on EPA pollution prevention R&D; EPA's potential for success is dependent on an active partnership with the ultimate users of pollution prevention solutions.

Cost-accounting systems that clarify the relative costs of pollution prevention and pollution control are needed. The cost of pollution control may be underestimated if full accounting is not made of disposal, exposure to liability, and other expenses. Full knowledge of costs, including those incurred and avoided across the various media, might encourage regulated organizations to choose pollution prevention solutions more often.

Media-specific legislation, regulations, permits, and organizational structures pose special obstacles to pollution prevention. The benefits of a multimedia approach can be significant, because this approach can better encourage the absolute reduction of unwanted byproducts. In power plants, for example, sulfur dioxide emissions from the burning of high-sulfur coal are often reduced by the use of wet flue gas scrubbers. However, these scrubbers generate solid wastes that must be landfilled and effluent discharges that must undergo treatment. A multimedia approach would encourage whatever pollution prevention and control measures led to the greatest byproduct reductions considering costs. For example, performance-based standards applied site-wide would facilitate diffusion of effective technology by allowing more flexibility to reduce pollution.

EPA, state, and local field personnel are too often unaware of technical information that would help them encourage pollution prevention in their permitting, compliance, and other interactions with firms. (Of course, they may not be in the best position to encourage pollution prevention anyway.) This problem results from the lack of programs to collect and provide this information (through sources the regulated organizations will trust and work with readily), and from the lack of adequate technical competence on the part of regulators. Moreover, local government agencies have problems evaluating and implementing EPA pollution prevention guidance because of a lack of information and expertise. They look to EPA as the provider of information on testing and evaluation, and a partner in developing incentives, training, and other support systems.

Finding 4

EPA's international diffusion activities are focused almost exclusively on developing and Eastern European nations; a much stronger and broader role is needed to enhance U.S. competitiveness.

The Committee supports the expansion of EPA's new international environmental programs that emphasize the diffusion of environmentally beneficial technologies to the developing world and to Eastern Europe. There are large environmental gains to pursue in the nations of these parts of the world, as well as opportunities to influence the direction of environmental institutions and policies at an early stage. EPA's activities seem to be "right on target" here.

Minimal EPA effort is allocated to the support of U.S. environmentally beneficial technology exports to the major world markets (the other industrialized nations). These markets together exceed the U.S. market, which is the largest in the world. Moreover, these countries are the home to the major competitors to the U.S. environmental industry, many of whom are active in the U.S. It is very important to the health of the U.S. environmental industry that EPA expand its activities in this part of the world. The Committee believes that this is the case because (1) there is benefit to being able to solve most domestic environmental problems domestically, (2) producing industries that are most competitive are often the cleanest (in part because they waste the least), and (3) the world environmental market is one of the fastest growing and presents significant opportunities for exports.

A good example of valuable government-industry cooperation has been seen in activities of the International Organization for Legal Metrology (OIML), a treaty-based organization whose Secretariat is the National Institute for Standards and Technology (NIST). A NIST-led U.S. delegation secured international agreements on standards -- for gas chromatography, atomic adsorption, high-pressure liquid chromatography, field instruments, and mass spectrometry applied to measuring pollutants (pesticides) in water, -- standards all based on U.S.-made instruments. The cooperation of industry and government was crucial to the international acceptance of these standards.

Minimal EPA effort is also directed toward gathering information on technologies developed overseas that could offer environmental and competitive benefits in the United States. To further U.S. environmental objectives, it is important for EPA to help identify environmentally beneficial technologies overseas for potential use in the U.S. Better technologies, wherever they come from, help hold down the costs of environmental improvement and of production.

EPA could contribute to higher environmental standards worldwide and to the nation's competitiveness by being a more active partner in such areas as harmonization of environmental standards and boosting environmentally beneficial trade. To do so, however, the Agency must have improved coordination with other appropriate government agencies, including the Departments of State and Commerce, the U.S. Trade Representative, the Export-Import Bank, and the Overseas Private Investment Corporation (OPIC), which have greater responsibility and experience in international relations and can provide legitimacy to EPA's involvement. EPA can, in turn, lend them its central focus on environmental improvement and its reputation and credentials as a worldwide environmental leader.

Finding 5

EPA's research programs do not adequately support the agency's diffusion mission.

EPA's environmentally beneficial technology research programs have three major roles to play that relate directly to EPA's capacity to perform its key function in the diffusion system. The first role is in planning and conducting environmentally beneficial technology research, the results of which are a major source of credible information that can be shared through diffusion programs. The second concerns influencing the R&D performed by others so that the data they generate will be of enhanced quality. The third is EPA's own role in the diffusion of credible environmentally beneficial technology information. In general, the Committee believes that, in order for EPA to derive major support from diffusion, ORD's role in diffusion must be sharpened and focused in each of these three areas.

Some of ORD's research and diffusion programs are very good. The Pollution Prevention Information Clearinghouse and the new federal facilities testing program are examples of a new activism by ORD in collecting and developing credible data that are needed by EPA's diffusion partners. EPA's sponsorship of the National Environmental Technology Applications Corporation (NETAC) represents its first venture to foster directly the commercialization of environmental technologies (without endorsing any one technology).

As noted earlier, EPA's environmental technology R&D spending constitutes less than five percent of the national total, and EPA's R&D is primarily aimed at obtaining data to support the regulatory process. The agency's environmental technology research primarily provides baseline data to establish new regulatory standards. While there is no question that EPA's R&D activities directly influence industry R&D decisions, the reverse is not so clear. With the exception of what amounts to *ex post facto* approval from Science Advisory Board committees, EPA R&D planners receive no direct and very little indirect input from industry and other major players in the field. Without any R&D planning input from regulated organizations and technology developers, EPA risks repeating research, applying older-generation approaches to scientific problems, or otherwise inefficiently allocating R&D resources. Compounding the lack of formal direct R&D planning input from industry is a complete lack of trained, dedicated market research personnel who could generate complementary information by gauging markets.

These facts ensure that EPA cannot play a leading role as a direct sponsor of environmentally beneficial technology R&D. Broadening the base for planning its environmental technology R&D programs would help EPA fill a serious need: that some organization coordinate governmental environmental technology R&D. EPA's own programs lack a clear ability to anticipate significant trends that will influence environmental technology problems and opportunities, and to understand markets. Similarly, EPA has only begun to implement mechanisms that ensure that the maximum leverage will be obtained from its own technology R&D programs and has not emphasized the commercialization end point in these programs. Co-planning and leverage will be especially necessary for EPA to support improved industrial technology and low-polluting products. (The Committee notes the real progress EPA has made in implementing the Federal Technology Transfer Act, although there is a real need to expedite the process for establishing CRDAs [cooperative R&D agreements].)

To assess federal agencies' FTTA activities and performance, the Focus Group established a special task force which met with representatives of EPA, DOE, USDA, and the U.S. Army. The task force found that EPA has entered into fewer CRDAs than these other agencies. The Department of Energy and/or its laboratories have entered into 190 CRDAs. USDA has entered into roughly 215 CRDAs, and the Army 171. EPA's current total is 31. EPA has also signed three licensing agreements.

Many factors account for the disparities described above, the two most important being EPA's regulatory nature and the relative size of EPA's R&D budget (e.g., the Army's research budget is roughly four times that of EPA's). Due to EPA's regulatory nature, an adversarial relationship has existed between EPA and its potential cooperative partners. This mutual antagonism has only recently begun to change and is in part responsible for the agency's slow start in developing CRDAs and licensing agreements. Five CRDAs were finalized by EPA in 1989, 12 by 1990, and 31 by 1991. Roughly 25 EPA CRDAs are in some stage of negotiation at the present time. EPA is to be commended for the accelerated pace **at** which CRDAs have been signed over the past year.

Also owing to EPA's regulatory nature, numerous offices review CRDAs at both the letter of intent and draft CRDA stages. (Some agencies do not even require letters of intent.) Coordinated by EPA's ORTA, the Office of Technology Transfer and Regulatory Support, CRDAs must be approved by EPA's Office of General Counsel, Grants Administration Division, Inspector General, and Office of Enforcement. To qualify, the industry CRDA partner must not be subject to sanctions resulting from a violation of a fiduciary duty or to any EPA enforcement action. These extra approvals are not required by agencies that play no regulatory role.

In the case of the Army, many individual laboratories have their own ORTAs and legal support, so approval authority is close to the negotiations process. Industry has worked closely for decades with USDA, and the transition to the CRDA format was relatively simple. EPA currently has only one ORTA, located at headquarters. The current EPA system may be inadequate to enter the number of CRDAs its potential suggests.

DOE, USDA, and the Army all have developed standardized CRDA documents that accelerate the internal review process. While the work statements vary considerably from CRDA to CRDA, clauses on licensing and confidentiality are generally non-negotiable. EPA has just introduced its own standardized CRDA format, which should accelerate EPA

review, and has dedicated new legal support for CRDA review. It is also preparing a draft manual describing the review process. All of these recent steps are reflected in EPA's improved CRDA performance and are to be commended.

In general, however, the extra approval steps required by EPA have slowed its review and also required more resources from the industrial partner. The TIE Committee believes that any changes lowering the transaction costs of establishing CRDAs, including the speeding of negotiation times, will benefit industry's efforts to bring new environmental technologies to market.

There appears to be a learning curve on both federal agency and industry sides of CRDA negotiations. USDA and Army results indicate that the first CRDA signed with a particular firm takes the longest time. Subsequent negotiations are far shorter. The first step in negotiations involves the preparation of a three-page work statement by the interested scientific or engineering personnel. Legal deliberations follow. In EPA's case, legal questions still play a significant role early in most negotiations.

The TIE Committee believes that lack of information about the potential benefits of FTTA cooperation is a key barrier to its expansion and ultimately to the development and commercialization of innovative technology. Education programs to explain the procedures for establishing CRDAs and licensing agreements and to stimulate the awareness of benefits and possibilities derived from the FTTA could better attune EPA researchers to the potential commercial applications of their work. The task force notes that EPA has hired a contractor to prepare internal education materials. Similarly, efforts to diffuse information on FTTA opportunities could inform potential industrial partners and increase their interest. The results of such internal and external awareness campaigns would be measured by the increase in CRDAs and licensing agreements signed by EPA and industrial partners.

Out of the group of agencies studied, the FDA appears to most closely resemble EPA in its regulatory and technology transfer mission. The FDA's implementation of FTTA includes the following features:

- CRDAs received final approval from the FDA Commissioner.
- A five member CRDA Review Board reviews all CRDAs before they are submitted to the Commissioner. Minutes of this review board are not published.

- The FDA principal investigator certifies the lack of a conflict of interest in the CRDA.
- The CRDA is reviewed by the division of Staff Ethics and Program Integrity, and simultaneously the CRDA is circulated to other FDA labs and staff offices for review. This all takes place after the lab director signs the CRDA and before it is presented to the Review Board.
- Conflict of interest investigations and Review Board actions are completed before the 30-day mandatory review period starts. This means that the review period is only used to obtain final approval from the FDA Commissioner.

The task force has found that the starting point of the 30-day review period mandated by FTTA legislation is arbitrarily determined by each of the agencies examined. For example, the FDA defines the starting date as the date the CRDA is ready for the FDA Commissioner's approval. The task force therefore believes that focusing on meeting the 30-day mandatory review period is not an effective measure of EPA's FTTA success. The focus should be on the total time required to obtain CRDA approval, because environmental technologies have a short period during which owners can profit from their use, sometimes as little as one year. Therefore, it is imperative that EPA work to shorten the CRDA approval process as much as possible.

Currently, when EPA research plans are developed, there are no formal requirements to plan for subsequent diffusion and use of the research results. Valuable findings often languish once their intended purpose (often of supporting the regulatory efforts of a program or regional office) is achieved. This is an additional concern.

An EPA emphasis on maximizing opportunities to improve the quality of information generated by others is important. Increasing joint or coordinated planning will help, as will jointly conducted research. Inadequate attention is being paid to standardizing test protocols, analysis procedures, and performance reporting.

The role of EPA's research program in the diffusion of credible environmental technology information requires considerable rethinking. ORD appears to rely primarily on its own R&D for information that it diffuses. Given its role as a minor developer of this information, this practice limits the effectiveness of ORD information bases and diffusion efforts. Another factor limiting ORD's diffusion success is its tendency to be a direct source of information, rather than to be an indirect source. One example of this is an

otherwise excellent ORD training program that is fully subscribed all year, but which only reaches a small percentage of the potential audience.

The government's role is critical. As the TIE Committee's 1991 report points out, most innovations trigger regulatory oversight during research, development, and/or demonstration, and all require regulatory approvals for purposes of compliance. The government roles of gatekeeper, overseer, and diffuser transcend that of investor in environmental technology innovation. Thus, while added government financial support would be helpful, improved regulatory and administrative processes are vital. These would include incentives to encourage diffusion.

VI. RECOMMENDATIONS FOR ACTION AND COMMENTARY

SUMMARY OF RECOMMENDATIONS,

1. **Make technology diffusion a major supporting mission for EPA.**

2. **Build a stronger partnership with technology diffusion providers and users.**

3. **Make diffusion and incentives the emphases of EPA's pollution prevention programs.**

4. **Expand support for the international diffusion of environmental technologies to help meet U.S. environmental and competitiveness objectives.**

5. **Increase the support of diffusion provided by EPA's environmental technology research programs.**

Introduction

The TIE Committee's recommendations are centered on two major areas of environmentally beneficial technology diffusion. First, there are actions EPA can take which will have a direct effect on the diffusion of environmentally beneficial technologies. Second, there are actions EPA can take in other parts of the environmental management system that support diffusion activities.

Some of the first group of recommendations will increase environmentally beneficial technology diffusion because they promote the diffusion of environmentally beneficial technologies, either inside or outside the agency. These actions are covered in Recommendations 1, 2, 3, 4, and subrecommendations 5.1 and 5.2. Recommendation 1 is the most important recommendation. The other recommendations are not prioritized in any order other than the grouping noted herein.

The second group of recommendations identifies actions EPA can take that lead to the diffusion of environmentally beneficial technologies by making changes in other parts of the environmental management system. These actions will indirectly lead to increases of environmentally beneficial technology diffusion because activities which are related and critical to diffusion -- but are not diffusion activities in and of themselves -- will be promoted. For example, it is recommended that EPA foster technology testing and the development of credible performance data by others, which it can do by increasing its efforts to standardize test protocols. That will lead to increased diffusion because more and better data can be made available through diffusion systems. These recommendations are covered in primarily in subrecommendations 1.5, 5.1, 5.2, and 5.3.

The Diffusion Focus Group has reviewed and now offers its support to Recommendation Four of the January 1991 TIE Committee Report, *"Permitting and Compliance Policy: Barriers to U.S. Environmental Technology Innovation."* Recommendation Four specifically addresses the support (diffusion) required for all stakeholders if recommendations about how to encourage innovation through permitting and compliance policy are to be effective. It is reproduced in Appendix 2 of this report. The Diffusion Focus Group has also reviewed and now offers its support to the recommendations from the TIE Committee to EPA's Committee On Technology Cooperation, made in September 1991. These recommendations, which deal with technology cooperation, technology innovation, and trade and the environment, are reproduced in Appendix 3 of this report.

Each major recommendation listed in the "Summary of Recommendations" is discussed fully in the "Detailed Recommendations and Commentary" section. The "Detailed Recommendations and Commentary" section contains decimal-level subrecommendations (e.g., 1.1, 1.2, 1.3) describing the types of changes needed to implement each major recommendation. Letter subpoints (1.1 "a", 1.1 "b", 1.1 "c") under each subrecommendation describe specific implementation actions for EPA. The items listed in the subrecommendations and letter subpoints are a starting point for future actions and are not intended to be an all-inclusive list.

DETAILED RECOMMENDATIONS AND COMMENTARY,

Recommendation 1:

Make technology diffusion a major supporting mission for EPA.

1.1 Create a high-level position to advocate and coordinate EPA's technology diffusion programs.

1.2 Modify and expand EPA's role and funding support for technology diffusion.

1.3 Create an internal system of support for agency employees that will promote and assist technology diffusion.

1.4 Improve the current partnership between the agency and users and providers of diffusion services.

1.5 Change the regulatory system to allow the diffusion system to operate more effectively.

Commentary

Technology solutions are essential to EPA's ongoing success in accomplishing its mission of environmental protection. The diffusion process involves the set of mechanisms that make technological solutions more useful and accessible: diffusion gives impetus and direction to the development and commercialization of environmentally beneficial technologies. Strong government diffusion programs play a necessary role in the environmental management system, ensuring that the widest range of technology solutions is available to regulated organizations and enabling them to find environmentally and economically efficient ways to comply with and exceed environmental requirements.

The environmental management system includes regulations; administrative practices and policies supporting the regulations; permitting programs; compliance and enforcement programs; technology diffusion programs; EPA grants to state programs; and federal, state, and local research programs supporting environmental objectives. The Committee believes that it is imperative for the agency to recognize and highlight diffusion programs as cost-

effective and efficient mechanisms that play a key and unique role in achieving EPA's mission. This role is unique in its ability to influence, rather than command, the activities of other environmental stakeholders.

The set of tools available in diffusion programs enables government to be an active, positive partner with environmentally beneficial technology providers and users. Through diffusion, EPA is able to influence a broad range of environmental stakeholders in a cooperative manner, without having to resort to the command and control authority given it by statute. The '11E Committee commends the agency for recognizing the need to incorporate non-adversarial approaches in its environmental protection strategy.

Diffusion is particularly important to EPA's effort to reach regulated parties that are not technologically sophisticated. These organizations have an intense need for diffusion support because they lack the in-house technical and financial resources to either generate technological solutions to solve their environmental problems or to fully evaluate the claims of vendors. They are often in industries that have poor compliance records. These parties require credible, trustworthy, and objective sources of technology information, such as trade associations, consulting engineers, or government.

There are two different needs that environmentally beneficial technology diffusion can satisfy on the part of regulated organizations. The first need is for environmental , technologies that allow and enhance efficient compliance with environmental permits and standards. The second need is for environmentally beneficial technologies that cooptimize both environmental and economic outcomes. The technologies that satisfy these two needs are often quite disparate. The first need is typically satisfied by end-of-pipe technologies that are evaluated on their ability to meet minimum requirements (e.g., emissions) and their total cost. The second need can be satisfied only with technologies that are integral to the production process. These technologies are often more innovative and complex than conventional environmental solutions and can affect choices from raw materials to production processes to finished products. The user of cooptimizing technologies is able to apply environmental solutions to do more than meet regulatory standards, since the cooptimizer perceives innovative compliance as a competitive advantage that can convey economic gain. Satisfying both of these needs is the ultimate task of a successful diffusion system.

How EPA approaches regulated organizations depends on their environmental position, namely: leader, follower, or laggard. Leaders are at the forefront of environmentally beneficial technology use and understanding. They are willing to apply innovative technologies even if there are significant risks, given the expectation of a reasonable reward. Leaders are technologically adept and are usually the larger members of their industry. They need to get good information and support for their use of innovative technologies, and often see innovative environmental compliance as a competitive advantage. Leaders can often be reached directly by regulators and are often interested in examining new technologies.

Followers are at the middle ground of the use of environmentally beneficial technologies. They usually use technologies that are widespread and commonly available, and are often most concerned about an environmental technology's cost. Followers often use outside firms (e.g., engineering firms, consultants) for advice about the new use of a technology, including evaluation and installation. They tend to be grouped at the middle range in size when compared to the other two groups. Their interest in a new environmentally related technology is usually based on changes in legal requirements, and then only if the technology is well proven.

Laggards are the final group of regulated organizations in the technology arena. They are usually the last to use innovative environmentally related technologies because they are interested only in staying out of the legal entanglement which threatens when they are not in compliance. Laggards tend to be much smaller firms than leaders or followers. Although there may be many more laggards than leaders or followers, they often represent a very small proportion of total discharge. The laggards are often single-site, privately owned operations that usually lack the ability to absorb any complex or unique environmental solutions.

EPA's technology diffusion role is particularly important in two areas of more recent concern to EPA: international competitiveness and pollution prevention. The TIE Committee concludes that it is in EPA's interest to support the international diffusion of environmental technologies to help meet U.S. environmental and economic objectives (see Recommendation 4). Diffusion is needed to not only increase the export of domestic environmental technologies and the competitiveness of all U.S. producer industries that pollute, but also to make the best environmental technologies in the world available to U.S. polluters.

Technology diffusion activities are critical to the successful implementation of pollution prevention strategies (see Recommendation 3). The TIE Committee notes that the motivation to apply pollution prevention techniques and technologies is different from the motivations that drive regulated organizations to comply. Government's ability to influence the decision to prevent, rather than control, pollution can be most effective through the creative use of diffusion programs. These programs would increase the range of choices available to regulated organizations, offer incentives that reward pollution reduction beyond regulatory minimums, and increase flexibility in permitting and compliance programs that encourage innovation and experimentation (as identified in the TIE Committee's report and recommendations on how to foster environmentally beneficial technology innovation through permitting and compliance policy). If the agency is to be successful in its pollution prevention efforts, it must feature the vigorous promotion of environmentally beneficial technologies through diffusion programs.

The following subrecommendations describe the major steps EPA must take if it is to mount a successful diffusion program. These steps include: establishing a person or group responsible for coordinating and advocating strong diffusion programs in the agency, the redeployment of resources needed to strengthen diffusion EPA activities, the creation of a system of internal diffusion support for agency professionals, the improvement of partnerships with outsiders to promote diffusion, and the changes needed in agency regulatory programs to make them compatible with the agency's diffusion programs.

1.1 Create a high-level position to advocate and coordinate EPA's technology diffusion programs.

Commentary

The establishment of a high-level diffusion position in EPA is needed to correct a variety of critical problems the Diffusion Focus Group found in EPA's diffusion programs and throughout the diffusion system:

- The technology diffusion leader would need to address the low priority, inefficiency, and lack of internal coordination of existing EPA diffusion activities.
- The diffusion leader would help address the need for the agency to actively promote (through diffusion activities) multi-media environmental approaches, pollution prevention, and environmentally beneficial innovation.
- Since EPA originates only a small number of environmentally beneficial technologies and generates only a small portion of the total environmentally beneficial technology information base, a critical function of the diffusion leader must be to pursue stronger technology diffusion partnerships.

Since EPA is only one of a large number of players in the field, and the other players have a wide variety of motivations and modes of participation, it is important that EPA take a leadership role, coordinating disparate activities so that the diffusion system operates as effectively as possible as a part of the environmental management system (see Recommendation 2).

a. ROLES OF THE DIFFUSION COORDINATOR: The TIE Committee recommends that EPA create a high level position reporting to the Administrator with responsibility to provide agency-wide advocacy, strategic guidance, and coordination to upgraded diffusion efforts. The diffusion leader should also provide coordination for the agency's widely dispersed, usually single media, and disparate types of technology diffusion activities. This diffusion leader should: promote a multi-media perspective, provide coordination for technology diffusion activities among the program offices,

increase the agency's gathering of credible information about innovative and pollution prevention technologies and techniques, establish within EPA a function to aid the collection of foreign information about environmentally beneficial technologies, and be a primary player in building partnerships with others involved as providers and consumers of diffusion activities in both the public and private sectors. The diffusion leader could also provide outside parties interested in technology diffusion with an initial point of contact that could direct them properly. The diffusion leader's first action should be to prepare a clear statement of agency policy for the Administrator's signature identifying technology diffusion as a major agency program supporting and complementing other agency programs.

b. **MODIFY THE AGENCY'S CULTURE:** If EPA is to meet the challenges of protecting human heath and the environment in the 1990's, a culture change is needed in the agency that reflects and encourages EPA taking a leading role in diffusion. This change will affect training, support, and incentives for employees, as well as their understanding of the relationship they have with other environmental stakeholders. A first step involves changing the conceptualization of EPA's role from that of environmental regulator to that of catalyst for environmental improvement, using the full range of tools in the environmental management system, including regulation. The diffusion coordinator should be at the center of this culture change.

This culture change should accompany and support improvements in the technology competence, training and retention of personnel. As described in Recommendation 4 of the 1991 TIE Report, improved data and technical information resource support is required (perhaps from ORD) to improve the technical competence of rule writers, permit staffs, compliance staffs, and technical assistance groups. Similarly, policy, job standards, reward systems, and other tools will be needed to modify the agency's culture so that EPA staff perceive their role as being that of catalyst for environmental improvement, rather than merely that of regulator.

As described in Recommendation 3, the TIE Committee believes that strong support for pollution prevention, innovation, and experimentation is a part of the necessary new culture. All of its employees need to think of, suggest, and be rewarded for working towards a new culture that involves these concepts. Subrecommendation 1.3 below describes the system of support that EPA staff will need, if the agency's appropriate role in diffusion is to be effected and the new culture installed.

1.2 Modify and expand EPA's role and funding support for technology diffusion.

Commentary

EPA's diffusion role needs to be modified and expanded to correct a variety of underemphasis, gaps, and inefficiencies the TIE Committee found throughout EPA's diffusion activities. The agency's diffusion programs are largely uncoordinated and single-media in nature, and are not designed to gain sufficient leverage from those knowledgeable about the need for environmentally beneficial technologies, from other developers of credible diffusion information, and from providers of diffusion services. Statutes, regulations, permits and the resulting EPA organizational structure are all single media oriented with little or no coordinated activity. There are numerous examples of how pollutants are chased from one media to the next. One example is the sulfur dioxide limits on coal fired power plants. The sulfur in the coal, combined with the coal and as iron pyrite, produces sulfur dioxide on combustion. Flue gas scrubbers are installed to reduce the sulfur dioxide emissions to satisfy the Clean Air Act and associated regulations, which results in a sludge byproduct that must be landfilled. In addition, it should be noted that current regulations do not encourage pollution prevention techniques, which might promote the use of low sulfur coal.

EPA could also reap significant gains by modifying its role in the technology diffusion system to recognize and take advantage of others' diffusion resources. EPA has made this adjustment in the area of remediation technologies. Here, EPA has identified the key stakeholders involved in making remediation decisions and strengthened its diffusion relationship with the consulting engineering community -- the group that most supports the responsible parties in choosing remedies. Another example, but one where EPA has not acted consistently, involves working with the Departments of Defense and Energy. The data produced in these programs are not systematically coordinated with EPA's testing protocols, data quality requirements, and reporting systems to assure that they can be directly input into EPA's information management systems. Here, and in other cases, EPA's unique position is not being fully exploited to take advantage of the benefits diffusion can offer.

Expanding EPA's diffusion effort with additional resources is also needed to allow the agency to achieve its environmental goals through the application of new and innovative technologies to environmental problems. As discussed earlier, an historic underutilization of diffusion programs in the environmental management system cannot be reversed merely through better coordination, advocacy, and policy encouragement.

a. EPA AS THE ULTIMATE FACILITATOR OF ENVIRONMENTAL TECHNOLOGY DIFFUSION: The agency's unique role at the apex of the environmental management system pyramid requires it to be the ultimate facilitator of technology diffusion, but does not require it to conduct all diffusion activities. EPA's wide-ranging roles in the diffusion of information about environmentally beneficial technologies (e.g., regulator, promoter, educator, researcher, buyer, approver, and certifier) give the agency the ability to encourage communications (a key element of any technology diffusion activity) across the broad spectrum of players that includes almost all environmental stakeholders. The agency's influence can be used both internally and externally as a powerful tool to support and promote technology diffusion, which in turn can strongly contribute to EPA's success in its environmental improvement mission.

b . EPA'S FIRST STEPS TO EXPAND AND PROMOTE TECHNOLOGY DIFFUSION: As a start, the Administrator should require that all agency program plans have a technology diffusion component that clearly identifies the users of the information contained in and generated by the program, the mechanisms for communication, and the program's technology diffusion component(s). The role of diffusion relative to other elements of the environmental management system should be clearly stated in the program plan. The technology diffusion component should be clearly labeled and have sufficient, earmarked resources. Both the labeling and the funding should be explicitly connected with overall agency objectives in diffusion. This would make diffusion efforts a standard part of EPA's activities, as well as make it easier to monitor, assess, and reward successful diffusion.

In working with many potential users of diffusion services, the agency should find ways to facilitate third-party information exchanges. These exchanges are particularly useful in communicating with untrusting and/or uninterested regulated parties. Their receptiveness to technology information will be greater if the diffusion process occurs through organizations with whom the regulated organizations are comfortable.

c .- **REDEPLOY EPA'S CURRENT DIFFUSION ASSETS** TO **INCREASE SUPPORT FOR TECHNOLOGY DIFFUSION: The TIE** Committee recognizes the agency's wide variety of diffusion programs, which should be redeployed since they are largely uncoordinated and single-media. Moreover, sufficient leverage is not gained from other developers and providers of diffusion information.

The Committee believes that EPA can create additional support for the transfer of environmentally beneficial technology information by increasing the efficiency of technology diffusion activities inside and outside the agency. Agency personnel, facilities, policies, and practices can all be managed more efficiently to this end. Increased support can therefore come at little or no cost to the agency, because it can come from the better use of current agency resources.

The TIE Committee recommends that EPA begin to examine the possibility of redeployment by conducting a total quality management exercise for diffusion programs. This exercise should include benchmarking with other federal, state, and local government agencies to find out how they shape their diffusion programs.

d . PROVIDE ADDITIONAL RESOURCES TO **SUPPORT** INCREASED TECHNOLOGY DIFFUSION: The TIE Committee also concluded that the agency should provide additional resources for its environmentally beneficial technology diffusion efforts. This increase is needed for two reasons: (1) the current resource level for diffusion activities reflects a significant and long-term lack of emphasis on government diffusion programs as contributors to environmental progress, and (2) the incorporation of multi-media, pollution prevention, international, and other understated elements of EPA's diffusion programs will require new resources.

As discussed previously, the TIE Committee believes that technology diffusion is an appropriate, efficient, and cost effective method of fostering the application of advanced technologies and techniques for environmental improvement. Consideration should be given to shifting, agency resources to technology diffusion activities or to seeking additional resources, if EPA determines that agency resource levels will be inadequate, even considering the beneficial effects of redeployment decisions. Such consideration should be made in the context that diffusion is one of the major, interrelated elements of the environmental management system.

1.3 Create an internal system of support for agency employees that will promote and assist technology diffusion.

Commentary

The diffusion of environmentally beneficial technologies is **people dependent.** The diffusion effort will ultimately succeed or fail solely based upon the efforts of agency participants. Two key tools are essential to mobilizing people for the diffusion effort: employee support systems and encouragement. Support systems are needed to provide the technical expertise, training, information systems, job hierarchy, and exposure to other organizations that are currently not sufficiently available to mobilize the diffusion effort. EPA's people also need additional encouragement (in the form of job standards and rewards) so that they will believe contribution to the agency's diffusion effort is in EPA's and their interest. The TIE Committee developed a clear perception that EPA staff do not feel that a strong diffusion role is required for success in the agency's mission.

The TIE Committee has found an additional EPA employee requirement for successful diffusion: the technical competence of regulatory, permitting, compliance, and other agency personnel must be improved. The Committee heard from multiple sources that there is a widespread lack of technical competence in EPA. This problem was attributed to two factors: a lack of technical background and the short tenure (and experience) of these individuals, particularly in permitting and compliance programs. If diffusion is to take place through these channels and be encouraged by them, it is important that these problems be resolved. The TIE Committee recommends that EPA institute or strengthen several employee support activities to advance EPA's diffusion programs and culture. These should be made to apply to rulewriters, permit writers, compliance personnel, diffusion staff, researchers, and others.

The rest of subrecommendation 1.3 discusses how to institute the system of support for agency personnel that will enable them to carry out an appropriate diffusion program, working with other environmental stakeholders.

a. ESTABLISH A **HIERARCHY** OR **JOB** LADDER AND INCORPORATE CRITERIA IN PERFORMANCE EVALUATIONS ALONG THAT PROMOTIONAL LADDER TO ADDRESS **THE** DEVELOPMENT OF EXPERTISE (SINGLE MEDIA, CROSS-**MEDIA, OR TECHNOLOGY-SPECIFIC, INCLUDING POLLUTION** PREVENTION): The TIE Committee's report and recommendations, titled *"Permitting and Compliance Policy: Barriers to U.S. Environmental Technology Innovation,"* describes on pages 87 - 88 how EPA might establish a hierarchy or job ladder that would create incentives and support for permit writers involved in innovation. This elements of this hierarchy, expanded to cover all agency personnel, has great applicability to the support of a diffusion program, as well. The Committee reiterates its support for this approach.

b. PROVIDE TRAINING AND MODEL TEMPLATES, **BASED** ON THE PRIOR TESTING AND USE OF INNOVATIVE AND POLLUTION **PREVENTION TECHNOLOGIES** AND TECHNIQUES, TO ALL PERMIT WRITERS: A concise, yet comprehensive, training program should explain the permit writers' role in fostering the successful use of these technologies and techniques for environmental purposes and identify information sources and networks with technical information. The training program should also educate regulators on how the motivation to innovate and to prevent pollution work in industry. It should describe the roles of government and other technology diffusion groups, with the goal of helping permit writers network to extend the use of environmentally beneficial technical information.

c . **STRENGTHEN** ORD'S ROLE AS IDENTIFIER AND **CONVEYER** OF TECHNICAL INFORMATION TO PERMIT WRITERS: ORD's roles in research and diffusion are discussed in detail in Recommendation 5. In general, ORD should undertake a more systematic approach in its diffusion role to help permit writers obtain performance data about the applicability of innovative and pollution prevention technologies and techniques. ORD should also assist permit writers frame permit conditions for unfamiliar technologies and techniques.

d. ESTABLISH PERFORMANCE **EVALUATION** STANDARDS AND REWARD SYSTEMS **THAT PROMOTE** GREATER **SUPPORT** AND CONSIDERATION FROM **PERMIT** WRITERS FOR INNOVATIVE **POLLUTION PREVENTION AND POLLUTION CONTROL** TECHNOLOGIES: EPA should highlight the diffusion role by including in performance standards and credits ("bean counting") the need and success of permit writers' work to achieve the goals set forth in the diffusion policy statement. The TIE Committee recognizes that extra time and risk are involved in processing permit applications for innovative alternatives. Extra risk is associated with supporting approaches that involve uncertainties, such as those associated with changes in standard technologies and in performance projections for innovative solutions. Financial incentives should be a part of this improvement, as well as recognition and merit awards. For example, DOE labs have recognition programs including awards banquets, and a DOE employee received "Lifetime Technology Transfer Achievement Award" at the NASA 2001 Exposition this past December. EPA might consider programs such as this one.

e. IMPROVE DATA AND TECHNICAL INFORMATION SOURCES TO AID PERMIT WRITERS IN **THEIR JOB** OF **REVIEWING** PERMIT APPLICATIONS INVOLVING **INNOVATIVE** AND POLLUTION **PREVENTING TECHNOLOGIES** AND **TECHNIQUES, PERHAPS THROUGH AN EXPANSION OF THE** "ATTIC" DATA BASE, **WHICH** NOW CONTAINS INFORMATION **ABOUT INNOVATIVE REMEDIATION TECHNOLOGIES: As** discussed elsewhere in this report, EPA should collect credible information from the widest possible range of sources and assemble the data and information in on-line databases for PC/Mac users. Information should be collected and assembled in information retrieval systems that are easily accessible to all permit writers. Information should include:

- Media affected by the technology.
- Emission/effluent/hazardous waste reductions achieved by the technology.
- Process descriptions.
- Location and results of tests, demonstrations, and early commercial uses.
- Level of cleanup (remedial technologies) achieved.

- Contact owner or licensee, and ORD technical experts.
- Existence of patents covering the technology and the availability of licenses.
- Key words; similar technologies; terms of art.
- Known limitations.
- Potential site incompatibilities.

f .- FACILITATE **THE MOVEMENT** OF **PEOPLE WITH ROTATIONAL OPPORTUNITIES BETWEEN EPA, OTHER FEDERAL** AGENCIES, STATE AND LOCAL AGENCIES, AND **THE PRIVATE** SECTOR: Environmental managers should understand the factors that influence the decisions of all stakeholders involved in solving an environmental problem. Rotational assignments are the best way for professionals involved in the diffusion effort to gain insight into the value structures and thought processes of others. They also increase the technical knowledge of EPA's scientific and engineering staffs.

EPA regulatory, permitting, compliance, research, and diffusion personnel need exposure to a variety of environments so they can better understand the perspectives, needs, and requirements of other organizations. Rotations need to include assignments:

Between and within the regulatory, research, and diffusion programs within the agency.

- Between the agency and other federal, state, and local government agencies.
- Between public and private organizations.

The creation of several endowed chairs to attract senior scientists who are leaders in their fields is a step in the right direction.

g . EXPAND THE RESIDENT RESEARCH ASSOCIATESHIP PROGRAM: One program already facilitates the movement of scientific and technical people to EPA. Incentives should be added that increase the attractiveness EPA's Resident Research Associateship Program to senior-level scientists from private industry, academia, and other federal agencies. These reforms include: streamlining the paperwork process, increasing compensation, and assisting in the visiting scientist's relocation, as needed.

1.4 Improve the current partnership between the agency and users and providers of diffusion services.

Commentary

The TIE Committee found that the requirement for technology diffusion exceeds EPA's limited resources. Moreover, a solely EPA-based diffusion effort would not be efficient, even if the necessary resources were available; in some situations, such as diffusing proprietary information, an EPA-based diffusion effort would be inappropriate. The TIE Committee has concluded, therefore, that EPA must emphasize working with others to leverage its diffusion resources and to improve the efficiency of the entire diffusion system. Four categories of diffusion partners were identified:

- Those who understand user needs (e.g., state and local regulators, engineering firms, consultants, users, trade associations).
- Developers of information about environmentally beneficial technologies (e.g., consortia, universities, research programs of other federal agencies, equipment and service providers).
- Providers of diffusion services (e.g., engineering firms, trade associations, information clearinghouses, state and local regulators, other federal agencies).
- Users or consumers of diffusion services (e.g., regulated organizations, state and local regulators, engineering firms and consultants, equipment and service providers).

Leveraging agency resources through the efforts of outsiders has additional benefits. Outsiders have different perspectives from which EPA could benefit. They have different relationships that also work towards environmental improvement (e.g., with consulting engineers, who advise regulated organizations on the best solutions to their environmental problems). Outsiders have information that EPA does not possess, but which would benefit the environment protection effort if shared more widely (e.g., through trade associations). Their motivations (e.g., the profit motive) differ from EPA's and are complementary to EPA's technology diffusion goals. Some outsiders operate in a less constrained environment than government regulatory agencies (which cannot endorse a technology without regulatory and legal implications) and can act more quickly.

Finally, there is the issue of credibility; people need information that is credible. Government, particularly EPA, is widely seen as a credible source of technology performance data. The problem is that while government is usually seen as credible, it may also be distrusted due to its regulatory role. If EPA's diffusion programs are to be successful, the actual diffusion of information should sometimes be carried out by EPA's diffusion partners. Thus, mutually supportive diffusion efforts can be used to overcome the distrust of EPA's regulatory position.

a. CREATE NEW AND **STRENGTHEN EXISTING PARTNERSHIP** RELATIONSHIPS: Efforts should be made to use and optimize new and existing mechanisms for the diffusion of information. ORD and the Office of Air and Radiation (OAR) provide technical support and guidance on air pollution control technology through the jointly supported Control Technology Center (CTC). It describes air emission factors and air pollution control technology for all air pollutants, including air toxics emitted by stationary sources. The Technology Innovation Office in the Office of Solid Waste and Emergency Response (OSWER) has a successful program that has greatly expanded EPA's relationship with key diffusion partners in the remediation technology field, e.g., the consulting engineering community. Consulting engineers advise responsible parties about their technology choices in site remediations.

The Technology Innovation Office (TIO) makes information available in various forms, including software, reports, newsletters, and seminars. These sources inform the public and users of remediation technologies about available innovative treatment technology products and services. TIO also provides a developers' guide to support services, which describes regulatory requirements, assistance programs (financial and technical), technology incubators, test and evaluation facilities, and technical expertise in basic and applied research. In addition, TIO has user friendly software that describes the availability and performance of a variety of innovative technologies. Another major 110 publication is the *Citizen's Guide on Innovative Technologies.*

Some of TIO's other efforts to reduce impediments to the use of innovative technologies include:

Institutional Methods:

- Award of a cooperative research agreement to the American Academy of Environmental Engineers to develop monographs containing operating parameters for eight innovative and established technologies.

- Organization of a users group of Fortune 500 companies to collaborate with the Air Force, Army, and EPA to evaluate innovative technologies at federal facilities that are applicable to corporate cleanup problems (see subrecommendations 5.1 and 5.2 "h").

- Development of a quick reference fact sheet on the regional experience with the procurement of innovative technologies at Superfund sites.

Regulatory Methods (see subrecommendation 1.5):

- Delegation of the authority to issue site specific treatability variances for contaminated soils to the regions.

- Authorization to additional states for the treatability exclusion rule, RD&D permit authority, and Subpart X permit authority to allow more flexibility for testing and demonstrating innovative treatment technology.

Training (see subrecommendation 1.3 "b"):

- Development of a series of satellite video conferences (the first on bioremediation).

- Development of teaching modules (one semester) on innovative technologies for use by graduate environmental engineering departments.

- Provision of two training sessions for states that are taking the lead in innovative technology development.

Development Activities:

- Development of ten "citizen fact sheets" to educate the public about innovative technologies.

- Development of a vendor information system for innovative treatment technologies (VISITT) that makes information available on hotline and user friendly software.

- Miscellaneous newsletters, publications and workshops.

EPA will need to work with the diffusion partners to receive information on the needs of regulated organizations for environmentally beneficial technologies. This work will help guide the cooperative development of diffusion systems and programs. The input of state and local governments, trade and professional associations, consortia, and other organizations should be brought into the agency's diffusion planning processes as early as possible.

State and local governments, for example, have networks in place for the diffusion of information to local regulated organizations. These networks have been developed through direct regulatory contact with local polluters. State and local agencies can be particularly knowledgeable about local air and water pollution problems. They can help regulated organizations by aiding in the diffusion of information about available technology performance data and information management systems. These agencies may be strongly motivated to help regulated organizations comply or become more efficient producers while complying, because of their interest in the local economy. EPA could strengthen the diffusion capability of local and state agencies by enhancing its efforts to provide information to STAPPA/ALAPCO's (State and Territorial Air Pollution Program Administrators/ Association of Local Air Pollution Control Officials) and others' networks. State economic development administrations are also very important potential sources of information that are independent of environmental regulatory organizations.

Similarly, trade and professional associations enable the agency to make quick and efficient contact with those whom it wishes to impact through workshops, seminars, conferences, publications, and personnel exchange programs. Consortia and institutes, e.g., the National Environmental Technology Application Corporation (NETAC), the New Jersey Institute of Technology, and the National Center for Manufacturing Sciences, also can provide strong connections between EPA and technology users and producers.

b. LEARN FROM **OTHER** AGENCIES' DIFFUSION **PROGRAMS:** EPA should use other agencies' technology diffusion efforts as potential models for its own. Several agencies, such as the Departments of Defense (DOD), Energy (DOE), Agriculture (DOA), the Food and Drug Administration (FDA), and NASA, have cooperative research and development programs with the private sector and non-profit organizations. They have also established long-term, successful diffusion relationships with the private sector. EPA could valuably "benchmark" with other agencies' technology

diffusion programs to gain from their experiences. This type of learning can also come through other types of formal and informal relationships with other agencies.

c. **BROADEN THE SOURCES** OF INFORMATION **CONTAINED** IN **EPA DIFFUSION PROGRAMS:** The TIE Committee has found that EPA is not taking full advantage of external sources of credible performance data about environmentally beneficial technologies in its diffusion programs. There is a considerable amount of performance data that can be evaluated, and if it is found to be credible, gathered and input into EPA's information management systems. Increased EPA efforts, particularly by ORD, to standardize the protocols and procedures for developing, collecting, and analyzing data to make it more acceptable to EPA and more useful would be beneficial (see Recommendation 5). The TIE Committee commends EPA for establishing a Federal Facilities Testing and Demonstration Program with the Departments of Energy and Defense (in response to an earlier TIE Committee recommendation). This program should expand the availability of credible performance data about environmentally beneficial technologies.

1.5 Change the regulatory system to allow the diffusion system to operate more effectively.

Commentary

The TIE Committee found that the regulation-based environmental technology demand system, with its current uncertainty and unpredictability, poses major barriers to technology innovation and diffusion. Regulators, technology developers and users, investors, and the public will perform their roles better when the regulatory system gives clear, predictable signals regarding objectives, processes, timing, risks, rewards, and uncertainties, and when it creates incentives to develop and apply innovative solutions. As discussed in the TIE Committee's report and recommendations on permitting and compliance policy, regulations and their strong, predictable enforcement "trigger and define the environmental marketplace. The federal signals dominate in the minds of regulated communities and technology developers. . . ." *(Permitting and Compliance Policy: Barriers To U.S. Environmental Technology Innovation,* page 27).

Uncertainty and unpredictability can be reduced, and greater flexibility introduced, in regulations and in permitting and compliance systems without compromising enforceability and assured compliance. The incorporation of these concepts in the environmental management system will encourage technology risk taking and experimentation, providing a constant incentive to innovate and to apply innovative technologies and techniques in the choice of environmental solutions. Both investment in the development of innovative and pollution preventing solutions and the widespread diffusion of environmentally beneficial technologies will thereby be encouraged.

The TIE Committee believes that the following very important steps should be taken in rulemaking, permitting policy, compliance systems, and support for regulatory personnel and non-regulatory partners. These steps suggest how EPA can encourage risk taking and experimentation, and make optimal use of diffusion among the tools available in the environmental management system.

a. INTEGRATE **TECHNOLOGY DIFFUSION** CONCERNS INTO RULEMAKING: Regulations can encourage the diffusion of innovative and pollution preventing technologies and techniques if they are cast in terms that specify performance, rather than technology. These performance standards need to include floors that prescribe regulatory minimums for all polluters, and offer incentives to those who successfully develop and/or apply approaches that exceed requirements (see Recommendation 3). In the long run, multi-media approaches to rulemaking should be developed.

Market-based approaches, such as the emission trading policies being pioneered by EPA, South Coast Air Quality Management District, and others, may prove to be successful in encouraging regulated organizations to exceed minimum standards and in increasing the market for innovative and pollution preventing technologies and techniques. Full cost pricing of environmental services is another market based approach that is aimed at the consumer. In general, by creating win-win situations, market-based approaches are thought to provide encouragement for efficient environmental solutions, innovation, and cooptimization of environmental and productivity results.

Regulations can encourage the diffusion of advanced environmental practices when they are both predictable and flexible. The regulatory process can become more predictable by giving an earlier and clearer goal-setting signal, by making known earlier in the rulewriting process when regulations will become effective, and by having a known schedule for regulatory revisions. The technique of negotiating regulations has increased predictability in some cases. EPA's recent regulatory innovation -- "regulatory clusters," under which the consideration of all pending regulatory actions related to a single industrial category are linked -- will increase predictability by focusing attention on the most important environmental problems.

b . DESIGN DIFFUSION CONCERNS INTO PERMITTING PROGRAMS: The TIE Committee has concluded that current permitting policies are strongly at odds with the initiative and risk taking that are necessary for innovation and pollution prevention. This conclusion pertains both to the permitting of tests and evaluations of these technologies, and to the permitting of proposed use of these technologies for compliance purposes. The TIE Committee report, *Permitting and Compliance Policy: Barriers to U.S. Environmental Technology Innovation,* enumerates and discusses in detail the suggested specific improvements. The TIE Committee reiterates

these recommendations, noting that EPA has made some progress in their implementation. The inflexibility of present federal, state, and local permitting practices also restricts the diffusion of innovative and pollution preventing solutions to environmental problems.

The flexibility to evaluate the capability of promising technologies under safe testing conditions is not adequately provided under current permit and associated administrative processes related to testing and demonstration. The Committee heard several examples where the time and the cost of testing became exaggerated by permit procedures, while the range of conditions tested was limited. One company told the Committee that it maintains a money-losing international operation primarily because of the lack of a reasonable, predictable testing process in the U.S. The inability to test sufficiently to define the useful range of performance limits knowledge about innovative approaches to environmental improvement, and in so doing, restricts the data available for diffusion programs.

The Committee recommends that permitting programs be modified to create specialized permit processes for the testing and demonstration of innovative environmentally beneficial technologies. Permitting processes for tests and demonstrations of innovative technologies should be instituted, expanded, and streamlined, and designed to encourage technology innovation under each of the major "media" statutes. At a minimum, existing statutory provisions should be fully employed to increase opportunities for and flexibility in permitted tests. The Committee recommends coordination of these specialized permitting programs across the environmental media. In addition, a new permitting process for tests and demonstrations might be created under a single authority. These processes should be designed to yield a predictable and timely process for regulatory oversight of testing, one that protects human health and the environment and simultaneously affords flexibility during testing.

The risk associated with early commercial uses for compliance purposes of an innovative technology is greater than risks associated with using known technologies in similar applications. Uncertainty about the capability of a newly-available innovative environmentally beneficial technology is greatest when it is first proposed for use in gaining compliance. At this time, permit writers and the public are unfamiliar with the technology and have a higher level of concern about it than about a well-proven technology. In some cases this concern may be well founded. In other cases it may not be. The record shows that the lack of public confidence and trust stands as a major impediment to the development and use of innovative technologies. This leads to

difficulty, delays, and extra expense associated with reviews of applications for operating permits. These problems are made worse by the need to satisfy, simultaneously and without coordination mechanisms, the requirements of various levels of government in potentially more than one of the environmental media.

These uncertainties combine to create a perception of excess risk that deters investors and technology developers from innovating, which in turn inhibits the introduction of innovative technologies into commercial use. The extra cost, time, and uncertainty associated with application drafting, negotiation of permit terms, and pre-permit data gathering for a proposed use of an innovative technology are so excessive as to discourage innovation and the use of innovative technologies Consulting engineers and prospective users of the innovative technologies thus tend not to recommend or use these technologies.

The TIE Committee recommended that permitting requirements must simultaneously protect human health and the environment, and be sufficiently flexible to encourage regulated facilities to cooptimize for environmental and productivity objectives. Several "characteristics of permitting systems that encourage technology innovation for environmental purposes" were identified by the TIE Committee:

- Flexibility: Permitting processes should authorize the permit writer to incorporate a greater degree of flexibility into each permit for testing or use of an innovative technology. The developer of innovative technology needs sufficient flexibility to define the performance envelope of a new technology. Facility operators should have the flexibility to focus on the result, rather than on the means used to achieve it.

- **Compliance:** People need to be confident that compliance will be required during testing, demonstration, and early commercial use of innovative technologies. Compliance efforts must therefore be consistent, predictable, and systematic. This is vital to allowing markets to develop for technologies, as well as for assuring that testers and users operate responsibly, knowing that enforcement programs will assure compliance. The need to protect human health and the environment during testing and early commercial use is considered paramount by the TIE Committee.

- Enforceability: Permit conditions must be enforceable. Introducing flexibility into permit conditions in the interest of technology innovation cannot be allowed to diminish the enforceability of their terms.

- Predictability: The schedule for processing permit applications for testing and early commercial uses of innovative environmental technologies needs to be consistent and predictable. The lack of predictability reinforces investors' perception of excess risk.

- Clarity: Clarity in permitting processes and in permit conditions are important to the testing and early commercial use of innovative technologies. Clarity is important to technology developers, technology users, regulators, and the public.

- **Confidentiality:** To encourage early discussions with regulators and other interested parties, assurance must be provided that secret information about innovative technologies will be protected. Confidentiality is particularly important when approaches that prevent pollution are involved, because they may involve the key competitive advantages that differentiate and sustain businesses.

The TIE Committee also recommends revitalized waiver authorities, greater flexibility to innovate without triggering facility repermitting, a two-phase permitting process, multi-media coordination and innovation in permitting programs, and top priority status for the review of permit applications involving innovative and pollution prevention technologies and techniques.

The TIE Committee recognizes that there is a pressing need to map the permitting process because how it works *in practice* is unclear both to applicants and to EPA employees who are part of the process. EPA should first develop detailed flow charts describing the permitting process and then seek input from applicants and EPA staff involved on streamlining measures. Appropriate measures should then be implemented.

c. DESIGN DIFFUSION CONCERNS INTO COMPLIANCE

PROGRAMS: The TIE Committee has called for the coordination of permitting and compliance policies to encourage the diffusion of innovative environmentally beneficial technologies.

c (1). THE NEED FOR FIRM AND PREDICTABLE

ENFORCEMENT: The Committee stresses that it is important that industrial, commercial, and other facilities subject to environmental requirements expect routine and rigorous enforcement of permit requirements. Otherwise, most will not purchase and use pollution prevention or innovative technologies. Without the expectation of the need to comply with environmental permit requirements, the market stability and consistency necessary to promote the use of innovative environmental technologies and pollution prevention solutions will be lacking. Consistent and predictable environmental compliance systems provide an incentive for the development and diffusion of both pollution control and pollution prevention technology because they assure that a market for

such technologies will exist (and be of predictable size and character). As is the case under EPA's current policies, penalties must be sufficient to remove any economic benefits that a facility might gain from non-compliance.

Such an approach to enforcement and compliance is fully consistent with the flexibility inherent in providing limited time delays in permit conditions, in the form of waivers for genuine, good-faith efforts, to develop and implement innovative technology. But it is important that the criteria for such waivers be clear and consistent, so that they cannot in any way be used as vehicles for avoiding compliance by facilities which are not genuinely attempting to implement an innovative approach and/or provide an overall, multi-media environmental benefit.

c(2). STATE EXPERIMENTATION WITH PREDICTABLE ENFORCEMENT: EPA can promote the necessary market consistency both through firm and predictable enforcement actions, and through support for and coordination with state and local enforcement efforts. One role which EPA is in an especially strong position to play, and which the Committee believes would be of great value, is to track innovative programs in state and local enforcement agencies. New approaches are being tried to provide consistency and predictability, to test multi-media inspection and permitting of entire facilities, and to stimulate information exchange between programs in different parts of the country. A number of new experiments in enforcement are currently underway in various states and localities, e.g., Minnesota, Massachusetts, and the South Coast Air Quality Management District (in California). EPA should promote the sharing of information on the results of these efforts.

The Committee notes that, with most compliance activities taking place at the state and local levels, it is imperative that EPA, State and local agencies coordinate their enforcement strategies to encourage experimentation, innovation, and wide use of improved solutions.

c(3). FLEXIBILITY IN MEETING **ENVIRONMENTAL COMPLIANCE REQUIREMENTS** IS **ESSENTIAL:** The agency must provide the freedom necessary to make the initial commercial applications of promising innovative pollution control or pollution prevention technologies. The TIE Committee believes strongly, however, that flexibility only works in a context of strong enforcement and meaningful penalties, so that there is no reward for making perfunctory efforts to comply.

Within a strong enforcement context, the Committee believes that flexibility is essential when innovative and pollution prevention technologies and techniques are involved. Approaches which may provide long-term environmental benefits often cannot meet short-term compliance deadlines. In addition, multi-media benefits which might result from innovative environmentally beneficial technology are not addressed by EPA's and states' media-specific programs. Further, the potential for a risk management strategy that is multi-media in scope can only be possible if greater flexibility is instituted in operating guidance and, potentially, statutory language. Flexibility in compliance situations is necessary when innovative and pollution prevention technologies and techniques are involved because they are inherently less certain than conventional technologies. A multi-media approach to compliance would include the development of multi-media inspection teams.

The TIE Committee has recommended that in order to deal with these factors, it is important to have effective programs for environmental waivers and variances (as discussed in subrecommendation 1.5 "b"). These programs should contain provisions for soft landings and for the creative use of compliance penalties, to the extent consistent with legal and regulatory requirements protecting human health and the environment, and for good-faith efforts which fall minimally short of compliance requirements. Flexibility has theoretically been introduced into EPA's enforcement programs in the "Interim Policy on Pollution Prevention and Recycling in Settlement Agreements" and the "Policy on Supplemental Environmental Projects."

These new policies allow the partial abatement of penalties and fines in exchange for the development of pollution prevention plans, along with the implementation of these plans and/or of innovative solutions at violators' facilities. In particular, where the agency and/or a state deems that an attempt to implement an innovative technology has met clearly delineated criteria for a good-faith effort, the punitive portion of penalties might be reduced for some predetermined period. During this period, the facility would be required to come into compliance by improving the performance of innovative technologies, or through the use of more traditional technologies. To the extent that these policies are highlighted in operating policies, training, and data base support, they are potentially important tools for encouraging flexibility through compliance policy.

The Committee commends the EPA Office of Enforcement for its National Enforcement Training Institute (which is diffusing information on pollution prevention), multi-media inspection encouragement to states, training for compliance officers, and penalty assessment reduction programs to encourage pollution prevention, which maintain a floor to insure that economic benefit from non-compliance is fully recovered.

It is important that support of various types be provided to compliance personnel in federal, state, and local agencies. Subrecommendation 1.3 discusses a system of support that is recommended by the TIE Committee.

d. IMPROVE THE SYSTEM OF **SUPPORT** FOR **REGULATORY** PERSONNEL TO ENCOURAGE DIFFUSION: The TIE Committee recognizes that EPA personnel are the most important component of the agency's regulatory programs. In order to encourage diffusion, the agency must provide additional support for staff, which should include: job hierarchy, training, performance evaluation standards and reward systems, data and technical information sources, expansion of the Resident Research Associate Program, and rotational opportunities (within and outside the agency). These recommended actions are covered in detail under subrecommendation 1.3.

Recommendation 2:

Build a stronger partnership with technology diffusion providers and users.

2. 1 Work with the full range of partners to actively promote the widespread diffusion of environmentally beneficial technologies.

2.2 Collect and generate credible information about environmentally beneficial technologies.

2.3 Strengthen and use the full range of technology diffusion mechanisms, and help make them widely available to other diffusers.

2.4 Define, collect, and analyze environmental business data to understand diffusion partners and information users.

2.5 Collect international environmental business and technical data to help U.S. **firms compete domestically and abroad.**

2.6. Support university curriculum development to increase literacy in environmentally beneficial technology.

Commentary

Recommendation 1.4 calls on EPA to strengthen its partner relationship with diffusion users and providers. The "Commentary" section of Recommendation 1.4 describes the critical need to strengthen relationships among the diffusion partners. Recommendation 2 describes how EPA can act to address this need.

EPA's historic role as regulator in a command and control based regulatory system has led to an adversarial, arms-length relationship between the agency, regulated organizations, and providers of environmental products and services. The historic nature of this relationship, and the resulting barriers between the players, makes it difficult for federal, state, and local regulators and regulated organizations to work together, even when it is in their mutual interest. These barriers must be reduced and the possibility enlarged for cooperation if the agency and regulated organizations are to work most effectively and efficiently for environmental improvement.

Diffusion programs play a key role in building this cooperation in that they expand the availability of information helpful to regulated organizations and regulators. Expanded information about environmentally beneficial technologies is essential to an expanded range of choices of solutions for regulated organizations and, therefore, to a more efficient market for environmental solutions. Regulated organizations should be apprised of environmental concerns, and regulatory requirements and procedures. Regulatory personnel should become aware of industrial concerns. Above all, the two groups need to communicate effectively. This will ultimately advance regulators' primary objective of protecting human health and the environment.

Regulators must build a partnership with those who can help them understand the environmental information needs of regulated organizations, those who develop environmentally beneficial technologies, those who develop credible information, and provider industries. EPA should become an active partner in the diffusion of environmentally beneficial technology to ensure the maximum use of improved these technologies within the shortest time frame. A stronger partnership relationship will help reduce the currently existing barriers to the diffusion of environmentally beneficial technologies and increase the availability of such information to those who need it. Clearly, EPA will not be the direct source of all such information, but it should work with the diffusion partners to their mutual advantage. EPA's environmental goals can be furthered by the increased availability of information about a wide range of choices of environmental solutions. The diffusion system is key to increasing choice.

One commendable example of agency-industry partnership building is the *Green Lights* program. In this program, EPA facilitates cooperation between users and providers of efficient lighting technologies. The diffusion efforts in EPA's *Green Lights* program also directly and indirectly help make potential users aware of cost-effective opportunities for lighting improvements. EPA's support for the project gives lighting technology providers extra legitimacy in dealing with potential users. There are now over 200 participants in each of the Green Lights user program and supplier programs.

There are not enough training programs available at the university level that teach tomorrow's managers and technologists how to effectively employ environmentally beneficial technologies. These programs would reach a wide range of individuals and affect the way environmentally beneficial technologies are used in the future. EPA should support these programs, like the one at the University of Michigan.

2.1 Work with the full range of partners to actively promote the widespread diffusion of environmentally beneficial technologies.

Commentary

The TIE Committee found that the need for technology diffusion is simply too large for EPA's limited resources, even if they were redeployed to maximize results. EPA cannot understand all diffusion user needs, nor develop all credible diffusion information, nor provide comprehensive diffusion services to all consumers. EPA cannot rely on its own resources to generate the data to be diffused because its resource base is so small. Moreover, an EPA-dominated diffusion effort would be inefficient even if the resources could be made available because other technology diffusers have unique capabilities that enable them to perform some diffusion roles more effectively than EPA.

In this subrecommendation, the TIE Committee suggests with whom EPA should forge a diffusion partnership, and how cooperative efforts can make the system work most efficiently and effectively. Notwithstanding the need for excellence in the agency's own diffusion activities, the Committee believes that it is essential for EPA to emphasize working with others to gain leverage (see subrecommendation 1.4 for list).

Thus, EPA should build and utilize a strong partnership for the widespread dissemination of environmentally beneficial technology. The TIE Committee believes that if it does, the technology options available to regulated organizations will increase, environmental efficiency gains will be obtained, and the marketplace for environmental products and services will work better.

a .- **LEVERAGE** EPA'S LIMITED DIFFUSION **RESOURCES BY ACTIVELY** SEEKING OUT DIFFUSION PARTNERS AND **PROMOTING** DIFFUSION ACTIVITIES: EPA must seek out as wide a range of diffusion partners as possible. It must work with the diffusion partners to define the various routes by which valuable information gets to those who make environmental decisions and those who influence those decisions. EPA and its diffusion partners must also consider the various motivations of each information receiver to tailor the information

to their individual needs. The pathways for the transfer of information must be considered, and feedback loops installed, so that EPA and its diffusion partners will know if the information is being received and utilized.

It is critical for EPA to recognize at the outset that it will rarely be the logical choice as the lead technology diffuser (for reasons previously explained in subrecommendation 1.4). The actual diffusion, when done by others, can still be greatly assisted by EPA, making EPA a key player in the diffusion process.

The TIE Committee commends the EPA's Office of Air and Radiation for sponsoring the "Clean Air Marketplace Conference." The conference was an open forum for a wide range of environmental stakeholders to learn about environmental issues, including newly available environmental and environmentally beneficial technologies.

b. WORK **WITH** STATE AND LOCAL **GOVERNMENTS AS CHANNELS TO DIFFUSE TECHNOLOGICAL INFORMATION:**

State and local governments have identified diffusion support as a primary component for an improved relationship with and support from EPA. State and local agencies are in an excellent position to be main sources of information for a wide variety of technology users because they are the principal regulatory contact for most regulated organizations. The close relationship of these agencies with local regulated organizations and others interested in environmentally beneficial technology information has been described above. EPA should strengthen its working relationship with the technology diffusion parts of state and local agencies, and should seek to help them diffuse credible environmental information and information services.

c.- WORK **WITH OTHER** MAJOR POTENTIAL **AND CURRENT PROVIDERS** TO DIFFUSE ENVIRONMENTAL INFORMATION:

To be effective, EPA needs to work with other technology diffusers, such as engineering firms, other federal agencies, state and local governments, public-private technology consortia, trade and professional associations and academia. EPA should actively seek out diffusion partners through a variety of channels to ensure the widest range of available potential partnerships. The search for diffusion partners would be led by the EPA's diffusion leader, as explained in subrecommendation 1.1.

EPA must examine the role of each technology diffuser and tailor EPA's support of individual users to simultaneously advance the agency's diffusion (and environmental) goals with those of the diffuser. In a few cases, EPA will be the lead diffuser, but more often it will find itself supporting the activities of its diffusion partner. This support can take many forms, including technical assistance, publication, technical review, promotion, contacts, access to data, and money among the many support tools available. Relationships with many diffusion partners will be new and unique to EPA and may require extreme patience and understanding before EPA's diffusion agenda can be advanced with those partners.

2.2 Collect and generate credible information about environmentally beneficial technologies.

Commentary

Technology users have a variety of biases against using a new technology. In the environmental arena, these biases are difficult to discern from real problems or willful non-compliance. These biases can include: concern about costs, lack of understanding about processes, lacking information about the existence of technology options, cultural attitude against change, and bias against the technology supplier (e.g., "I won't use any technology that was developed in Japan!"). A relatively easy way to overcome resistances expressed by technology users is through the dissemination of credible information.

Credible information about environmentally beneficial technologies can overcome many of the biases expressed by technology users when they consider a new technology for installation. The desired data includes detailed analysis of the cost of performance, process and engineering details, case studies showing how prior users obtained significant benefits from the new technology, and announcements about newly available technologies. By overcoming these biases, diffusion can allow new technologies to gain acceptance. EPA can also supply testing protocols, arrange physical inspections, provide technical reviews, and conduct user polling and case study research to ensure that the information about a new technology will be credible.

The TIE Committee recommends that EPA undertake two critical activities to build a strong diffusion program: (1) understand the pollution problems and environmental technology needs of regulated organizations, and (2) collect credible information about needed technologies and disseminate it through appropriate diffusion mechanisms. The Committee found that EPA is not taking advantage of the full range of sources of understanding about problems and needs in its diffusion programs. Indeed, the agency should do more to increase the credibility of information developed by potential partners (see subrecommendation 5.3). This subrecommendation, 2.2, discusses how EPA can be most successful in collecting and generating credible information, and emphasizes that EPA's most important role is in collecting information, rather than in generating it.

The TIE Committee's perspective about EPA's role in increasing the pool of credible performance data about environmentally beneficial technologies is discussed in detail in Recommendation 5. The Committee believes that the critical focus for EPA should be on collecting credible information developed by others on working with others to expand their generation of credible data. An outstanding example of how EPA accomplish this exists in the new program, conducted cooperatively among EPA, DOD, DOE, and the private sector, to test and evaluate innovative technologies and techniques at DOD and DOE facilities (see subrecommendation 5.1 and 5.2 "h").

a . IDENTIFY AND WORK **WITH THOSE WHO UNDERSTAND INFORMATION** USERS' NEEDS: There are a wide variety of groups that have particularly good "windows" on the technology information needs of regulated organizations and others. It is extremely important for EPA to identify each of these groups and understand its special perspective, form a systematic working relationship with each, and apply the insight gained to the design and information contents of diffusion mechanisms. This information can also be valuable in the ORD research planning process. For illustrative purposes, the sections below discuss some of the groups with special "windows."

a(1). WORK **WITH** STATE AND LOCAL GOVERNMENTS TO **IDENTIFY** INFORMATION USERS' NEEDS: State and local governments are particularly aware of the diffusion needs of regulated organizations and others. This awareness is derived from their direct role in helping solve local pollution problems, their understanding of stakeholder perspectives and information needs, their understanding of permit and compliance status and schedules, and their appreciation of local economic conditions and trends.

a(2). WORK **WITH** CONSULTING ENGINEERS TO **IDENTIFY** INFORMATION USERS' NEEDS: Consulting engineers have a unique position in the diffusion system that can be particularly useful to EPA. Consulting engineers are often called in by regulated organizations as a "third party" to assist in the application of technical solutions to pollution problems. They have great insight into the environmental problems of regulated organizations, and can supplement this insight with their special knowledge about a regulated firm's proprietary manufacturing processes and competitiveness considerations. Consulting engineers often are the outside technical experts supporting in-house design, production, and/or environmental engineering staffs.

As noted in the commentary to Recommendation 1, consulting engineers play a particularly important role in reaching environmentally beneficial technology followers.

EPA should work closely with consulting engineers to identify information user's needs. Their special insight into the technology concerns of regulated organizations make them extremely valuable diffusion partners. The TIE Committee commends the development of a diffusion strategy by EPA's Technology Innovation Office (TIO) that is founded in large part on forming a working relationship with consulting engineers to help them give better advice to their clients. This relationship is a two-way street, with the insights of the consulting engineering community being brought to bear on the diffusion systems EPA is establishing to support faster, lower cost, more effective cleanups. Other areas of EPA could benefit from similar diffusion programs.

a(3). WORK **WITH OTHERS** TO **IDENTIFY** INFORMATION **USERS'** NEEDS: A broad range of other organizations possess insight about the information needs of technology users. These groups include: trade associations, research consortia, state technical assistance programs, other federal agencies, and universities. Research consortia, such as the National Center For Manufacturing Sciences, and the Center for In-Process Analytical Chemistry (CPAC), can be useful for reaching a large number of firms simultaneously.

The TIE Committee commends EPA's diffusion work with the National Environmental Technology Applications Center (NETAC), and believes that this program may be a useful model for future EPA diffusion partnerships. Through a 4-year cooperative agreement that emphasizes a partnership arrangement, EPA/ORD, through its Office of Environmental Engineering and Technology Demonstration (OEETD), and the University of Pittsburgh Trust, created NETAC in 1988 to assist in the commercialization of environmental technologies. Since then, NETAC has worked closely with industry, government, and academia to help guide environmental technologies to the marketplace. Two factors that make NETAC attractive to industry are its ability to engage in confidentiality agreements and its ability to help companies overcome the regulatory and other hurdles of the commercialization process. NETAC offers industry services in the following areas: technical and commercial assessments; technology development assistance; permitting and regulatory assistance; and patent, royalty, and licensing agreements. It is most helpful to small to medium sized businesses that do not have this capability in-house.

b. WORK **WITH OTHERS WHO** GENERATE AND COLLECT **CREDIBLE INFORMATION ABOUT ENVIRONMENTALLY** BENEFICIAL TECHNOLOGIES: Since EPA's environmental technology research resources constitute only a small fraction of the nation's total investment, the agency cannot become a self-sufficient generator of information. Therefore, EPA's principal roles are to help others: (1) improve the quality of data they generate (see subrecommendation 5.3) and (2) collect information on environmentally beneficial technologies. Just as EPA must work to identify users' information needs, it must form partnerships with others who generate and collect the needed information. This will give the agency the technological information it needs to aid the diffusion process. The diffusion partners discussed in subrecommendation 2.1 "c" are all potential sources of information for the diffusion system.

2.3 Strengthen and use the full range of technology diffusion mechanisms, and help make them widely available to other diffusers.

Commentary

As discussed above, a major role for EPA is to improve the quality of data included in diffusion mechanisms (and the quality of the vehicles for diffusion themselves), help make credible technology information available on a timely basis, and promote the use of the full range of available technology diffusion mechanisms, including its own and those of other diffusion partners. A wide variety of technology diffusion mechanisms is available today, including:

- Automated and non-automated technical information systems of various kinds (e.g., design manuals, expert systems, databases, clearinghouses, interactive videos).
- Technical assistance programs (from a variety of sources).
- Training programs based in universities, government, industry, and other places. These programs include seminars, forums, training courses, society meetings, short courses, workshops).
- Educational programs at the graduate and undergraduate level (covered in 2.3e).
- Publications.
- "Hot lines" (phone lines from which people can get quick answers and assistance).
- Trade fairs and conferences.
- Peer to peer matching programs.
- Rotational assignments.
- Licensing programs.
- Libraries.

Subrecommendation 2.1 enumerates the diffusion partners and suggests how EPA could work with them to strengthen and promote the widest possible use of the diffusion mechanisms. This subrecommendation (2.3) discusses what methods are available to accomplish diffusion and outlines suggestions for EPA's relationship with them. All types of credible environmental information should be addressed, including environmental business data (see subrecommendation 2.4) and international environmental business and technical data (see subrecommendation 2.5).

EPA should develop and maintain technology diffusion systems that contain the widest possible variety of credible information about environmentally beneficial technologies, **and** support others as they develop technology diffusion efforts. This support should include helping others disseminate information through all available means. EPA's position of credibility is a strength, but as noted in the Findings, EPA is so limited in the information it collects and in its ability to improve the quality of data produced by others (see subrecommendation 5.3) that its efforts in this area are insufficient and not adequately leveraged. It is similarly not possible for EPA to understand all users' needs for diffusion services, nor can it provide all services.

a. EXPAND EPA'S CURRRENT DIFFUSION MECHANISMS: The Committee believes that the agency's current diffusion programs should be reviewed and revised. The value and impact of ORD's efforts can be increased. ORD's emphases now are publications, information systems, and training-based diffusion programs. The agency also has a number of hot lines. Libraries are available in regional offices. In addition, the agency, and particularly ORD, coordinates and participates in trade fairs. Many of these activities are high in quality. Some of them, however, reach only a small percentage of their intended audiences.

b. NEW AND **IMPROVED DIFFUSION MECHANISMS MUST BE** INCLUDED IN EPA'S PROGRAMS: To reach a larger audience and make a greater impact, the Committee suggests that ORD become less insular and more of a partner, expanding the impact of its programs through leveraging of the efforts of the many other groups who have a diffusion interest and possess diffusion capabilities. ORD should work with its partners to broaden its use of less-emphasized diffusion methods and broaden the informational content of its diffusion data bases. For example, EPA has undertaken a valuable effort, in conjunction with DOD and DOE as part of the Strategic Environmental Research and Development Program (see subrecommendation 5.3 "a") to

expand the reach and impact of federal environmental technology research by coordinating federal approaches to producing and transferring environmental technology related data.

Similar efforts should be made to extend this type of coordination. The Committee has suggested that more attention be paid to a variety of steps to enhance the expertise of EPA personnel, such as rotational assignments, peer-to-peer matching programs, and educational programs (see subrecommendation 1.3). These types of effort would improve the ability of EPA personnel to communicate with their counterparts in industry and elsewhere. As discussed in subrecommendations 5.1 and 5.2 "1", expansion of CRDA's and licensing agreements would provide benefits. Also, as discussed in subrecommendation 3.1, ORD diffusion programs need to particularly support the agency's pollution prevention program. In order to accomplish this, the PPIC clearinghouse needs to be given a higher profile both inside and outside the agency.

2.4 Define, collect, and analyze environmental business data to understand diffusion partners and information users.

Commentary

There are two major types of environmental business data: (1) data documenting the national expenditure for pollution abatement, capital investment, and operating costs, and (2) data documenting the business that provides products and services used for environmental purposes, from consultants to equipment supplies to clean-up services to research laboratories. In short, these two types represent the two sides of environmental transactions: the purchase and the sale.

Taken together, collecting and analyzing the two types of data would add a missing piece necessary for EPA to clearly understand the impacts of current environmental programs and policies on the nation's ability to meet environmental goals, to innovate and adapt, and to remain competitive internationally. This understanding is critical to our ability to predict the impact of future policies. It is also important to have an understanding of the limits of the national economy to reduce pollution and the need for efficiencies in specific sectors of the economy in meeting environmental objectives. It is, after all, the private sector in the U.S. that provides most of the products and services that clean up environmental problems.

EPA has little data characterizing the industries that provide these products and services (e.g., data on the markets for environmental products and services in the U.S. and internationally, data on the financial health of these industries, or data on research and development investment for better technology). Without these data, EPA is restricted to interpreting the national ability to abate pollution in terms of scientific (or technological), statutory, or political limitations.

a. ESTABLISH A BUREAU OF ENVIRONMENTAL STATISTICS: A Bureau of Environmental Statistics should be created. The Bureau would serve to coordinate planning, execution, analysis and diffusion of environmental data, including the necessary collection, analysis, and dissemination of environmental business data described below.

b . DETERMINE HOW ENVIRONMENTAL BUSINESS DATA CAN BE USED EFFECTIVELY FOR POLICY PURPOSES, WHAT DATA ARE NEEDED, AND IN **WHAT** FORM: EPA should organize an effort to work with the potential information sources, analyzers, and users, as well as with its other environmental partners, to determine how environmental business data can best be used by government and industry to select policies that support a successful partnership. This effort should include an evaluation of what kinds of data and analyses are required and how the results will be used. Partners should include the Census Bureau, the National Science Foundation, and other organizations to develop a concept for an ongoing system for environmental data gathering, analysis, and dissemination. The effort should also address a means for sharing data with industry and other interested parties.

Studies should be conducted both domestically and abroad to determine the major users of environmental business data (e.g., federal, state and local government, users and developers of technologies). Surveys and other data collection efforts should be conducted to determine the needs of EPA and other users, to determine what data are available, and to understand how to obtain data that are not available. The above research should be carried out keeping in mind the confidentiality requirements of business.

At a minimum, data should be obtained on: markets, the financial health of the environmental industry, who is doing what R&D, how much is being spent on R&D in various sectors, and the purposes of the R&D. To accomplish this, a breakdown of data among the categories of technologies, e.g., pollution prevention, pollution control, remediation, is required. This information should be generated for the recent past and present time and continue to develop trends. Data should be related to SIC codes to the extent possible.

In an allied effort, an analysis of the role that EPA's R&D funds have played in stimulating and supporting private sector environmental spending **should** be **conducted** for all categories **of** environmentally beneficial **technology. An** effort **should** be **made to**

quantify expenditures (absolute and as a percentage of R&D) on diffusion by EPA and others (e.g., federal agencies, private industry), and to measure of their impact on technology application both domestically and abroad.

c. WORK **WITH OTHERS** TO COLLECT NEEDED DATA: EPA should determine what required information has already been collected and how to access it. EPA should also determine where additional required data are located or can be collected. Moreover, the agency should create and implement a cost-effective plan to collect it, using existing data-gathering sources to the extent possible (e.g., publications, survey organizations). In doing this, EPA should take advantage of all existing sources of information and data-gathering services, including the National Science Foundation and the Bureau of the Census of the Department of Commerce. EPA should consider going beyond these sources as needed to develop its own data gathering resources. This can be done through contracting agencies or universities. On-going reviews and modifications of the data collected, the data collection process, and data dissemination systems should be made.

d. IMPLEMENT A PLAN TO ANALYZE AND **APPLY THE** DATA FOR POLICY MAKING AND TO SUPPORT DIFFUSION PROGRAMS: EPA should develop and implement a plan to analyze environmental business data and to disseminate the data and the results of analyses. Data analysis should include reviews of the business strategies of different firms to determine the relative technology posture of each. Additional analysis tasks will be identified as a result of subrecommendation 2.4

2.5 Collect international environmental business and technical data to help U.S. firms compete domestically and abroad.

Commentary

American business has a strong interest in more active support from EPA and other government agencies (e.g., the Departments of State and Commerce) in the international environmental arena. Government's role has two elements:

- On the one hand, the export of U.S. environmental values and technologies can be a significant factor favoring both an improved world environment and an improved trade balance. Working with others in and out of government to help collect environmental business data about foreign markets is an important and underemphasized role.
- On the other hand, governmental efforts to collect and disseminate information about environmentally beneficial technologies that exist in foreign countries can be helpful to U.S. firms in a competitive world market.

EPA should expand its diffusion activities internationally. The TIE Committee's recommendations in this area are discussed specifically in Recommendation 4.

2.6. Support university curriculum development to increase literacy in environmentally beneficial technology.

EPA should expand its work with universities under the Environmental Education Act of 1990 to expand environmental technology literacy. This recommendation applies to at least business, engineering, scientific, and political science curricula. Curriculum development support should be aimed at expanding the perspective of future technologists and managers so that they understand the cultural and technological implications of: (1) the concepts of cooptimization of productivity and environment (in other words, that productivity and environmental outcome are related), (2) multi-media (or comprehensive) approaches to environmental management, (3) pollution prevention, and (4) alternative ways to set environmental priorities.

The TIE Committee commends the University of Michigan and EPA for the new pollution prevention course development program, and recommends that similar programs be supported by EPA at other leading universities to develop courses at the undergraduate and graduate levels. EPA should also support the efforts of business, science, engineering, and political science schools to develop and teach courses on the management of technology, including government-industry relations. These schools should also be assisted in their efforts to design exercises that improve students' cooperative skills. In addition, public policy departments should be aided in their efforts to educate students on the policy aspects of technology as it relates to the environment and the economy. By reaching students at the early stages of professional development, the agency can ensure a long term awareness of the techniques and benefits of the roles and uses of technology in environmental management by future technologists and managers.

Recommendation 3:

Make diffusion and incentives the emphases of EPA's pollution prevention programs.

3.1 Increase the use of data-based, non-regulatory drivers, including diffusion programs, in EPA's pollution prevention strategy.

3.2 Create pollution prevention incentives, including multi-media approaches, for regulated and non-regulated organizations.

3.3 Diffuse the pollution prevention ethic within EPA, and establish a system of incentives and support for diffusion efforts by EPA personnel.

3.4 Increase resources for EPA's pollution prevention technology research and development.

Commentary

The TIE Committee has long felt that pollution prevention is the preferred approach to environmental improvement. Preventing pollution is preferable to correcting it after it is generated. Further, cooptimizing environmental and productivity objectives can lead to the lowest overall costs of production and pollution reduction, and often lead to competitive advantages.

The Committee is concerned that conventional regulation will become the government's predominant approach to encouraging pollution prevention. It is important to recognize that a continuing commitment for pollution prevention has unique drivers; these are internally maintained and cultural in nature, and in some organizations are related to a commitment to total quality management. Compliance-based environmental management strategies by regulated organizations, on the other hand: (1) are usually motivated most by the threat of penalties associated with non-compliance, (2) do not benefit from incentives to exceed required performance (and are therefore usually merely compliance oriented), and (3) usually do not involve technological risk taking (outside the application of the best available technologies on which the regulatory requirements were based).

Regulated parties that take a pollution prevention approach involve a different in-house team than do organizations taking a compliance-oriented approach. This is because the identification of prevention approaches requires the collaboration of process and product design engineers with environmental staffs. Together, they design products and production processes that waste less, are more efficient, and produce fewer toxic wastes (and less of them). Waste treatment has a greatly reduced role in the pollution prevention approach. Regulated parties that do not look first to pollution prevention focus on the measurement and control of production wastes; they rely primarily on separate environmental staffs.

The TIE Committee found that many regulated organizations and others believe that additional fundamental problems exist that doom a regulation-first pollution prevention strategy by government.

- First, this strategy is considered by many to contain regulations and permitting and compliance policies that are too rigid. Experimentation, innovation, and the use of innovative solutions are all perceived to be bad risks, particularly as a result of inflexibility in permitting and compliance policies and the lack of diffusion support.

- Second, many regulated organizations perceive a pattern that government agencies, including EPA, require the application of best practices used at any one site at many or all sites. Thus, regulatory requirements are seen by many to be ratcheted, capturing every advance, in an *ad hoc* manner that makes the regulatory process even more unpredictable. This practice constitutes a major disincentive to innovation and pollution prevention.

- Third, government staff is criticized by others as lacking technical competence, both in general and especially with respect to production processes and industrial decision making practices. In combination with the second problem, this perception generates great fear in regulated communities about the potential extension of regulatory intervention beyond the end of the pipe into production processes and product design.

It should be noted that the protection of confidential business information will become an even more prominent issue as environmental agencies increase their involvement in pollution prevention. This will be the case in both regulation-based and in diffusion and incentive-based programs. The public disclosure of environmental information already creates a window on businesses that can be used to gain competitive advantage. To the extent that government agencies become more knowledgeable about confidential business information, there will need to be greater care taken that it is not inadvertently revealed.

As discussed in subrecommendation 1.5, the Committee believes that regulations and their strict, predictable enforcement trigger and define the environmental marketplace. While the Committee believes that relying on regulatory approaches to encourage pollution prevention can work against the internally motivated drivers involved in pollution prevention, weak and/or inconsistent enforcement undermines the drivers of pollution prevention in permitted organizations. Federal regulatory and enforcement signals are critical in setting a baseline for the minimum environmental performance that helps level the playing field in the minds of regulated communities and technology developers. To make pollution prevention work, government will also need to make credible information as widely available as possible to increase options and create incentives to go beyond regulatory minimums.

Uncertainty and unpredictability can be reduced, and greater flexibility introduced, in regulations and in permitting and compliance systems without compromising their enforceability and the assurance of compliance. The incorporation of these concepts in the environmental management system will allow greater risk taking and experimentation, providing a constant incentive to innovate and to apply innovative technologies and techniques in the choice of environmental solutions. Both investment in the development of innovative and pollution preventing solutions and the widespread diffusion of environmentally beneficial technologies will thereby be encouraged. Support and collaboration from EPA's research and development program on pollution prevention technologies and techniques can also provide encouragement.

Based on this analysis, the TIE Committee recommends that EPA's pollution prevention programs have a diffusion and an incentive focus. As discussed above, though, the establishment of regulatory minimums and their strict, predictable enforcement are considered critical to create a level playing field of across-the-board improvement for all regulated organizations. An internal system of incentives and support for this focus is needed to ensure that the pollution prevention ethic is understood and practiced by regulatory, permitting, and compliance personnel at the federal, state, and local levels. The subrecommendations below describe how to use data-based, non-regulatory drivers, including diffusion programs and incentive strategies, to foster pollution prevention.

3.1 Increase the use of data-based, non-regulatory drivers, including diffusion programs, in EPA's pollution prevention strategy.

Commentary

Information-based, non-regulatory approaches to pollution prevention are important when seen from the perspective of leaders, followers, and laggards. As discussed in subrecommendation 1.5, leaders are usually the larger, more successful, and more technologically sophisticated regulated organizations. They are also more self-sufficient than other organizations. Followers, the middle ground organizations, are cost-conscious, and are compliance oriented. They usually use technologies that are widespread and commonly available, and use third parties for technology advice and procurement. Laggards are usually the last to use innovative technologies and often comply under duress. They are typically the small firms in an industry and usually lack in-house technological capability. Followers and laggards generally outnumber leaders.

If EPA seeks to encourage pollution prevention successfully, data-based, non-regulatory drivers are particularly important for the followers and the laggards. In each case, a regulatory "push" is seen as needed by the Committee to create a market "pull." But, because followers and laggards seek help from third parties that are credible information sources, the ability of EPA to increase the availability of information through its own and others' diffusion systems and to establish drivers that make people want to improve environmental outcome is important.

This subrecommendation discusses how EPA can succeed with this approach. It should be noted that the need to create support systems for rule writers, permit staffs, and compliance personnel is discussed in subrecommendation 3.2; such support systems are critical if environmental agency personnel are to consider their diffusion role to be important on a daily basis. The role of the diffusion coordinator which is discussed in subrecommendation 1.1, also has great value in promoting pollution prevention.

a. STRENGTHEN THE USE OF DATA-BASED, NON-REGULATORY DRIVERS TO FOSTER WIDESPREAD **ADOPTION** AND **USE** OF **POLLUTION PREVENTION CULTURE AND APPROACHES TO** ENVIRONMENTAL **IMPROVEMENT:** In the past few years, federal, state, and local governments have initiated trials of data-based, non-regulatory drivers of environmental improvement. These include the SARA Section 313 release reporting requirements, facility planning requirements that are now in place in nearly half of the states, the "33 - 50" program, the "Green Lights" program, and expanded training programs and information clearinghouses. The Committee believes that most of these either already have or will prove to have been valuable expansions of traditional government interventions on behalf of the environment.

- Section 313 of SARA (the Superfund Amendments and Reauthorization Act) requires regulated organizations who release certain toxic substances to make an annual report giving an inventory of the amount of each released. This toxic release inventory has proven to be a significant driver of industrial change and pollution prevention-based environmental improvement because it creates accountability through internal data management and public reporting. Since SARA Section 313, regulated organizations can no longer operate on the theory that what cannot be measured can be ignored. Regulated organizations now have a clear knowledge of their waste of certain raw materials, and many are taking steps to prevent some or all of that waste. Thus, SARA 313 encourages pollution prevention through environmental accounting and reporting, rather than through regulation.

- Facility plans are now required in at least fifteen states. This requirement obligates facilities to undertake a series of pollution prevention evaluative steps as a condition of continued operation. Some programs emphasize planning for toxics use reduction, rather than just reductions in generation or release of hazardous wastes or toxics. Whether planning is linked to more extensive pollution prevention permitting requirements or enforcement actions depends on the individual program, but even in those where there is no "hammer," these facility plans are an effective tool to focus facility designers and operators on the toxicity and hazardousness of feedstocks, processes, and waste. The exercise of writing a plan allows these managers to identify opportunities to improve their productivity and environmental performance.

- The 33 - **50 program** encourages voluntary participation by industry to reduce toxic releases and off-site transfers of seventeen specific chemicals from all media. The program has targeted reductions of 33 percent by 1992 and 50 percent by 1995. Begun as a national effort, it is now augmented by several regional programs. The 33 - 50 program is "back stopped" by regulatory carrots and sticks and is

therefore only partially non-regulatory in nature. However, it has produced significant results: over 600 companies have agreed to eliminate 290 million pounds of emissions.

- **Green Lights** is a voluntary EPA program that encourages industry and states to install high efficiency lighting. The agency also works with suppliers under the Green Lights Ally Program to promote the benefits of energy efficient lighting. There are over 200 participants in each of these programs. In this program, EPA has successfully encouraged significant capital investment in environmentally beneficial lighting technology. If this program can help increase the market penetration of high efficiency lighting significantly, environmental contaminants associated with the production of electricity will be proportionately reduced.

b . STRENGTHEN PROGRAMS TO **DIFFUSE** POLLUTION **PREVENTION** R&D RESULTS, OPERATING **EXPERIENCE, AND** ACCOUNTING **METHODS** TO REGULATED ORGANIZATIONS. USE **MECHANISMS SUCH** AS **THE** POLLUTION **PREVENTION** INFORMATION CLEARINGHOUSE (PPIC): For data-based, non-regulatory drivers to successfully foster pollution prevention practices, credible information from a wide variety of sources should be made available. EPA's diffusion functions should have prominence in the Office of Pollution Prevention and Toxics (OPPT), ORD, and the media-specific programs, where pollution prevention opportunities should be an area of emphasis and multi-media information should be provided. EPA regional offices should become more visible and aggressive in support of pollution prevention, and EPA should continue, but upgrade, its work with the states.

Credible information on contacts, costs, techniques, technologies, as well as impacts, should be made available, whether originated by EPA or not. EPA has begun a potentially major program to disseminate pollution prevention information. This system is called the Pollution Prevention Information Clearinghouse (PPIC), which offers users several services at no charge, including a pollution prevention hot line, a 24-hour on-line electronic information system (called PIES), a repository of pollution prevention research data, and an outreach program. The TIE Committee supports PPIC, and believes that it should be given a higher profile both inside and outside the agency. The section of the electronic database dealing with industrial case studies should be showcased. Credible data from a wide number of sources should be added.

An effort should be made to develop standardized accounting procedures to determine true costs and to calculate whether a pollution prevention approach is more cost effective than pollution control and remediation technology options. Costs associated with pollution control are relatively simple to ascertain, based upon the cost of the control and costs associated with the disposal of waste materials. Costs associated with pollution prevention are more difficult to ascertain, since they may involve process changes, feedstock changes, efficiency savings, and savings associated with avoiding the need for additional permits.

The agency should develop specific initiatives for technology diffusion within its program offices that include at least the following three elements: (1) targeting specific technologies and techniques, and potential users, based on the severity of environmental hazards associated with production processes and products, and multi-media opportunities for improvement, (2) providing multi-media information on costs and economic benefits, and (3) linking providers of technology and potential users. The agency should also facilitate the early use of pollution prevention techniques. To this end, R&D performance data (both favorable and unfavorable) on pollution prevention technologies and techniques should be documented and made available to information diffusers and regulated organizations. Additionally, the agency should continue to sponsor conferences and workshops on pollution prevention. The more EPA promotes successful pollution prevention technologies and techniques, the more these technologies will become available, and the more the agency's goal of increased pollution prevention will be advanced.

c. USE OTHER ORGANIZATIONS TO DISSEMINATE INFORMATION

To repeat an earlier point, EPA cannot be the sole or even the major diffuser of environmentally beneficial technologies, especially pollution prevention technologies and techniques. It should share the effort with consulting organizations, professional associations, trade associations, and state and local governments. The users of diffusion services are in many cases reluctant to work closely with regulatory agencies. It is therefore very important that the agency redirect its diffusion efforts to take advantage of partnerships with these other organizations.

State and local governments are today much closer to most regulated organizations, and are in truth the regulating arm of the system. The agency should make a special effort to assure that it works closely with state and local agencies in planning diffusion programs, that it satisfies state and local government needs, and uses the diffusion paths they already have in place.

3.2 Create pollution prevention incentives, including multi-media approaches, for regulated and non-regulated organizations.

Commentary

In moving the environmental management system towards strategies that encourage pollution prevention, the TIE Committee recommends that EPA apply both regulatory and incentive approaches. Together, these two approaches establish a foundation of progress that levels the economic "playing field" for all regulated organizations and reinforces management philosophies and practices that seek continuous improvement in productivity and environmental outcomes. Significantly, the combination of regulations and incentives, supported by diffusion, encourages regulated organizations to gain the greatest economic and environmental results most efficiently. What is needed is for EPA to define, promote, and implement an environmental management system that demonstrates the benefits of pollution prevention.

The Committee therefore recommends that careful consideration be given by EPA and other environmental agencies to instituting in all parts of the regulatory system incentives for the encouragement of pollution prevention. Incentives reward a desired behavior, and can work in conjunction with a regulatory/compliance-based approach. Effective incentives introduce flexibility and foster innovation. As discussed in subrecommendation 3.1, the TIE Committee believes that EPA's pollution prevention strategy should feature data-based, non-regulatory drivers, especially diffusion. The following sections recommend specific steps that EPA should take to incorporate incentives in the environmental management system. The sections on support (see subrecommendation 1.3) and multi-media offer a more complete discussion.

a . EXPAND MULTI-MEDIA APPROACHES TO ENVIRONMENTAL MANAGEMENT: The Committee emphasizes that although EPA is organized on a media-specific basis through legislation and the administration of regulatory programs, pollution prevention would be best supported by a multi-media approach. The multi-media perspective should be built into regulatory, permitting, and compliance programs, as well as diffusion programs.

Several experiments are underway within EPA and state and local authorities to expand multi-media thinking. In regulations, the Office of Water is exploring how to build pollution prevention into the effluent guidelines by considering how to bring to bear the concepts of multi-media, innovation, and flexibility. The agency's efforts to work with three "model states" in an experiment with multi-media, facility-wide (or coordinated) permits that encourage pollution prevention has been discussed earlier. Nearly half of the states have been exploring the idea of a multi-media approach to enforcement, and EPA enforcement policies now are beginning to encourage pollution prevention planning by non-compliers.

b. PROVIDE POLLUTION PREVENTION INCENTIVES, TRAINING, AND **OTHER SUPPORT** TO **REGULATORY PERSONNEL:** Support for the people involved in the regulatory system is also critical. Subrecommendations 3.3 and 1.3 discuss the need for a system of incentives and support for regulatory agency personnel to play an effective role in implementing a pollution prevention approach. Both general technical and pollution prevention training should be provided to EPA's (and other environmental agencies') rulemakers, permit writers, and compliance personnel. Allowing the use of pollution prevention approaches requires regulatory personnel to have a better understanding of industrial processes and other technical areas. Similarly, better technically trained personnel are needed to write regulations and permits and to evaluate compliance options that encourage pollution prevention. Recommendation 5 discusses an increased role for ORD in providing technical support rulemakers, permit writers, and compliance personnel.

c . DESIGN REGULATIONS AND **REGULATORY** PROCESSES TO ENCOURAGE **POLLUTION** PREVENTION: Regulations and regulatory processes should be designed to encourage pollution prevention. Technology-based regulations provide a foundation for environmental improvement, but may not encourage wide choices of approach to compliance, pollution prevention, continuous improvement, or going beyond the minimum. Where possible, regulations should encourage the use of pollution prevention procedures to meet the regulatory requirements.

As discussed in subrecommendation 1.5, there is a need to increase regulatory certainty and predictability to encourage **technology** innovation and diffusion. This same point applies to pollution **prevention.** The **ability** to **anticipate regulatory targets,**

promulgation dates, and compliance dates is critical to all technology developers and regulated organizations that seek improved manufacturing technologies and techniques to meet environmental objectives. The ability to anticipate regulations is equally important to regulated organizations seeking environmental solutions that cooptimize between environmental and productivity objectives. Effective regulatory encouragement of the use of pollution prevention solutions will facilitate the application of innovative and efficient technologies and techniques to environmental problems.

Technology-based standards have an important role to play in encouraging pollution prevention in that they establish a base for environmental improvement. Thus, these standards can create a level playing field for all regulated organizations. A total reliance by regulators on the "best" available technology approach, however, can reduce the incentive to find innovative technology solutions that prevent pollution, both with respect to cost of the same performance and of improved performance. In this approach, technology tends to become frozen with respect to environmental performance.

Moreover, media-specific requirements for industrial categories have been developed independently of regulations for the same industrial categories in other media. In some cases, more important environmental problems associated with that industrial category have gone unaddressed, while regulatory requirements are set for less important problems. EPA's recent regulatory innovation -- "regulatory clusters," under which the consideration of all pending regulatory actions related to a single industrial category are linked -- is a strong step in the right direction.

d . BUILD ENCOURAGEMENT FOR **POLLUTION PREVENTION** IN PERMIT AND COMPLIANCE POLICIES AND PROGRAMS: As discussed in the Commentary and in subrecommendation 1.5, permitting and compliance approaches are widely seen as being strongly at odds with the initiative and innovation that are necessary for pollution prevention. This conclusion pertains both to the permitting of tests and evaluations, and of proposed uses of these technologies and techniques. Because the development and use of pollution preventing approaches is reduced by existing permitting and compliance policies and programs, data is not generated that can be made available through diffusion systems. The TIE Committee reiterates its conclusions and recommendations in its report, *Permitting and Compliance Policy: Barriers to U.S. Environmental Technology Innovation.*

The Committee further recommends that permitting and compliance systems should be modified to increase flexibility. Greater flexibility aimed at encouraging regulated organizations to consider alternatives to best available technology in permit applications is particularly important. In some locations, the use of best available technology has become *a de facto* requirement. Multi-media approaches to permitting and compliance programs and policies are important to the encouragement of facility-wide environmental planning, which in turn provides greater opportunities to discover pollution prevention approaches. Permitting and compliance policies also need to be coordinated across federal, state, and local jurisdictional lines to maximize the effort to favor pollution prevention. An easy step, discussed in subrecommendation 1.5, would be to assign top priority status for the review of permit applications involving innovative and pollution prevention technologies and techniques.

Flexibility with respect to compliance schedules and penalties should also be provided. Flexibility features might include the possibility of compliance waivers and extensions for *bona fide* efforts to comply using pollution prevention and other innovative solutions. In subrecommendation 1.5, the TIE Committee commends the supplementary enforcement policy which encourages a non-complier to institute pollution prevention techniques in lieu of fines or penalties. This policy change is a step in the direction of encouraging pollution prevention options in compliance systems.

In addition, efforts to achieve compliance through pollution prevention techniques should be encouraged through "soft landings." Soft landings can take the form of postponement or reduction of penalties for a specified period to allow the regulated organization, acting in good faith, to make the necessary changes to bring the new equipment and/or procedures into compliance or to use conventional approaches to comply. These modifications will send clear signals to all environmental stakeholders that the agency supports pollution prevention solutions to environmental problems.

Pollution prevention training for permit writers and compliance staff to improve their technical competence and to provide a better understanding of pollution prevention practices is necessary. The Committee notes that EPA has initiated pollution prevention education programs, one at the American Institute of Chemical Engineers and the other at the University of Michigan. Technical support should be provided on a standby basis by ORD and/or others to assist permit writers and compliance staffs involved in reviewing pollution prevention techniques.

3.3 Diffuse the pollution prevention ethic within EPA, and establish a system of incentives and support for diffusion efforts by EPA personnel.

Commentary

As discussed in subrecommendation 1.3, the diffusion of environmentally beneficial technologies is people**dependent.** Whereas diffusion is critical to the success of pollution prevention, so too pollution prevention success depends on the activities of the people of EPA. Many of the actions needed to support this recommendation have already been discussed in detail in subrecommendation 1.3. To gain the full support of EPA's personnel for its pollution prevention diffusion effort, the TIE Committee recommends the following additional actions:

a. CREATE **SUPPORT SYSTEMS** FOR RULE WRITING, **PERMITTING, AND COMPLIANCE PERSONNEL INCLUDING** POLLUTION **PREVENTION** INCENTIVES, TRAINING AND **OTHER** SUPPORT: EPA should provide its personnel with incentives to demonstrate their support of pollution prevention activities. The pollution prevention support activities should be clearly measurable and rewarded in a public and timely manner. Awards should be provided both within and outside the agency to those personnel who surpass agency standards. Pollution prevention should be built into agency personnel evaluations. EPA should consider methods of extending this support to state and local regulatory personnel.

Both general technical and pollution prevention training should be provided to EPA rulemakers, permit writers, and compliance personnel. The nature of pollution prevention procedures requires a better understanding of the industrial processes than pollution control and remediation technologies. Therefore, better technically trained EPA personnel are needed to write regulations and permits and to evaluate compliance options. Such training could be provided by a number of organizations familiar with industrial processes and pollution prevention techniques (e.g., AIChE). In addition, technical support should be provided to EPA rulemakers, permit writers, and compliance personnel from within the

agency (e.g., ORD). The additional training will allow the agency to increase the use of pollution prevention technologies.

b . USE THE DIFFUSION COORDINATOR POSITION TO PROMOTE POLLUTION PREVENTION: As mentioned in subrecommendation 1.1, the diffusion leader would actively promote pollution prevention through his/her diffusion activities. The diffusion leader would steer EPA's gathering and dissemination of credible information about pollution prevention technologies and techniques, inside and outside the agency. In addition, the diffusion leader would be a key supporter of action item "c", which follows.

c . MAKE A STRONG **POLICY** STATEMENT IN **SUPPORT** OF TECHNOLOGY DIFFUSION: The agency has made a strong policy statement favoring pollution prevention. EPA should make a similar statement about the future role of technology diffusion, and use this policy statement to encourage its employees to increase the use of diffusion and incentive approaches that prevent pollution. One step is to ask for suggestions about how to implement pollution prevention procedures agency-wide.

The Diffusion Focus Group recognizes the recent organizational change involving the Pollution Prevention Office. It hopes that this will raise the visibility of pollution prevention within the agency and place greater emphasis on promoting pollution prevention. A policy statement related to technology diffusion should reinforce the pollution prevention focus within EPA's environmental management strategy.

3.4 Increase resources for EPA's pollution prevention technology research and development.

This new area of R&D is an important one for EPA, but EPA's potential for success is dependent on an active partnership with industry and others who will be the ultimate users of the prevention solutions. A partnership is needed at the planning stage, in the conduct of R&D, and in developing and carrying out a diffusion strategy for promising prevention technologies and techniques. The need for these partnerships is so great in this program that EPA should seriously consider requiring that private sector co-funding be obtained for any pollution prevention technology and technique R&D project (see subrecommendations 5.1 and 5.2 "f'). EPA resources to support pollution prevention R&D are also a potentially important incentives to be used in conjunction with other aspects of an overall agency approach to encourage pollution prevention, as suggested elsewhere in Recommendation 3.

Other recommendations made in this report are important to the success of this EPA R&D program. These include the need to (1) increase the technical expertise of EPA staff in areas that are relevant to pollution prevention technologies and techniques, such as the design and operation of manufacturing processes and products (see subrecommendation 1.3), (2) focus on the commercialization end point in this research (see subrecommendation 5.4), (3) protect proprietary information EPA acquires about the processes and operations of its R&D partners (see subrecommendation 1.5 "b"), and (4) require careful plans for the diffusion of R&D results to be developed during the design of research programs and updated throughout the R&D life cycle (see subrecommendation 5.1).

Recommendation 4:

Expand support for the international diffusion of environmental technologies to help meet U.S. environmental and competitiveness objectives.

4.1 Help U.S. firms market environmental technologies in developing countries.

4.2' Help U.S. firms market environmental technologies in developed countries.

4.3 Assist in gathering information on state-of-the-art environmentally beneficial technologies developed abroad.

Commentary

A complete international "technology cooperation" program at EPA requires two complementary parts: (1) support for the diffusion of domestically developed environmental technologies into foreign markets, and (2) making information on innovative technologies developed overseas available to U.S. regulated organizations. The diffusion of domestically developed environmental technologies in new markets will promote domestic investment in these technologies. This will make more environmental technologies available for domestic and international application, and help improve the environment locally and globally. The expanded availability of environmentally beneficial technologies from overseas will give U.S firms a broader range of production and environmentally beneficial technologies to choose from, resulting in increased efficiency and possible competitive advantage.

Technology diffusion depends both on demand (technology pull) and supply conditions (technology push). Attempts to promote environmentally beneficial U.S. technologies overseas may be ineffectual without the strong demand created by effective environmental regulations and strong public awareness.

EPA recently initiated an international diffusion ("technology cooperation") program to diffuse information about environmental technologies to developing nations and Eastern Europe. This pilot program is coordinated with other relevant federal agencies. The increase in EPA's international efforts is a positive step (although since they are only pilots,

they are not sufficient); EPA is doing more than ever to help other countries build institutional systems for the environment. These systems support sustainable economies with strong environmental values, and help create a lasting demand for U.S. environmental products and services where the need for them is acute.

Unfortunately, these pilots highlight a significant gap in EPA's international diffusion effort. There is insufficient aid to the diffusion of U.S. technologies to developed countries, working with the private sector and others. Developed countries represent the majority of the international market for environmental products and services and the homes of the major competition for U.S. environmental technology developers. By ignoring these markets, EPA fails to help U.S. companies make the diffusion connection with the largest international markets. The largest export opportunities for U.S. firms exist in these markets. The TIE Committee believes that it is in the U.S. interest to have strong domestic providers of environmentally beneficial products and services, and to involve and strengthen U.S. firms in these markets.

The TIE Committee has found, however, that smaller and medium sized firms lack the resources to promote their environmental products and services internationally. Most environmental firms with over $100 - 150 million in annual sales appear to have sufficient resources. Firms with sales under $10 million appear to be unlikely to have a commercial technology. Their first priorities are usually commercialization and the pursuit of undeveloped domestic markets. Firms between $10 and $100 - 150 million in annual sales probably have environmental products or services of interest to international markets, but they lack the resources to reach those markets. Aiding them should be a particular focus of the activities recommended herein.

Since EPA is the only federal government agency with the protection of the environment as its highest priority, it should act as a national leader to advance environmental aspects of the international agenda. Other federal agencies have competing goals, so if EPA does not take the leading role, no other agency will. The TIE Committee recognizes, however, that the several agencies -- the Departments of State and Commerce, along with AID, the U.S. Trade Representative, the Export-Import Bank, and the Overseas Private Investment Corporation -- all have leading roles in various aspects of international environmental activities. EPA will need to work closely with these organizations in the technology diffusion arena, on both imports and exports.

4.1 Help U.S. firms market environmental technologies in developing countries.

4.2 Help U.S. firms market environmental technologies in developed countries.

Note to the Reader: *Subrecommendations 4.1 and 4.2 are very similar, and therefore share many of the actions recommended by the TIE Committee. In the interest of brevity the action items for these two subrecommendations are listed together. Their applicability to developing and developed countries where appropriate, and a concluding reference to the appropriate subrecommendation(s) is included with each action item.*

Commentary

EPA's current international diffusion efforts in support of the export of environmental products and services are focused on the developing countries, and very little effort is being expended on the developed country markets. The TIE Committee is very supportive of EPA's new international activism with respect to technology diffusion (in the broadest sense) to developing communities (although large unmet needs associated with severe environmental problems in these communities will not be fully addressed by EPA's new international programs.) The TIE Committee believes, in addition, that the lack of significant effort in the developed countries constitutes a severe deficiency in EPA's international diffusion program (see Recommendation 4).

As discussed in the Commentary for Recommendation 4, the TIE Committee commends EPA for its efforts in the international diffusion of environmental technologies. It believes that the international diffusion of environmental institutions and environmental technologies to developing countries carries with it the potential for large environmental gains. There is a large need associated with sometimes severe environmental problems for which a large number of potential applications of technological solutions exists. Other countries need help building institutional systems that are supportive of a sustainable economy, and possess strong environmental values that could create a lasting demand for environmental products and services.

The TIE Committee recommends that EPA, in conjunction with traditional lead agencies in some of these areas, take the following actions to help build environmental institutions abroad and to support U.S. firms in the marketing of their environmental technologies overseas:

a. PROMOTE ENVIRONMENTAL CONCERNS INTERNATIONALLY: EPA should promote environmental concerns in other countries to help improve environmental quality worldwide and to "level the playing" field for U.S. industry. Both steps will help establish new markets and expand existing ones for U.S. environmental technologies because U.S. environmental requirements are stronger than those in most countries. Moreover, these requirements are associated with environmental technology leadership and industrial competitiveness. EPA has enormous technical knowledge on the fundamentals of running environmental protection programs (monitoring, permitting, risk assessment, source inventorying, etc.) which could strengthen programs in other countries and build the demand for clean technology. The U.S. Environmental Training Institute and the Asia Environmental Partnership are steps in the right direction.

As noted above, EPA's promotion activities should be coordinated with all other federal agencies which have international operations. The expansion and elevation of environmental concerns has the potential to reduce pollution in a large number of areas of the world where environmental problems have a low priority. In several newly democratic countries of Eastern Europe and South America, laws have been passed expanding the public's right to know of environmental risks and decisions. Duly recognizing international differences in political philosophies and systems, EPA should stand ready to cooperate with other countries when asked, and provide technical assistance in the design of regulatory procedures. This would ensure public participation and rights to information. Although, this is a long range effort with an uncertain outcome, it represents the best chance for world environmental improvement. This action item particularly supports subrecommendation 4.1.

b . ENCOURAGE INTERNATIONAL HARMONIZATION OF ENVIRONMENTAL STANDARDS: EPA could simultaneously promote environmental improvement and U.S. firms through the international harmonization of environmental standards. As noted in the Commentary, there is a strong relationship between stringent standards and environmental improvement, and between stringent

standards and technology leadership, both with respect to productivity and environmental outcome. NACEPT's Trade and Environment Committee has developed recommendations on this subject.

EPA recently established the U.S. Environmental Training Institute, which is training foreign technology experts in U.S. environmental management standards, practices, and technologies. EPA should take additional actions to encourage exports, such as by helping trade associations and others promote the use of U.S. measurement standards and technology protocols worldwide. Importantly, EPA's work to encourage exports should complement the work of the private sector; it is in the interest of U.S. firms to work together to establish a unified position on environmental technology specifications and to encourage the harmonization of environmental standards worldwide. These firms should lead the effort to have the U.S. standards formally adopted worldwide. For example, ICOLP (the Industry Cooperative for Ozone Layer Protection), a voluntary industry effort to diffuse technology on CFC (chlorofluorocarbon) substitutes, embodies an effective pioneering approach that has received EPA support and encouragement. EPA could beneficially expand its successful cooperation with ICOLP to allow it to expand its operations internationally. Action item "b" supports subrecommendations 4.1 and 4.2.

c. HELP DEVELOP INFORMATION ON INTERNATIONAL

MARKETS: EPA and other agencies should gather, disseminate, and deploy information on foreign environmental technology developments, markets, and barriers to competition. "Environmental Attaches," similar in function to Agricultural Attaches, are valuable. One of their roles should be to promote the use of U.S. environmental products and services abroad. With the help of other agencies and the private sector, assessments should be conducted to develop data on overseas needs and markets, as well as to evaluate areas where the U.S. is a global technology leader. Information should also be gathered and transmitted on the performance and cost of state-of-the-art environmentally beneficial technology. Information of value would be sent throughout EPA and other environmental agencies and made available to American firms. Increased information availability to U.S. firms will reduce the risks and/or costs associated with their own environmentally beneficial technology investment, thereby encouraging increased investment in this area. This action item supports subrecommendations 4.1.and 4.2.

d. PROVIDE SUPPORT FOR TRADE SHOWS SHOWCASING DOMESTICALLY DEVELOPED ENVIRONMENTAL

TECHNOLOGIES: In the past few years EPA has begun to co-sponsor trade shows for U.S. environmental products and service firms. The TIE Committee commends this action, and believes it should be expanded to help U.S. firms compete internationally. EPA should expand relationships with other government agencies to help promote the sale of U.S. environmental technologies in foreign markets through conferences, trade shows, and other means. These shows should be held as closely as possible to the target market of the conference or trade show. The presence of EPA in all-industry trade shows and conferences will indirectly provide a boost for U.S.-made products and services because of EPA's international credibility. This activity is not to be confused with an endorsement for the use of any individual environmental technologies. This action item supports subrecommendations 4.1 and 4.2.

e . PROVIDE SUPPORT FOR BUSINESS DEVELOPMENT CENTERS:

As noted in the Commentary, small and medium-sized firms lack the resources to independently develop international markets for their environmental products or services. These firms are large enough to develop and commercialize innovative technologies. However, they lack the resources to market them overseas. One goal of these firms, for example, may be to test and demonstrate technologies overseas, in light of severe testing constraints in the U.S. EPA and other federal agencies can help address this problem by supporting the establishment of business development centers.

These centers could provide three general types of assistance for firms that want to develop an international market for their environmental technologies: (1) technology brokerage, (2) project management, and (3) financial services. The technology broker function would include some or all of the following activities: (1) gathering and disseminating information on U.S. environmentally beneficial technologies developed by small and medium firms with promising overseas applications: (2) gathering and disseminating information on overseas market opportunities in the application of environmentally beneficial technologies, and (3) bringing together potential importers and U.S. technology exporters. The project management function could help lower the costs and risks to small and medium sized technology exporters and importers, by (1) providing information and assistance on meeting foreign regulatory, technology licensing and patenting, and investment requirements; (2) facilitating negotiations; (3) providing services

in monitoring license agreements; and (4) assuming or reducing some of the risks of technology transfers through arranging or providing tests, demonstrations, insurance, and performance bonds. The financial services function could help assemble private and public capital for investment projects and joint ventures, including participation from such sources as OPIC and the EXIM Bank. This action item supports subrecommendation 4.2 and 4.1.

f. **ENCOURAGE PERSONAL INTERACTION WITH FOREIGN** TECHNOLOGISTS: EPA should expand opportunities for direct contact between U.S. and foreign environmental stakeholders, including technologists, technology users, and government and business managers. EPA's establishment of a U.S. training institute for foreign environmental managers, technologists, and business operators will help create these opportunities. The institute could promote U.S. environmental perspectives and institutional systems (see action item a), help establish marketing contacts for U.S. environmental product and service vendors (see action item c), and encourage harmonization of environmental standards (see action item h). These contacts will increase the diffusion of technologies across international boundaries and make cooperative activities on an international level more likely. This action item supports subrecommendations 4.1 and 4.2.

g. **HELP U.S.** SELLERS OF **ENVIRONMENTAL TECHNOLOGY DEVELOP** MARKET CONTACTS: EPA has a broad range of contacts that should be made available to U.S. environmental technology vendors. (Additional contact mechanisms are suggested in action items a, b, c, e, f, and g). There should be a central area established for these contacts, so that firms do not have to become engaged in long and costly searches for contact persons. The agency needs to create a foreign contact reporting system to gather contact data, coordinate it within the agency, and make it easily available to outsiders. This action item supports subrecommendations 4.1 and 4.2.

h. OBTAIN ADDITIONAL **EXPORT PROMOTION ASSISTANCE** FROM **OTHER** FEDERAL OFFICES: EPA should also work with the Export-Import Bank and the Overseas Private Investment Corporation to provide additional financial support for U.S. environmental technology firms. These agencies provide loan guarantees, investment insurance, and pre-feasibility studies to U.S. firms to promote U.S. exports. The Export-Import Bank is currently limited to developing countries. However, its mission should be expanded to developed countries, where the largest environmental products and services markets currently exist. The Trade and

Development Program at the Department of State provides market studies and reverse trade missions. This program should be asked by EPA to focus on the markets for environmental technologies and services. The resulting studies should be shared throughout the domestic environmental industry. The diffusion coordinator (mentioned in Recommendation 1) should have responsibilities that include promoting U.S. Environmental exports. This action item supports subrecommendations 4.1 and 4.2.

i. **SUPPORT PROTECTION** OF **INTELLECTUAL RIGHTS** TO **TECHNOLOGY:** With respect to a relatively small number of countries, one problem with U.S. technology exports is protecting them from intellectual theft and re-export by unscrupulous parties. While this is not the major problem in exporting to most developing nations and to nations complying with international agreements on this subject, it can be an impediment to exports to certain areas of the world. EPA should encourage other agencies (such as the U.S. Trade Representative and the Department of Commerce) to provide legal and structural support to discourage piracy of environmental technology overseas. One use of data gathered and made available on foreign environmental technology developments, markets, and barriers to competition is helping to protect U.S. technology firms from patent or license infringements. This action item supports subrecommendations 4.1 and 4.2.

4.3 Assist in gathering information on state-of-the-art environmentally beneficial technologies developed abroad.

Commentary

The U.S. has a tremendous need for new and innovative solutions to environmental problems. EPA has not emphasized in its programs the potential to find better environmental solutions overseas. The developed world, however, has been successful in developing innovative technologies to improve environmental quality and sustain industrial activities. EPA must now increase its efforts to help make technologies developed overseas available to domestic regulated organizations so that they can reduce their waste and emissions, and remain competitive. The task of forming business relationships to bring these environmentally beneficial technologies to the U.S. must remain in the private sector, but it is in the interest of both government and industry to identify and bring to the U.S. technologies that may convey environmental and productivity benefits. The TIE Committee therefore recommends that EPA:

a.- COOPERATE **WITH OTHER** AGENCIES IN **GATHERING** STATE-**OF-THE-ART INFORMATION ABOUT ENVIRONMENTALLY** BENEFICIAL TECHNOLOGIES : As explained in the Commentary for Recommendation 4, other federal agencies have overseas activities that could gather data on EPA's behalf. Both the National Science Foundation and the Agency for International Development have established environmental technology institutes overseas that could help gather information. Since these institutes are funded by the United States, they could provide a ready conduit for information about environmentally beneficial technologies. EPA should expand its international technology information gathering activity to cooperate with federal agencies that possess the necessary resources for cooperation.

b. INCLUDE **CREDIBLE** FOREIGN **ENVIRONMENTALLY** BENEFICIAL TECHNOLOGY INFORMATION IN U.S. INFORMATION SYSTEMS: The data gathered should be made widely available through the diffusion system described in Recommendation 2.3. The data should also be used to guide U.S. governmental R&D efforts and other policies.

Recommendation 5

Increase support for the diffusion of technology provided by EPA's research programs on environmentally beneficial technologies.

5.1 Adopt a leadership position with respect to U.S. environmental technology R&D throughout the research and development life cycle.

5.2 Build and expand efforts to coordinate environmental technology R&D among all participants (including industry, federal agencies, state and local governments, universities, and research consortia).

5.3 Use EPA's R&D program to improve the quality of data generated by others about environmentally beneficial technologies.

5.4 Emphasize the commercialization end point in EPA's and in EPA-led R&D on environmentally beneficial technologies.

Commentary

The TIE Committee has concluded that EPA's research program, centered in the Office of Research and Development (ORD), should become a primary focal point for increased support of the diffusion of technology by EPA. As the Committee previously noted, ORD should become "a more systematic provider of credible information about environmentally beneficial technologies." The Committee believes that if EPA intends to make the diffusion of technology a major element of the environmental management system, it will need to focus and sharpen ORD's activities throughout the technology life cycle. The terms "technology life cycle" and "R&D life cycle" includes R&D planning, the conduct of R&D (including research, development, demonstration, testing, and evaluation), and the dissemination of the results of these activities.

There is no EPA office other than ORD that has a technology-neutral, multi-media perspective about environmental problems and their technological solutions. Thus, while the media-specific regulatory offices build a stimulus for experimentation, innovation, and pollution prevention into regulations, permitting programs, and compliance policies, the

Committee recommends that ORD become the operating spearhead of EPA's diffusion activities, working closely with the high-level diffusion advocate/coordinator (discussed in subrecommendation 1.1).

EPA, whose environmental technology R&D spending comprises a very small percentage of the national total, cannot play a leading role as a direct sponsor of environmental technology R&D. EPA's environmental technology R&D spending ranks at most as the fourth largest among the federal agencies. The Departments of Defense and Energy (DOD and DOE) and the National Aeronautics and Space Administration (NASA) each has a much larger program in this area than EPA. All told, federal environmental technology R&D spending is less than one-fourth of the national total. If spending on the development and demonstration of technologies that prevent pollution are included, the federal percentage declines even further.

This leads the TIE Committee to conclude that EPA must concentrate on two important areas of emphasis in its R&D programs on environmentally beneficial technologies:

- Maximizing the impact of ORD's technology research, in large part by leveraging and influencing the much larger R&D spending of others inside and outside of government through an increased coordination role.

- Sharpening and emphasizing ORD's role in the technology diffusion partnership.

There are very specific steps that EPA and ORD can take to realize the first emphasis. They include modifying the research planning process to incorporate more input from knowledgeable and affected groups outside EPA, leveraging its research spending by increasing cooperation with non-EPA researchers, improving the quality of information about environmentally beneficial technologies generated by others, and emphasizing the commercialization end point in ORD's environmental technology research program. Similarly, there are specific steps EPA and ORD can take to realize the second emphasis, that ORD become a more systematic provider of credible information on environmentally beneficial technologies. Unless the agency takes these or equivalent steps, the Committee believes that EPA will remain a minor "player" in the environmental technology field and will lose a major opportunity to increase its effectiveness as the leader of the environmental management system.

The Committee notes that EPA's lack of understanding about the marketplace and of industry needs and perspectives is particularly acute in the research program (although it is also apparent in other programs). This shortcoming, among other factors, dulls ORD's ability to anticipate market needs and trends, and has hampered that office's ability to maximize the value of its environmental technology research programs. Customer-oriented organizations work with consumers to understand their needs and with suppliers to understand their capabilities. In R&D, projects that contain some degree of "market pull" are more readily successful than those that are driven by "technology push." The planning of these programs must take into account such factors as changing socioeconomic trends -- including shifts in industrial patterns, technologies, consumption, and products -- to anticipate future environmental opportunities and problems. EPA's R&D on environmentally beneficial technologies of all types must be anticipatory, precisely targeted, and leveraged. Its R&D will have to be carefully designed to fill critical technology niches, have a high rate of commercial success in development efforts, and become a primary force in EPA's diffusion programs as a collector, developer, and provider of credible performance information.

The Committee is optimistic that, after getting a slow start, EPA is accelerating its program to establish CRDAs (cooperative R&D agreements with non-governmental organizations) and licensing agreements. These agreements lead to the commercialization of proprietary products emerging from EPA's environmental technology R&D.

The Committee is favorably impressed with the breadth of EPA's environmental technology research program, with the energy and talent of its researchers, and with the value, and in some cases, the uniqueness of its facilities and expertise. The Committee believes that ORD should continue its R&D program in pollution prevention (see Recommendation 3) and in other areas (without commenting on any individual research projects or the overall strategic approach of the individual programs, which it did not review). It is important, however, that when EPA becomes a developer or co-developer of innovative environmental solutions, it emphasize the commercialization end point (see subrecommendation 5.4). Subrecommendations 1.3 and 5.4 describe the value to EPA of building expertise in marketing, economics, and commercialization, and of increasing the overall technical competence of its staff through a variety of means, including rotational assignments in the public and private sectors.

The Committee wishes to reemphasize, however, that EPA should not intend to become a major developer of environmental technologies. Further, the agency has no significant independent role to play in developing industrial technology improvements that are useful to preventing pollution. EPA's primary role will be to foster and to influence the technology development and commercialization efforts of others, and to increase the rate at which better technological solutions gain wide use for environmental improvement. Assuming this role requires ORD leadership. This is the case regardless of ownership or whether technologies prevent, control, remediate, measure, analyze, or process information.

Recommendation 5 focuses on actions that ORD can take throughout the technology life cycle so it can carry out an expanded diffusion role: (1) adopting a leadership position in planning and conducting R&D on environmentally beneficial technologies and in reporting credible results, (2) building and expanding efforts to coordinate R&D on environmentally beneficial technologies with all participants, (3) **enhancing the quality of technology performance data generated by others, and (4) emphasizing the commercialization end point in EPA's and in EPA-led R&D on environmentally beneficial technologies. The recommendation thus describes how EPA can play a more effective role in the diffusion of credible information about environmentally beneficial technologies from all sources.**

5.1 Adopt a leadership position with respect to U.S. environmental technology R&D throughout the research and development life cycle.

5.2 Build and expand efforts to coordinate environmental technology R&D among all participants (including industry, other federal agencies, state and local governments, universities, and research consortia).

Note to the Reader: *Subrecommendations 5.1 and 5.2 are closely related, and therefore share many of the actions recommended by the TIE Committee. In the interest of brevity, actions recommended by the Committee for these two subrecommendations are listed together. These two subrecommendations are closely linked in that they outline actions the Committee believes would optimize EPA's leadership and coordination role throughout the R&D life cycle process so that the agency is better positioned to emphasize its diffusion role. Proposed actions cover all integral components of the R&D life cycle -- the areas of planning, conducting, and coordinating research in the public and private sectors, and disseminating technology information.*

Commentary

If EPA is to emphasize technology diffusion in its environmental management strategy, the TIE Committee believes that it is necessary for the agency to adopt a leadership and coordinating role in R&D on environmentally beneficial technologies. As noted above, EPA is a small-scale player in the world of environmental technology R&D, even within the federal government. There is no federal or national environmental technology leader throughout the R&D life cycle -- in planning and conducting R&D, and in the reporting of results. This anarchic condition operates to the clear detriment of the overall federal effort. It also represents a major missed opportunity for federal leadership in fostering environmental and economic gains from improved technology. Ultimately, EPA's influence in environmental technology R&D must transcend the immediate power of its resources.

The Committee did not seek out examples of duplicative or other wasteful practices that could result from this lack of coordination, and is confident that EPA managers attempt to avoid them. It did hear, however, of results of federal R&D on environmentally beneficial technologies that had limited value because protocols, data quality requirements, and reporting were too different. The Committee also heard examples in which a lack of EPA leadership contributed to a lengthened, more costly technology development processes in both the public and private sectors -- even cases of total failure. While recognizing that Cabinet status would perhaps convey more "clout" to EPA, the Committee notes that EPA has not visibly attempted to take on a leadership role throughout the R&D life cycle for environmentally beneficial technology, to the detriment of the overall federal program.

The TIE Committee is concerned that environmental technology R&D programs at EPA, DOD, DOE, and NASA are not coordinated at the planning stage, and that coordination during research and the reporting of results is sporadic. A critical need exists for EPA's ORD to spearhead an effort within the federal government to coordinate the planning and conduct of environmental technology R&D and the diffusion of R&D results. To accomplish this, EPA must make the most efficient application of its own scant resources toward realizing its most important priorities. EPA's must extend its influence beyond its limited resources with respect to both public and private sector R&D on environmentally beneficial technology. EPA should begin to prepare ORD for its leadership role by redirecting agency resources toward broadening the scope of ORD's planning process.

ORD's planning is focused around the "research committee" process, in which EPA's media regulatory programs and, to a lesser extent, regional offices help ORD plan future research agendas. In addition, for many years the external reviews of the Science Advisory Board have been invaluable in commenting on ORD research strategies from the perspective of scientific excellence. The limits of this planning process give rise to the TIE Committee's concern that ORD's planning has focused on providing support to regulatory offices, without also fostering a technology partnership on behalf of the environment among EPA, the providers and users of environmentally beneficial technologies, and the regulators who oversee the application of these technologies for environmental improvement. Even in working with in-house clients, it is difficult for ORD to draw general and multi-media lessons from the separate planning inputs received from each media regulatory office. Except in a few programs, such as the remediation **technologies** research program, there remains a great need for ORD to put in place feedback loops with

non-EPA sources. Feedback loops should be constructed with consulting engineers, trade associations, state and local environmental authorities, and others who are knowledgeable about the technology needs of polluters, today and in the future, and the productivity and environmental R&D developments of external research programs.

The best opportunity for EPA to establish a leadership and coordination role in the performance of environmental technology R&D is through pursuit of a strategy of partnership and leveraging involving all participants. The Committee will recommend that EPA apply a variety of approaches to accomplish this objective, including: the institution of a co-funding requirement for a portion of its technology research, broadening avenues of cooperative research, expanding its use of the Federal Technology Transfer Act (FTTA), and aiding others' R&D through the establishment of a formal industrial user facility program. Through such mechanisms as increasing co-planning of research with other sponsors of environmentally beneficial technology and expanding its support for research consortia (sponsored by universities, other federal and state agencies, and trade groups or others), EPA can establish a leadership role and gain a significant leveraging effect on its own resources.

The Committee believes that a major purpose of the new approaches discussed above is to enable ORD to become a more systematic provider of credible information about environmentally beneficial technologies. ORD's leadership and coordination roles in planning and conducting R&D will create opportunities to collect and compile credible performance information -- most of it generated outside of EPA's R&D program -- and to work with EPA's diffusion partners to facilitate its dissemination. The Committee believes that ORD's current technology transfer efforts require significant reorientation and redeployment to achieve this goal.

The Committee suggests that ORD's new effort to engage in cooperative research through joint planning, leveraging, cooperating, testing, and evaluating will directly encourage others to generate credible information about environmentally beneficial technologies. The Committee also believes that ORD's activities to help others improve the credibility of data they generate are important to the effort to sort "good" from "bad" information; the standardization of protocols, QA/QC, analysis procedures, analytic procedures, and reporting requirements will ease the effort to distinguish what information is credible. Additionally, the Committee notes that by increasing its understanding about the marketplace, EPA can learn to focus its data sorting efforts, attending earliest to areas of

greatest need, controversy, or opportunity. EPA's greater anticipatory ability will also be very useful here.

In summary, the specific action items recommended below propose how EPA's environmental technology research program should change to (1) maximize its impact on the much larger spending of others and thereby become a more effective partner with the broader research community in the public, private, and non-profit sectors and (2) address how EPA's research program can sharpen its effectiveness in the technology diffusion partnership, becoming the operating spearhead of EPA's diffusion activities:

a . INVOLVE INDUSTRY IN **THE PLANNING** OF **EPA'S** TECHNOLOGY RESEARCH: EPA should create direct mechanisms for meaningful exchange with industry in the planning process for its R&D on environmentally beneficial technologies. Both users and providers of environmentally beneficial technologies should be involved. In the case of users, EPA should establish contact to ascertain what problems they feel most need better technology solutions. In the case of providers, EPA should develop close R&D relations so that reported research results are compatible and, when possible, complementary. Subrecommendation 5.3 discusses the need for EPA to work with others who conduct research to improve the quality of the data about environmentally beneficial technology they generate. This subrecommendation, on involving others in EPA's R&D planning, discusses how EPA can better target its R&D, build relationships with other research organizations, and establish a better basis for a strong EPA role in diffusion activities.

By working more closely with industry and other major technology developers, ORD could also better anticipate future technology and societal trends that affect the environment, along with the industrial and environmental technology fields. The ability to provide a warning about emerging environmental threats associated with socioeconomic and technology trends is essential to managing EPA's technology R&D programs. A closer working relationship with the private sector and others during R&D planning will help in this regard by influencing the research of others and by guiding the direction of EPA's own research.

Involving industry in EPA research planning can be accomplished in a variety of ways, which include establishing joint R&D advisory committees with industry and trade associations, holding R&D planning workshops, directly consulting industry experts, and

establishing more CRDAs. Research planning relationships with university-based and other consortia (e.g., the National Center for Manufacturing Sciences) constitute another important vehicle. Technology user and provider input should be sought for both long-term planning and current year planning. For example, the National Institute of Standards and Technology (NIST) uses an "Assessment Board" of outside advisors (academia, industry and researchers) that meets at least annually to review the programs at each NIST Center.

EPA should also expand and upgrade its Resident Research Associateship Program, making it more attractive to senior-level private sector scientists, who can then provide insight valuable for EPA's R&D planning and create other opportunities for the exchange of professionals, as discussed in subrecommendation 1.4.

b. INCLUDE CONSORTIA AND **OTHERS** IN **EPA RESEARCH** PLANNING: In the past several years, EPA and other federal and state agencies have helped establish research and commercialization consortia, often university-based. Examples of these include the Hazardous Waste Institute at the New Jersey Institute of Technology, and the National Defense Environmental Corporation at Johnstown, Pennsylvania. Although they differ in mode of operation, membership and contributors, and area of technology focus, in general they combine governmental, university, and industrial and other polluters as co-sponsors. Dedicated to finding technical solutions to mutually identified environmental problems, they are natural and neutral places where all parties can come together to identify R&D needs, co-sponsor R&D, and share results by some formula. These centers arc potentially extremely valuable to EPA R&D planning, and EPA should devise a systematic approach to working with them in the planning process.

c. INCREASE **THE** ROLE OF STATE AND LOCAL GOVERNMENTS IN **EPA RESEARCH PLANNING:** EPA should work more closely with state and local agencies in its R&D planning. These agencies today play a leading role in the environmental regulatory system in that the administration of about eighty percent of the regulatory programs are delegated to the states. Accordingly, states write most permits and initiate most compliance actions. Thus, it is the states that have a "hands on" relationship with most regulated parties.

The state and local regulatory role establishes a unique level and character of communication with polluters sited in their areas. As discussed in Recommendation 2,

state and local agencies are most aware of the pollution problems and technology needs of local polluters. They are concerned that cost-effective solutions be found to help the local environment improve and the local economy to thrive. It is therefore in the mutual interest of EPA and state and local agencies to make use of these regulatory networks to identify R&D needs (and to work through them to disseminate needed information on pollution preventing and other environmental technologies).

EPA should take maximum advantage of the STAPPA/ALAPCO network, its own networks, and other information distribution channels to determine needs and supply the needed information. This new intergovernmental coordination of R&D planning will help EPA play the leadership role it should in environmental technology R&D and lead to increased technology diffusion involving the wide variety of stakeholders.

d. REQUIRE DIFFUSION PLANS IN **EPA ENVIRONMENTAL** TECHNOLOGY R&D PLANS: EPA environmental technology R&D plans should explicitly describe what the expected commercialization end point is for each research project, and how the end point will be reached. In addition, EPA's research project plans should be required to state the market objective, the clients (or anticipated users), what the clients' intended uses are, and most importantly, EPA's approach to diffusing the information to clients, and in what form, so it is most useful and accessible. In order for EPA planners to accomplish this, EPA should either develop in-house, or obtain contracted, expertise to understand clients' orientations and needs. This new emphasis on commercialization will increase the value of agency R&D results by focusing R&D resources on market needs and requirements (see subrecommendation 5.4).

e. **TAKE** A **LEADERSHIP** POSITION TO INCREASE **INTERAGENCY** COOPERATION IN **ENVIRONMENTAL TECHNOLOGY** R&D: As discussed in the Commentary, EPA is a small-scale player in the world of environmental technology R&D, even within the federal government. Far larger programs exist at DOD and DOE and at NASA. As noted in the Commentary, there is no federal, or national, environmental technology R&D leader -- in planning, conducting, or reporting results from environmental technology R&D. This anarchic condition operates to the clear detriment of the overall federal effort.

The TIE Committee is concerned that the various federal programs are coordinated only to a limited extent at the planning stage, and that coordination during research and the

reporting of results is sporadic, at best. The Committee believes that EPA will become more effective in its diffusion focus if ORD undertakes to facilitate cooperation among federal agencies' R&D programs on environmental technologies.

The Committee recommends that EPA (ORD) take the leadership position in coordinating federal environmental technology research throughout the R&D life cycle. EPA should spearhead the formation of an "R&D cooperation council" for environmentally beneficial technology that would be made up of representatives of all sponsoring agencies. This council should have as its purpose the steady increase of federal-wide coordination and cooperation throughout the R&D life cycle.

f .- **REQUIRE PRIVATE** SECTOR CO-FUNDING FOR **PART** OF EPA'S TECHNOLOGY R&D: The TIE Committee recommends that, to ensure that its efforts to develop environmental solutions be focused on specific market needs, a portion of ORD's research on environmentally beneficial technology be subject to a requirement for co-funding by the private sector. While it does not suggest a specific percentage of this research for a mandatory co-funding requirement, the Committee suggests that the percentage be significant and that it be reviewed and revised, depending on the success of this strategy. The increased resources recommended for EPA's pollution prevention technology R&D program (see subrecommendation 3.4) are a prime candidate for the co-funding requirement because the need for partnering is so great in carrying out this program successfully.

Mandatory leveraging requirements between government and industry for development, testing, and demonstration should help increase the currently low level of investment in environmental technology because risks will be spread. This requirement will also support the idea that EPA's selection of R&D projects should be market-focused and needs-based. It should be noted that it is important to recognize in any management design that mandates leveraging to distinguish between the risk levels associated with stage of development (i.e., to recognize that early stage technologies are the most risky).

g . EXPAND SUPPORT FOR **THE ENVIRONMENTALLY BENEFICIAL TECHNOLOGY R&D OF OTHER FEDERAL** AGENCIES: As discussed previously in this report, EPA's resources for R&D on all environmentally beneficial technologies stand in a poor fourth place, at best, among the federal agencies. EPA should therefore become directly involved in other agencies'

environmentally beneficial technology R&D throughout the R&D life cycle, even to the point of co-funding research with them.

It is important here to draw attention to the large government programs that support the development of advances in a variety of technologies that have potentially large positive or negative environmental implications. DOE, for example, in addition to having a larger program than EPA's for R&D on environmental control and remediation technologies, has large R&D programs to advance a number of environmentally significant technologies, including clean coal combustion, fuel cells, solar energy, wind energy, electric cars, industrial energy conservation, solar energy, and energy efficient buildings. It is very important for EPA to become involved in and supportive of these R&D programs, both to ensure that environmental problems and opportunities are considered and to promote the use of environmentally beneficial technologies that emerge. The "Green Lights" program, which promotes the use of energy efficient lighting in industrial and commercial buildings, is an example of the environmentally positive diffusion that can result from successful energy technology research. The Committee believes that EPA will be better able to develop programs that are analogous to the Green Lights program if it becomes more involved with these R&D programs. Such involvement will also be important to the success of EPA's expanded R&D program on pollution prevention technologies and techniques (see subrecommendation 3.4).

h. EXPAND EPA'S PROGRAM **WITH THE DEPARTMENTS** OF DEFENSE AND **ENERGY** FOR **THE** TESTING OF **ENVIRONMENTALLY BENEFICIAL TECHNOLOGIES AT** FEDERAL FACILITIES: The TIE Committee commends EPA for establishing an important new program with the Departments of Defense (DOD) and Energy (DOE) to facilitate the testing of environmentally beneficial technologies at federal facilities. Private parties, as well as government researchers, are allowed to conduct cooperative technology trials at some federal sites in this new program. Rigorous, but expedited, regulatory oversight is provided, and cost sharing is encouraged. Using federal sites accelerates the testing of innovative technologies because EPA and states work closely with DOD and DOE to assure compliance with environmental requirements, while encouraging the testing and evaluation of better environmental solutions. Some potential sites have facilities or other conditions that would enhance the safety of testing and evaluation with respect to environmental and public health protection.

The first federal facility has been designated a "testing center" under this program (McClellan Air Force Base in California). EPA hopes to establish others. At a recent meeting, EPA invited major private parties to participate in the program, and several tests and evaluations are already being conducted or negotiated.

This program is a model for several of the recommendations being made in this report. EPA will be working jointly with other federal agencies and the private sector on joint R&D on environmentally beneficial technologies. Leveraging of EPA's resources will be obtained. Results of tests and evaluations will be shared to the greatest extent possible while protecting confidentiality, and credible performance data will be made available through the widest possible set of information management systems.

i. CONTINUE AND EXPAND **COOPERATIVE ENVIRONMENTAL** TECHNOLOGY R&D EFFORTS: Over the past five years, EPA and other federal agencies have used a new mechanism to bring government, academia, and industry together to work on environmental problems in a neutral setting. Among the most successful of these are research consortia, or institutes, that may involve federal or state sponsorship, university or other neutral institutional bases, and participation by public and private sector organizations, including technology developers and industrial polluters. These institutes have great value as a venue for the cooperative support of research on environmentally beneficial technologies.

The TIE Committee supports this approach, and encourages EPA to exploit this mechanism further. Recently, for example, the agency signed a memorandum of understanding (MOU) with the National Center for Manufacturing Sciences (NCMS), a consortium of industrial and government organizations (with Department of Defense support) that is involved in improving U.S. manufacturing technology. This MOU is designed to enable EPA to become involved with the NCMS partners in their R&D on environmentally beneficial technology advances, including pollution controls and manufacturing advances that prevent or reduce the formation of pollution. Because one criterion for NCMS resource support for any project is the partnership and co-support of at least two companies on a common problem, EPA will be assured of joint planning with industry and another federal agency, a commercial end point for the R&D, significant leveraging of any EPA resources supporting the project, and diffusion of the results, subject to the protection of the proprietary interests of the developers.

j. **INSTITUTE AN INDUSTRIAL USER FACILITY PROGRAM:** EPA should also institute an industrial user facility program. Under this program, EPA would invite industrial and other outside organizations to use the agency's unique and specialized facilities (e.g., containment facilities) for testing, evaluation, and/or demonstration. Such a program would provide an excellent opportunity for government/industry and government/university cooperation. This concept creates a routine and systematic process to allow outside organizations to make use (whether fees are charged or not) of EPA's unique and specialized facilities that they otherwise would have to duplicate at potentially great expense and delay. EPA would have to impose reasonable constraints (e.g., time of use, suitability of activity) on the use of its facilities so that government use will be unhindered. If fees are charged, EPA could at least cover the costs of external use, if not gain a small source of revenue.

Opening up agency testing facilities is more than a new source of funds to the agency. It also represents a significant opportunity for the agency to clearly demonstrate its support for private sector technology investment and innovation. The ability to share facilities, and thereby costs, with the private sector is an additional efficiency benefit derived from this recommendation.

This program could be similar to the extensive and successful user facility program described to the Diffusion Focus Group by representatives of the Department of Energy's Oak Ridge National Laboratory (ORNL). Many companies have located their facilities nearby ORNL to take advantage of the user facility program, which has resulted in extensive government-industry, person-to-person technical exchange.

To turn the concept of an industrial user facility program into a reality, EPA will need to develop guidance about at least the following: criteria for selecting facilities to be included in the program, the types of use that are contemplated; the legal mechanisms (e.g., contract, CRDAs) for use agreements with EPA; the required relationship of outside uses, if any, to EPA's mission; the basis for determining fees; and the basis, if any, for abating fees. Further, the lessons learned from other agencies' programs should be examined and a program should be developed to make potential users aware of the availability and capability of EPA's facilities.

EPA should establish a joint EPA/industry team to identify facilities that should be considered for inclusion in the program. Among the possible ORD facilities that could be included in this program are the Edison underground storage tank leak detection test apparatus, the air testing chamber in Research Triangle Park, the test and evaluation facility at the City of Cincinnati's sewage treatment works, the Center Hill stabilization research facility in Cincinnati, and the incineration research facility near Pine Bluff. EPA should also determine the availability and procedures for using other federal agencies' facilities for industrial environmental R&D.

k . ESTABLISH PROCEDURES FOR **THE USE** OF **EPA LABORATORIES** FOR **THE** TESTING **AND EVALUATION** OF **TECHNOLOGIES DEVELOPED OUTSIDE EPA:** There is a great demand for EPA to provide a testing and evaluation function for environmentally beneficial technologies, but not necessarily a technology or approval function. EPA is currently performing both a testing and evaluation role and a certification function (in the test and measurements areas), but is not certifying technologies. The TIE Committee recommends that EPA should establish procedures defining how private parties can obtain testing and evaluation services at ORD's and other EPA laboratories.

The TIE Committee found that there is a strong demand for credible data about the performance of environmentally beneficial technologies and that this demand is not being satisfied. Indeed as discussed earlier, the Committee believes that the deficiency in the availability of credible performance data is a serious problem and that an important role of ORD's research programs is to help satisfy this need, directly and indirectly.

Both providers and users of diffusion services are attracted to ORD's objectivity about technology performance and to its capability to develop its own and to guide the development of others' credible performance data. These people want EPA to publish (and make otherwise available) performance results of technologies under a variety of operating conditions, without giving them a "stamp of approval." This increased availability of credible data would facilitate decision making about use. An expanded testing and evaluation function would benefit U.S. industry and other polluters both domestically and internationally by clarifying and verifying performance claims. ,

1. CONTINUE AND EXPAND ON CURRENT IMPROVEMENTS IN EPA'S IMPLEMENTATION OF THE FEDERAL TECHNOLOGY

TRANSFER ACT OF **1986** (FTTA): The TIE Committee has found that time is a critical element in the development of Cooperative Research and Development Agreements (CRDAs) and licensing agreements. In the environmental field many, though not all, innovations experience a rapid loss of value because they have a short product life cycle.

In light of this conclusion, the TIE Committee is optimistic that, after a slow start, EPA's FTTA performance has improved over the past year. The agency is to be commended for this turnaround. It should take immediate steps, however, to further streamline and expand the use of the CRDA and licensing negotiation processes. EPA should look for efficiency-enhancing measures, and implement them. For example, the Committee found that the disbursement of "reward" dollars to the originators of EPA-licensed technologies has been very slow, sometimes taking up to one year or even more. These disbursements appear to be low in priority, and are not made in a timely manner. Correcting this practice would create a positive incentive for EPA researchers to participate in the FTTA program and, more importantly to EPA's mission, to concern themselves with commercially and therefore environmentally beneficial innovation.

EPA should also launch outreach programs which invite industry to establish CRDAs and licensing agreements. Many institutions (such as universities) offer to license technologies and establish joint projects. EPA should view its licensing and CRDA efforts as a marketing opportunity with other technology providers. The Committee expects the agency's expansion of current FTTA activities to yield increased CRDAs and additional R&D funding from the private sector.

1(1) . CONTINUE AND EXPAND CRDA TRAINING AND PROMOTION ACTIVITIES: EPA should continue to develop and launch its comprehensive, agency-wide, ongoing internal training on the processes and benefits of FTTA CRDAs and licensing. To create a positive motivation for the researchers, laboratories, and the agency to use the FTTA, an understanding of the benefits is particularly important, along with an understanding of how to prevent conflicts of interest and other abuses. EPA has engaged a contractor to develop internal training materials for ORD laboratory personnel on the benefits and mechanisms for CRDAs and licensing agreements. Training should occur at all EPA laboratories (not only at ORD's), with

particular emphasis on laboratories involved with technology research. Training should include success stories and other motivational elements, as well as detailed descriptions on how EPA personnel can participate in FTTA. There should be an effort to compare the EPA's FTTA activities to those of other federal agencies.

Similarly, EPA should launch a campaign to make U.S. firms aware of the possibilities for beneficial cooperation with EPA through CRDAs and licensing agreements. This campaign could take the form of successful efforts made by universities and other federal agencies to attract cooperation with industry. For example, the U.S. Army reports that its FTTA representatives advertise in industry publications, undertake direct mailing campaigns, and participate in conferences and trade fairs.

1(2). MAKE **THE** CRDA **APPROVAL PROCESS** FAST: EPA has made numerous strides to improve the speed of CRDA and license negotiation and approval. For example, a standardized CRDA format which should speed negotiation and approval times was recently introduced. As reported by USDA representatives, the closer the final agreement is to the standard document, the quicker the approval process will be. As discussed above in 5.2 "1" above, however, time is very important to EPA's commercialization partners; it is therefore essential that EPA continue efforts to expedite the process as much
as possible.

The Committee believes that EPA should continue gathering performance data, including numbers of CRDAs signed, licenses issued, fees paid to the agency, numbers of training sessions held, and length of time from first contact to final agreement. Analysis of this data will point out areas for streamlining and improvement. Another valuable step would be to "benchmark" with other agencies' active FTTA programs.

To further speed the CRDA review process, EPA should delegate approval authorities to one office, consistent with the need to prevent conflicts of interest and other abuses. For example, the Grants Administration Division could delegate its authority to the Office of General Counsel, which could then make all rulings, except in extraordinary cases. EPA should also increase the Office of General Counsel staff available for CRDA review.

1(3) . EXPAND THE CAPACITY OF **THE CRDA APPROVAL** SYSTEM: The agency expects the expansion of current FTTA activities to yield increased CRDAs and additional R&D funding from the private sector. If this happens, EPA's current organization of having one Office of Research and Technology Applications (ORTA) for the entire agency could become a bottleneck. EPA should consider establishing ORTAs in major laboratory complexes like Research Triangle Park and Cincinnati. The creation of additional ORTAs will create the capacity needed for this expected increased level of FTTA effort.

m.- **STRENGTHEN** EFFORTS **BY** ORD TO COLLECT **AND REPORT CREDIBLE INFORMATION ABOUT ENVIRONMENTALLY** BENEFICIAL **TECHNOLOGIES:** Previous sections of Recommendation 5 and subrecommendation 2.2 have discussed that wide range of potential EPA R&D partners on environmental technologies. The interests of nearly all of these groups make them willing to engage now with EPA -- whether in co-planning; in cooperatively conducting R&D, testing, and evaluation; or in collecting and reporting credible performance data. Moreover, the motivational structures of the remaining groups make them potential diffusion partners. EPA's Technology Innovation Office in OSWER has recognized this potential and designed programs to take advantage of their mutual interests with EPA. In particular, TIO's diffusion programs target a partnership with the consulting engineers who advise responsible parties on cleanup technology options.

The Committee noted that EPA's efforts to collect and report this information are not well coordinated. This is the case across the agency, throughout the major offices (although with a few notable exceptions, as noted above). It is also the case within ORD, which has a number of disparate data bases, many of which do not have a cross-media perspective. Some data bases contain information that is reported as anecdotal but which actually has broader applicability. Moreover, ORD's data reporting is usually not coordinated with efforts outside EPA, such as those of DOE, DOD, professional associations, state and local networks, consulting engineers, and consortia. The Committee recommends that ORD assign responsibility to a small group to sort out its data collection and reporting programs, discover what is working well and what could use the most improvement, and take action to improve ORD's efforts.

n . INCREASE ORD'S EFFORTS, ,WORKING **WITH EPA'S DIFFUSION PARTNERS, TO DISSEMINATE INFORMATION ABOUT ENVIRONMENTALLY BENEFICIAL TECHNOLOGIES:**

As discussed in subrecommendations 2.3 and 5.3, a major role for EPA is to work with its partners to improve the quality of data included in diffusion mechanisms (or vehicles) and the effectiveness of the vehicles for diffusion themselves. Further, EPA should promote the use of the full range of available technology diffusion mechanisms, including its own and those of other diffusion partners. The wide variety of available technology diffusion mechanisms is listed in subrecommendation 2.3. As the operating spearhead of EPA's technology diffusion programs and the technology neutral, multi-media oriented part of EPA, ORD has a special and key role to play with the diffusion partners inside and outside of EPA to strengthen and broaden U.S. information dissemination patterns.

The Committee believes that ORD's diffusion efforts need to be reviewed and revised to increase their value and impact. Its diffusion program incorporates publications, information systems, and training. These activities are high quality in every respect. Some of them, however, reach only a small percentage of the intended audiences for a variety of reasons. To remedy this, the Committee suggests that ORD needs to become less insular and to develop its partnership capacity. ORD will then be able to expand the impact of its programs through the leverage of the efforts of the many other groups that have a diffusion interest. This implies a planning, as well as a performance, involvement with the diffusion partners, and a more multi-media approach in its diffusion programs. ORD should also work with its partners to broaden its use of less-emphasized diffusion methods and to broaden the informational content of its diffusion data bases (discussed in subrecommendation 5.3 above). As discussed in subrecommendation 3.1, ORD's diffusion programs also need to support the pollution prevention programs of the agency.

Support by EPA for technology diffusion must be extended to other agencies and areas beyond EPA. By encouraging the diffusion of technology across current barriers and into these areas, EPA stands to receive the benefit of the technical resources of all of these players. Very importantly, it is only by taking this approach that EPA can demonstrate its leadership and make diffusion a major part of the environmental management system. As noted throughout this report, the benefits of such information sharing are potentially very large for environmental improvement.

5.3 Use EPA's R&D program to improve the quality of data generated by others about environmentally beneficial technologies.

Commentary

As discussed earlier, because EPA's environmental technology R&D program is so small relative to the total U.S. effort, the agency should adopt a strategy of leveraging its efforts whenever possible. The practice of leveraging is crucial to producing useful performance, cost, and reliability data. Its importance cannot be overstated; every stakeholder group presented itself to the Committee as being limited by the lack of credible information about innovative and pollution preventing solutions. In any technology field related to the environment -- environmental restoration, environmental compliance, hazardous assessment, pollution prevention, etc. -- the usefulness of a technology or technique for a compliance purpose (to potential users, regulatory overseers, and other stakeholders) requires that acceptable data exist describing performance that meets regulatory standards.

Research results that are not generally accepted as credible have little potential to have an impact, to be transferable, to satisfy the needs of potential users, and to thereby meet the needs of those who produce them. The Committee heard a number of cases in which data provided to EPA by federal agencies and private organizations were not of acceptable quality for a variety of reasons. (It has commented in subrecommendation 5.1 and 5.2 about the need for greater coordination among the federal agencies in planning, conducting, and reporting results from environmental technology R&D.) The Committee also heard many times that potential users or financiers of innovative or pollution preventing solutions were deterred by a lack of data they could trust and the inability to obtain approval from federal, state, or local permit writers to use these solutions due to the lack of credible data. Finally, the Committee was informed of many situations in which public concerns about the capability and safety of a proposed solution could not be allayed using available data, because it was not considered credible.

The TIE Committee has concluded that a much greater emphasis should be placed by ORD on helping others improve the quality of the data and information they generate about environmentally beneficial technologies. In this subrecommendation, the Committee emphasizes the value and necessity of this activity to all environmental stakeholders, and suggests some of the steps that will help accomplish it. This conclusion is also reflected in subrecommendations 5.1 and 5.2 (involving others throughout the life cycle of EPA's environmental technology R&D), 5.1 and 5.2 "g" (increasing coordination with other federal agencies), 5.1 and 5.2 "h" (expanding the program for coordinated testing and evaluation of environmentally beneficial technologies at federal facilities), 5.1 and 5.2 "i" (expanding cooperative R&D efforts on environmentally beneficial technologies through consortia and other arrangements), 5.1 and 5.2 "k" (establishing procedures for the testing and evaluation of privately developed technologies by EPA), and 5.1 and 5.2 "1" (expanding cooperative R&D under the FTTA).

There are two additional points that reinforce the need for ORD to place an emphasis on helping others improve the credibility of data they generate. First, the Committee believes that the technology conclusions of industrial scientists are often considered by regulators to be biased, sometimes with good reason. Second, EPA researchers often look upon working with any company as favoritism and hence undesirable. The Committee believes that by engaging with the private sector specifically on the point of improving the credibility of data they produce, EPA will be performing a task that is important to all environmental stakeholders.

a .- USE EPA'S R&D PROGRAM TO INCREASE **THE** STANDARDIZATION OF TEST PROTOCOLS, ANALYSIS PROCEDURES, AND PERFORMANCE DATA **REPORTING:** One key leadership role that EPA must play is in expanding the pool of data produced by R&D on environmentally beneficial technology that have mutually acceptable quality, comparability, and transferability. It is in the interest of the credibility of the agency to seek and gain a consensus about data quality, comparability, and transferability. It is extremely important for EPA to lead an effort to reach agreement about the approaches for planning and conducting technology tests and demonstrations, for gathering and analyzing test data, for producing predictive models, for quality assurance and quality control (QA/QC), for all associated assumptions, and for reporting results. This task could be undertaken by the "R&D cooperation council" for environmentally beneficial technology that would have as

its purpose the steady increase of federal coordination and cooperation throughout the R&D life cycle (see subrecommendation 5.1 and 5.2 "e").

The Committee was informed that EPA plans to initiate an effort to increase the standardization of approaches to R&D, in conjunction with DOD and DOE, as a part of the Strategic Environmental Research and Development Program (SERDP). This important effort, if successful, would immediately expand the reach and impact of federal research on environmental technologies and environmentally beneficial technologies by coordinating federal approaches to producing and transferring environment-related data. The Committee commends its staff and the Office of Cooperative Environmental Management for spearheading this effort. Analogous efforts should be made to extend this coordination to include other public sector R&D partners and the private sector.

b . ESTABLISH PROCEDURES FOR **THE USE** OF **EPA LABORATORIES** FOR **THE** TESTING **AND EVALUATION** OF **TECHNOLOGIES DEVELOPED OUTSIDE EPA: In subrecommendation** 5.1 and 5.2 "k", the TIE Committee points to the need for EPA to provide a testing and evaluation function -- or service -- for environmentally beneficial technologies developed outside EPA, but not necessarily a technology certification or approval function. EPA is currently performing both a testing and evaluation role and a certification function (in the analytic testing and measurements areas), but is not otherwise certifying technologies. An expanded testing and evaluation role would benefit the U.S. by helping technology developers produce better and more credible performance data about their technologies, as well as by helping clarify and verify performance claims. EPA has taken on just this role at the underground storage tank leak detection test center in Edison, N.J., to the great advantage and plaudits of all concerned.

This suggestion relates to the need to leverage EPA's scarce environmental technology R&D resources. It will contribute to realizing the data quality recommendations in this section, which are critical to EPA's ability to play amore successful role in diffusion.

5.4- Emphasize the commercialization end point in EPA's and in EPA-led R&D on environmentally beneficial technologies.

Commentary

As discussed earlier in Recommendation 5, EPA's resources supporting technology innovation represent only a small portion of the total national investment for this purpose. Within the federal government alone, EPA is at best the fourth largest financing source. It is therefore critical for EPA to get a large "bang for the buck" in its R&D programs on environmentally beneficial technologies. One key way to do this throughout the R&D life cycle is to increase EPA's focus on the commercialization end point.

Improving the productivity of its environmental technology R&D is a management issue of significant dimension to EPA. The lack of credible cost of performance characteristics for some environmental technologies, whether EPA has a proprietary interest in them or not, limits the nation's ability to meet its declared environmental objectives.

Accordingly, it is important for the agency to focus its efforts on the commercialization end point when it plays the role of technology developer, when it acts as a tester and evaluator of new technologies, and when it functions as a designer or certifier of test methods and protocols. The following discussion suggests some specific steps that EPA should take to build the commercialization end point into its technology R&D activities:

a. **BUILD THE COMMERCIALIZATION** END **POINT** INTO EPA'S TECHNOLOGY R&D EFFORTS: Commercialization potential should become an explicit consideration in R&D planning, targeting, and funding decisions; in decisions about whether to continue support for individual lines of research; as a factor in designing test protocols; and as a focus of data analysis and reporting. The agency should think of the internal transfer of technology information as a "first use" of the information, and plan for subsequent uses by permitted organizations. EPA should similarly encourage the "R&D cooperation council" for environmentally beneficial technology to focus on the commercialization end point throughout the R&D life cycle (see subrecommendation 5.1 and 5.2 "e").

The trend for EPA to support university-based consortia, combining the efforts of government, industry, and academia to develop and commercialize environmentally beneficial technology, has been an important development over the past several years. This trend should continue, because it encourages cooperation, leveraging, and commercialization potential (see subrecommendations 5.1 and 5.2 "i"). The proposal of a mandatory leveraging requirement for a significant portion of EPA's annual investment in technology-related R&D is made in large part to encourage EPA to focus on high potential technologies (see subrecommendation 5.1 and 5.2 "f"). Further, as discussed in subrecommendation 5.1 and 5.2 "d", EPA's environmental technology R&D plans should explicitly describe what the expected commercialization end point is for each research project, how progress towards the end point will be evaluated, how the end point will be reached, and how the results will be diffused. This new emphasis on commercialization will increase the value of agency R&D results by focusing its R&D resources on market needs and requirements.

b. BUILD EXPERTISE IN ECONOMICS, MARKETING, AND COMMERCIALIZATION: To become a partner with industry, EPA will have to become more knowledgeable about market trends and behavior, and develop the skills necessary to recognize what is commercially relevant. EPA should develop expertise in market planning, product development, and the dynamics of supply and demand in regulated industries. These skills should be widespread and decentralized. All parts of EPA will need to increase their capacity in this area, including the regulatory programs which will find these skills particularly useful in light of their experimentation with incentive based environmental management strategies. Every technology laboratory should have these skills in house, as well as ORD headquarters and the media offices.

This expertise can enhance the agency's R&D efforts on environmentally beneficial technologies throughout the R&D life cycle by making them more able to detect and more responsive to market needs. The expertise is needed to help strengthen EPA's effectiveness as a key player in the diffusion system, as well as in conducting R&D and in writing regulations. It is also important to the efficient allocation of resources for the diffusion of EPA-owned technologies, which requires knowledge of what regulated industries are demanding and what provider industries can do.

Although EPA is not a major developer of environmentally beneficial technologies, the agency should be careful that what it does develop meets real world needs. Careful market-based planning and a strengthened relationship with industry can increase EPA's ability to anticipate these needs in R&D programs. Commercializing promising technologies requires expertise in market analysis and product development. Even if EPA does not actually commercialize and market technologies itself (which is not recommended by the TIE Committee), the ability to engage in systematic, mutual feedback with technology developers and users will enhance and focus all environmentally related technology development, testing and evaluation, data collection, and commercialization efforts, both public and private. This ability will therefore enable EPA to increase the leverage it gains with its research resources.

This new expertise will enhance the agency's environmentally beneficial technology diffusion efforts by making them more responsive to market needs and requirements.

c .- MAXIMIZE **THE USE** OF FTTA TO **ENSURE COMMERCIALIZATION OF EPA'S ENVIRONMENTAL** TECHNOLOGY RESEARCH SUCCESSES: In subrecommendation 5.1 and 5.2 "1", the TIE Committee suggests steps that EPA should take to make greater use of the Federal Technology Transfer Act (F1˙1'A) to enhance the commercialization chances of EPA's environmental technology research successes. These suggestions are important to the realization of the commercialization recommendations in this section.

d . REQUIRE PRIVATE SECTOR CO-FUNDING FOR **PART** OF EPA'S TECHNOLOGY R&D: In subrecommendation 5.2 "f", the TIE Committee points to the necessity of leveraging EPA's scarce environmental technology R&D resources through the requirement of private sector co-funding for part of EPA's program. These suggestions are also important to realizing the commercialization recommendations in this section.

Appendix 1: Presenters and Participants at Diffusion Focus Group Meetings

Presenters' and Participants at the Diffusion Focus Group Meeting, January 15-16, 1991 Research Triangle Park, North Carolina

Mr. John W. Adams	National Environmental Technology Applications Corp.
Mr. Benjamin Bochenek	EPA Office of General Counsel
Mr. William W. Carpenter	Martin Marietta Energy Systems, Inc.
Mr. John Convery	EPA Risk Reduction Engineering Laboratory
Mr. James Hall	U.S.D.A. Agricultural Research Service
Ms. Margaret Kelly	EPA Office of Solid Waste and Emergency Response
Mr. Calvin Lawrence	EPA Center for Environmental Research Information
Mr. Blair Martin	EPA Air and Energy Engineering Research Laboratory
Mr. Michael Mastracci	EPA Office of Environmental Engineering and Technology Demonstration
Mr. Bruce Mattson	National Institute of Standards and Technology
Mr. Scott McMoran	EPA Grants Administration
Mr. Michael Moore	EPA Office of Technology Transfer and Regulatory Support
Mr. Ronald Patterson	EPA Atmospheric Research and Exposure Assessment Laboratory
Ms. Francis Richards	EPA Research Triangle Park Grants
Dr. Jon Soderstrom	Martin Marietta Energy Systems, Inc.

Presenters and Participants at the Diffusion Focus Group Meeting, July 29-30, 1991, Cincinnati, Ohio

Mr. John W. Adams	National Environmental Technology Applications Corp.
Mr. Frank Altmayer	Scienfic Control Laboratories, Inc.
Mr. Jay Benforado	EPA Office of Technology Transfer and Regulatory Support
Mr. William W. Carpenter	Martin Marietta Energy Systems, Inc.
Ms. Patricia Cook	EPA Office of Research and Development
Mr. William Copa	Zimpro-Passavant
Dr. Robert Detroy	Allied Signal Corporation
Mr. Charles (Ed) Gross	EPA Office of Water
Ms. Katherine Hain	Department of Energy Technology Development Office
Mr. Richard Kibler	Department of Defense
Mr. Calvin Lawrence	EPA Center for Environmental Research Information
Mr. Michael Moore	EPA Office of Technology Transfer and Regulatory Support
Dr. Peter Preuss	EPA Office of Technology Transfer and Regulatory Support
Mr. John Schofield	IT Corporation
Mr. Joel Szabat	EPA Committee on Technology Cooperation
Mr. Thomas Zosel	3M Corporation

Presenters and Participants at the Diffusion Focus Group Meeting, October 22-23, 1991, Washington, D.C.

Mr. John W. Adams	National Environmental Technology Applications Corp.
Mr. John Cross	EPA Office of Pollution Prevention

Presenters and Participants at the Diffusion Focus Group Meeting, October 22-23, 1991, Washington, D.C. (continued)

Dr. Samuel Doctors	California State University, Hayward
Mr. Robert Finnigan	Finnigan Corporations
Dr. Bruce Guile	National Academy of Engineering
Mr. Brent M. Haddad	Technology Transfer Consultant
Mr. Alan Hecht	EPA Office of International Activities
Mr. Michael Mastracci	EPA Office of Environmental Engineering and Technology Demonstration
Mr. Richard Marczewski	General Motors Advanced Engineering Staff
Ms. Jan McAlpine	EPA Office of Cooperative Environmental Management
Mr. Rodney Sobin	World Resources Institute
Mr. Donald Walukas	National Center for Manufacturing Sciences, Inc.

Presenters and Participants at the Diffusion Focus Group Meeting, January 22-23, 1992, Washington, D.C.

Mr. Keith Betton	EPA Office of General Counsel
Mr. John Cross	EPA Office of Pollution Prevention
Mr. Alan Ehrlich	EPA Office of General Counsel
Mr. Daniel Esty	EPA Office of Policy Planning and Evaluation
Mr. Robert Finnigan	Finnigan Corporations
Mr. Tom Gorman	EPA Office of General Counsel
Mr. Peter Green	Department of Energy
Mr. Brent M. Haddad	Technology Transfer Consultant
Mr. Mark Joyce	EPA Office of Air and Radiation
Mr. Steve Lingle	EPA Office of Research and Development
Dr. Alan Lloyd	South Coast Air Quality Management District
Mr. Jim Lund	EPA Office of Water
Mr. Michael Mastracci	EPA Office of Environmental Engineering and Technology Demonstration
Ms. Emma McNamara	EPA Office of Administration and Resources Management
Mr. David Osterman	EPA Office of Administration and Resources Management
Ms. Kathy Porter	Kerr & Associates
Mr. Alex Ross	EPA Office of Environmental Engineering and Technology Demonstration
Mr. Ronald Slotkin	EPA Office of Technology Transfer and Regulatory Support
Mr. Joel Szabat	EPA Committee on Technology Cooperation

APPENDIX 2: Recommendation 4 from the TIE Committee's 1991 Report & Recommendations, "Permitting and Compliance Policy: Barriers to U.S. Environmental Technology Innovation"

Recommendation 4:

Support regulators and other involved communities to maximize the effectiveness of improvements recommended in permitting and compliance systems.

4.1 **Institute a system of incentives, training, and support to retain experienced state and federal permit writers who participate in permitting decisions involving the testing or early commercial use of innovative environmental technologies.**

4.2 **Institute a system of incentives, training, and support to retain experienced state and federal inspectors and compliance staff who participate in decisions involving innovative environmental technologies.**

4.3 **Provide support to prospective innovative technology permittees (including technology developers and technology users).**

4.4 **Emphasize the role of EPA's Office of Research and Development (ORD) as consultant to federal, state, and local government permit writers and inspectors to provide information on innovative technologies for environmental purposes.**

4.5 **Institute systems to provide the public with information and support related to the testing and use of innovative environmental technology.**

4 . 1 Institute a system of incentives, training, and support to retain experienced state and federal permit writers who participate in permitting decisions involving the testing or early commercial use of innovative environmental technologies.

Commentary

The TIE Committee recommends that a systematic program be instituted for the purpose of retaining experienced permit writers. and to encourage. support. reward. and train those permit writers to be better prepared. and more favorably disposed. to processing permits involving testing and/or introduction of innovative technology. Both increased continuity and specialized support and training are critical to the success of permitting systems to encourage testing and implementation of new technologies because, at present, there is little or no incentive for permit writers (who often have limited experience) to take the risk of recommending or authorizing testing or use of a new technology.

a. **THE** IMPORTANCE OF **RETAINING PERMIT** WRITERS: *The TIE Committee believes that improving the continuity of permit writers would be an important step towards ensuring the timely and consistent permitting of innovative environmental technologies.* The Committee heard evidence of cases where, in attempting to permit a new technology, technology developers had to deal with a seemingly constant stream of new permit writers. All of the hard-won verbal agreements that were reached with the old permit writer were nullified when the new permit writer came on board. Other developers presented case studies of how the rapid turnover rate of permit writers had protracted the permitting of a new technology to such a degree that the expected market niche disappeared by the time the technology finally received permits. Regulatory agencies indicated that the turnover rate problem damaged their ability to adequately consider permit applications on a timely basis, both in terms of staff and their knowledge base.

b . ENCOURAGING **FEDERAL** AND **STATE PERMIT** WRITERS: Comments heard during the Fact Finding meetings indicated, however, beyond the issue of experience, that permit writers are often discouraged, by unwritten policy, by the lack of guidance, or by other factors, from writing permits for testing and/or implementation of new technology. The results were often counterproductive to the development and use of innovative technology. For example, in those cases where RCRA permits were

entertained for testing new technology, the regulators pushed for full permitting -- e.g., for RCRA technology testing, essentially a complete Part B -- that limited testers' ability to define performance envelopes, restricting the value of testing and increasing its cost. *This situation must* ***be reversed,*** *so that permit writers are* ***encouraged*** *to and rewarded for* ***issuing permits*** *for safe testing of innovative technology for environmental* ***purposes.***

It ***should be*** *noted that changes* ***at*** *the federal level will have little* ***actual*** *impact if there are not corresponding changes in state programs.* State laws and regulations for the various programs are generally modelled on those of EPA -- but there can be significant differences, such as California's "permit by rule" for mobile treatment units for treating non-RCRA wastes. Permit writers in state programs will also have to be brought into the incentives "loop." State and local participation in the permit team strategy outlined in subrecommendation 2.3 should be encouraged.

c . **INCENTIVES SUPPORTING PERMIT** WRITERS: As one possible model of an incentives program aimed at encouraging, supporting, and training permit writers at federal, state, and local agencies, *the TIE Committee recommends the following:*

1.- *Establish a hierarchy or job ladder for permit writers and incorporate criteria in performance evaluations along that promotional ladder to address the permit writers' development of expertise (either single media, cross-media, or technology-specific).* The ladder might include the following elements:

Single-media permit writers. Single media permit writers should be networked to facilitate information sharing within regions. These media representatives could serve as team members on the coordinated permit review teams described in subrecommendation 2.3.

National expert single-media permit writers. A national expert permit writer program could be established within each of the single media areas as a next step in the ladder. National single-media experts could serve as a nationwide information (both technical and regulatory) resource locus in dealing with innovative technologies. They would also provide institutional memory in cases where local conditions favor high turnover rates. (State experts might also be eligible for this program.)

Cross-media permitting experts within each region,. A rung in the ladder could be for permit writers who obtain expertise across the media. In designing the cross-media permit expert role, much use could be made of the experience gained in current EPA and state (e.g., Massachusetts, New Jersey) cross-media inspection and integrated permitting pilot projects. Team leaders for the coordinated permit reviews discussed in subrecommendation 2.3 should be drawn from this pool.

- Regional liaison permit writers. Regional liaison permit writers would serve as coordinators, facilitating access to regional and state single-media and cross-media expertise.

2. *Provide training and model templates, based on the prior testing of innovative technologies, to all permit writers.* A concise, yet comprehensive, training program should explain the permit writers' role in fostering the successful use of innovative technologies for environmental purposes and on information sources and networks for identifying technical information. The training program should also educate the regulators on how industry innovation works, and on the role of ORD and technology groups within other federal agencies, with the goal of improving the permit writers potential networking base for technical information.

3. *Strengthen ORD's role as identifier and conveyer of technical information to permit writers.* Establish a centralized clearinghouse where permit writers can easily access needed information. ORD should help permit writers sift through the technical details of newly proposed technologies, explaining how, and if, the innovation will be beneficial, and under what conditions, and help the permit writer frame permit conditions for unfamiliar technologies. ORD might also be the Agency lead for the ombudsman function (see subrecommendations 1.3 and 4.4).

4. *Establish performance evaluation standards and reward systems that promote greater support and consideration from permit writers for innovative pollution prevention and pollution control technologies.* The first step, as mentioned elsewhere throughout this report, would be develop a clear, strong policy statement about EPA's role in promoting technology innovation. Other steps could include modifying performance standards and credits ("bean counting") to reflect the degree to which a permit writer works to achieve the goals set forth in the technology innovation policy statement. The TIE Committee recognizes that extra time and risk are involved in processing permit applications for innovative alternatives, and for the risk associated with supporting approaches which involve the uncertainties in changes in standard technologies and the uncertainties in performance projections for innovative solutions. Financial incentives should also be considered, as well as recognition and merit awards.

5. *Improve data and technical information sources to aid permit writers in their job of reviewing permit applications involving innovative technologies, perhaps through an expansion of the "ATTIC" data base, which now contains information about innovative remediation technologies.* EPA should collect the information from federal, state, and other sources and assemble the data and information in on-line databases for PC/Mac users. Information should be collected and assembled in information retrieval systems easily accessible to all permit writers. Information should include the following:

   - Media affected by the technology
   - Emission/effluent/hazardous waste reductions achieved by the technology
   - Process descriptions
   - Location and results of tests, demonstrations, and early commercial uses
   - Level of cleanup (remedial technologies) achieved
   - Contact persons, including owner or licensee, plus ORD technical experts
   - Existence of patent covering the technology and the availability of licenses
   - Key words; similar technologies; terms of art
   - Known limitations
   - Potential site incompatibilities.

4.2 Institute a system of incentives, training, and support to retain experienced state and federal inspectors and compliance staff who participate in decisions involving innovative environmental technologies.

Commentary

The TIE Committee recognizes that the need to both maintain continuity of personnel and promote a more positive approach to innovative environmental technology applies to inspectors and compliance staff, as well as to permit writers. As *a result. the TIE Committee recommends that measures to train and support compliance and inspection personnel be undertaken by EPA and the states.*

a . **THE** SUPPORT ROLE OF FEDERAL AND STATE **COMPLIANCE** POLICIES: *If EPA and state agency compliance staffs and their respective compliance policies are not supportive of measures to promote innovation in pollution prevention or pollution control technology, compliance requirements will remain a barrier to efforts to innovate.* The Committee therefore recommends that EPA open discussions with state enforcement officials on how best to promote such changes. Some state programs (e.g., New Jersey and Massachusetts) are already in the first stages of implementing compliance programs to promote multi-media pollution prevention. *The Committee also recommends that EPA provide support for evaluation, implementation and expansion of existing state efforts, and for communication between the states on the success of alternative approaches.* Coordination with state efforts to implement HSWA land disposal phaseout provisions consistent with their SARA corrective action plan responsibilities are of particular importance from a technological perspective.

b . THE NEED TO REFORM REWARD PRACTICES: Standard bean-counting approaches to measuring the performance of inspection and enforcement officials are a disincentive for these officials to support innovative responses to compliance requirements. Few compliance officials have experience with multi-media approaches to evaluating facility compliance options. In addition, working with facilities with the opportunity to develop or implement innovative alternatives presents potential significant risks and few potential rewards for the compliance official. Reviewing an innovative approach, or working with a facility to develop such an approach, is almost certain to require more time than imposing a standard compliance requirement and may involve

increased scrutiny by managers. Evaluation of an innovative approach is intrinsically more difficult, since operational capabilities and parameters are generally more uncertain than standard alternatives, whether for innovative manufacturing evolutions or innovative pollution control methods. This poses the risk that the compliance official will be held responsible for blessing an alternative that fails.

c. **ELEMENTS OF A SUPPPORT SYSTEM FOR COMPLIANCE PERSONNEL:** ***If compliance officials are to be willing to undertake the greater difficulties posed by innovative alternatives, there must be clear*** *policy direction, support, and rewards for their efforts. Three mutually reinforcing elements are key:*

1. *First and foremost, EPA or the relevant state agency must have articulated a compliance policy which clearly establishes promotion of environmentally beneficial innovation as a major goal.* Once such a clear policy is established, many of the necessary tools are available. For example, the Agency could more effectively implement the innovation waiver tools which it has largely neglected in the past. The TIE Committee reiterates its January 1990 recommendation (1.4.h) that EPA expand the use of existing statutory provisions which trade compliance delays for improvements in technology (e.g., CWA Sections 301(k) and 301(n); CAA Sections 111(j) and 113(d)). The Office of Water has plans to draft revised guidance for the Section 301(k) waiver process, but in most cases the authorities carry little practical guidance and are seldom used. (See a further discussion of waivers under subrecommendations 2.1 and 3.3.) The *Enforcement in the 1990s Project* describes several innovative enforcement approaches that the Committee believes are compatible with the greater risk-taking necessary to encourage technological innovation.

2. *Second, the performance evaluation and reward system must be amended to provide special credit for the compliance official who takes the risk of seriously evaluating and encouraging such approaches.*

3. *Third, in order to promote attention by compliance officials to innovative technology alternatives and to promote the retention of inspectors and compliance staff knowledgeable of and favorably disposed to considering the use of innovative technologies, the TIE Committee recommends a parallel incentives program to that outlined above for permit' writers.* The major headings below identify the basic program content (see subrecommendation 4.1 for details):

- *Establish a hierarchy or job ladder for compliance staffs and incorporate criteria in performance evaluations along that promotional ladder to address the staffs' development of expertise (either single media, cross-media, or technology-specific).*

- *Provide training and model templates, based on the prior testing of innovative technologies, to all compliance personnel.* Such training should include explanation of the role of inspectors and compliance staff in promoting technology innovation for environmental purposes.

- *Strengthen ORD's role as identifier and conveyer of technical information to compliance personnel.*

- *Improve data and technical information sources to aid compliance personnel in compliance situations involving innovative technologies.*

4.3- Provide support to prospective innovative technology permittees (including technology developers and technology users).

Commentary

The TIE Committee has previously recommended (January 1990, recommendations 1.2 and 1.7) that the Agency should build into its technology innovation promotion strategies comprehensive approaches to inform regulated parties, particularly small and medium-sized businesses, about (a) applicable environmental requirements; (b) the advantages of developing and using innovative technologies to meet these requirements; and (c) EPA's specific programs to foster innovative problem solving. The current recommendation builds on the January 1990 recommendations and provides some concrete details on possible informational approaches, some of which are being used today and all of which can be put to greater use in cost-effective fashion. Many of the support functions for prospective permittees which follow might be carried out by the "technology advocate" (see 1.3 and 4.4). These functions include the following:

1.- Outreach seminars on innovative technology permit and compliance policies and processes.

2.- Information dissemination programs related to innovative technologies. These can involve coordinated efforts by EPA offices (especially ORD [see January 1990 recommendation 1.5.b]), industry associations, state agencies, economic development authorities, local authorities, professional associations, and others. Opportunities to assist executive branch organizations and non-governmental organizations inform their memberships have particular potential. Examples of potential dissemination mechanisms are:

   - Newsletters
   - Press releases
   - Reports
   - Seminars.

3. Access to the on-line database to be developed under subrecommendation 4.1 (item 9). Additional information relevant to technology users and potential permittees might be added to the database, including permit requirements used in similar technologies and other permit application informational needs. Technical

information might also be added to the RCRA/CERCLA "Hotline." Similar mechanisms could also be found for water and air. Consideration should be given to enlisting the cooperation of a private service (e.g., DIALOG) to ensure wide access to the information. Among the advantages of an environmental technology clearinghouse are that it would help innovators track the state of the art and it would promote selection of appropriate technologies and invention of new ones.

4.- Utilization of ORD personnel for technical assistance and subsidized testing. This would coincide with establishing an ombudsman function, as described in subrecommendations 1.3. and 4.4. Subsidized testing should be increased, although note should be taken of the January 1990 recommendation 1.5.a, which calls for expanding testing protocols in the SITE program and analogous testing efforts to define performance envelopes.

5.- Assure that the confidentiality of applicants' trade secrets is maintained. The TIE Committee notes that the statutory language for trade secret protection varies from statute to statue in terms of the procedure for asserting trade secrets. This can create confusion among technology owners, licensees, and users, and complicates the role of permit writers and compliance personnel involved in the consideration of tests and uses of innovative technologies. Trade secret protection information and procedures should be readily available, and to the extent that there are substantive differences among the environmental media statutes, these should be normalized.

4.4- Emphasize the role of EPA's Office of Research and Development (ORD) as consultant to federal, state, and local government permit writers and inspectors to provide information on innovative technologies for environmental purposes.

Commentary

The TIE Committee reiterates its previous recommendation (January 1990 TIE Recommendation 1.5.b) that the Agency should investigate ways to strengthen ORD's roles in fostering technology innovation as (a) identifier and conveyer, with the regulatory offices, of information about present and future technology gaps; and (b) a non-regulatory forum that works closely with technology user communities, as in the SITE program, to evaluate and guide technology development efforts. An analogous role for ORD within the federal government, the need for which has become more prominent, is to maximize the flow of environmental technical information among all parts of the government, including the Departments of Energy and Defense and the national laboratories.

a. "TECHNOLOGY ADVOCATE": *Subrecommendation 1.3 calls for **EPA** to consider establishing a "technology advocate."* Its function would provide a single point of contact for technology developers, prospective users of innovative technology, permit writers and compliance officers at all levels of government, and the public so that people can find out information about:

1.- The policies relating to technology innovation

2.- Permitting processes relevant to proposed tests, demonstrations, or uses of an innovative technology

3.- The status of permit applications -- for individual tests and demonstrations, testing centers, and early commercial uses -- at both federal and state agencies

4.- The results of tests, demonstrations, and early commercial uses of innovative technologies, including information about the performance envelopes of individual technologies.

The function could also profitably include the ability to intervene to encourage timely consideration of permit applications or even to mediate between permit applicant and permit **writer.**

Currently, the EPA office most closely matching the requirements for the ***ombudsman*** *role is ORD.* ORD has strengths in its knowledge of and objectivity about technology, and in its multi-media orientation, and would need to strengthen its knowledge with respect to permit processes and permit status.

b . ORD ROLE **WITH PERMIT** TEAMS: *ORD also* ***should*** *play a complementary and significant role in the permit team concept propounded in subrecommendations 1.3 and 23.* Other roles for ORD in fostering technology innovation in this document include (a) developer of guidance documents on permitting technology testing centers and (b) collator of information (e.g., clearinghouses, on-line databases) discussed under incentives for permit writers and compliance staff (subrecommendations 4.1 and 4.2). These roles should be made prominent within the ORD system and integrated with existing technology transfer and regional scientist processes.

4.5 Institute systems to provide the public with information and support related to the testing and use of innovative environmental technology.

Commentary

The Committee believes that one of the most significant barriers to implementation of innovative environmental technology is lack of public trust in the information presented during the permitting process. as well as in the actual process of permit review and approval. As a result, siting of new facilities, or use of new technologies in existing facilities, often faces insurmountable public resistance.

a. THE- NEED FOR AN **EARLY, SUBSTANTIVE** ROLE FOR **THE PUBLIC WITH RESPECT** TO **INNOVATION:** The public concern and fear of things that are new, whether associated with innovative technology or not, must be understood and addressed. It is important to realize that no study can prove the absence of an adverse effect. Every effort must be made to supply the public with as much data as is available (with understandable explanatory information) and to involve the public in the permitting process as early as possible. If this is done, by the time permits are issued for a facility it may not seem as "strange" or "new" but, in fact, very familiar. In addition, for this reason, care should be taken in the permitting processes with the designation "new", whether with reference to entire facilities, production processes, or changes to facilities and processes.

b . STEPS FOR **PUBLIC** PARTICIPATION: ***The*** *Committee recommends two measures which EPA should undertake to improve the quality of public participation in permitting.* Implementing these measures may involve statutory, as well as administrative, changes:

1. *Provide detailed information on all facets of a new technology for which a* ***permit*** is *sought, and provide (or require the applicant to provide) substantial information on all known risk factors relevant to any permit application.*

2. *Redesign permitting processes to afford the public an early and more* ***substantive*** *role in the actual design requirements for facilities that affect them*. An improved use of public hearings should be considered, but it should be noted that public involvement can occur in other ways, as well.

c . TECHNICAL SUPPORT TO LOCAL COMMUNITIES: One way would be to address the limited resources available to communities that are wrestling with the problem of how to respond to proposals for environmental compliance made by local regulated organizations. In particular, communities find it difficult to obtain adequate technical expertise to assist the community in evaluating the potential contribution of a new technology and in developing a confident understanding of the level of safety being provided. Communities often lack knowledge about the regulatory and administrative processes associated with innovative technologies.

Environmental policy makers must consider how to provide neutral technological and regulatory process advice beyond that provided by the regulated organization involved or the governmental authorities who must approve permits. The Committee notes that some communities are now entering into agreements to purchase neutral expert advice, using funds provided by the regulated organization and, in some cases by governmental units. EPA, for instance, can provide such support under the "Technical Assistance Grant" authority of CERCLA (Superfund). Such community-chosen experts may provide the confidence bridge necessary for having a fair and equitable decision making process. The Committee suggests that environmental policy makers consider how to make it possible for local communities to obtain such neutral advice as a matter of routine and on demand, whenever the use of an innovative technology for environmental purposes is proposed. One suggestion to this end is that EPA consider the idea that an independent foundation be established, with partial government funding, to provide communities with access to independent expert technical and process support.

d. THE TWO-TIERED PERMIT PROCESS: *The two-tiered permitting process recommended earlier could help achieve positive public involvement.* Under such a process (see subrecommendation 2.2), phase one -- a screening step -- would consider the basic principles and parameters for a potential facility permit, and phase two -- the detailed consideration step -- would weigh detailed technical information and result in the issuance or denial of permits. Phase two would commence on if issues identified in the phase one have been resolved.

The public would be involved deeply in each phase. Use of the two-tiered process could reduce the time and investment required to explore permits for innovative technologies, either by identifying and resolving basic issues (e.g., characterization of wastes produced, environmental and health risks, and process efficiency) early in the process, or by reaching the point during phase one that no agreement is possible. In this

latter case, public input to the project could be made earlier, and the project modified or abandoned before regulators, applicants, and the public have expended as much time and resources as they would have to if a complete permit application has to be provided. Importantly, by involving the public in the process early and in a substantive way, the two-tiered process allows all parties to build the confidence necessary for a successful dialogue.

Appendix 3: Recommendations to EPA on Technology Cooperation, Technology Innovation, and Trade and the Environment

Recommendation 1: Adopt as a major supporting mission of EPA fostering efforts by the industrial and academic communities to develop and evaluate environmentally beneficial technology (to improve environmental quality and also to improve the competitiveness of U.S. firms in the domestic and international marketplace).

Commentary: Technology solutions are essential to the successful execution of EPA's mission. EPA needs to recognize its role in maintaining the viability of the environmental technology industry, in its broadest sense, by supporting its competitiveness in domestic and international markets. Some of EPA's programs present barriers to innovation and to the use of innovative technologies; these need to be addressed, if technology solutions are to be developed and applied to meet domestic goals. Further, advancing economic well-being should be a part of the environmental mission. This can best be accomplished and, indeed, gains efficiency when cooperation and teamwork are established, without sacrificing desired environmental results.

Working relationships must be strengthened between governments at the federal, state, and local levels, and with industry, academia, and environmental groups. To this end, regulatory and regulatory administrative systems (e.g., permitting, compliance, certification programs) must encourage regulated entities to consider the widest possible range of technology options for maintaining compliance and, more broadly, for solving environmental problems. (The term "widest range of technology options" is meant to include pollution prevention, pollution control, remediation technology, measurement and analytic technology, and information management technology.) Further, the technical competence of government personnel, a system of incentives and support for these people, and technical assistance programs must be improved for regulated entities and others who need information about technology.

Actions:

- Draft statement for Administrator's signature stating the objectives of this recommendation.

- Establish the technology advocate function, the function of which is to:

  Be a spokesperson for EPA regulations, and supporting policies and programs that encourage the development and use of innovative technologies to solve environmental problems and maintain compliance.

  Act a as single point of contact for all EPA activities relating to technology innovation and diffusion (e.g., regulations, permit programs, guidance, R&D, technology performance and availability).

- Foster information transfer.

Encourage industry/government interaction (i.e., dialogue, exchange of personnel).

Maintain clearinghouse on innovative technologies and techniques.

- Implement regulations and supporting programs that enable environmentally beneficial innovation to occur domestically.

  Write regulations and regulatory administrative actions that encourage innovation and diffusion.

  Provide opportunities (e.g., facilities, regulations, permits, compliance policies) for testing, demonstration, evaluation, and communication of innovative technology.

- Create a performance evaluation and a reward system to encourage and recognize- government personnel who take actions to promote environmentally beneficial innovation, a system that recognizes the risk taking associated with some innovation.

- Establish TIE Committee activity to maintain a long term industry/government/public dialogue on innovative technology.

Recommendation 2: **Promote professional competence and technical capability of EPA and state and local rulemakers, permitters, and compliance staffs.**

Commentary: Industry has consistently and pointedly informed the TIE Committee that EPA staff lacks adequate technical competence and has an insufficient understanding of industrial processes and outlook. Strengthening technical capability will be important to the efficiency of transactions between regulators and regulateds, whether about rules, pending regulations, permit applications, permits, and compliance situations. The Committee notes that, in response to its previous recommendations on this point, the American Institute of Chemical Engineers (AIChE), working with EPA, UCLA, and MIT, has begun to develop training courses that will help elevate the technology competence of federal, state, and local staffs.

Actions:

- Strengthen technical training programs for existing EPA staff involved in rule writing, permitting, and compliance activities, and provide on-site industrial experience for rulemakers, permit writers, and compliance staffs.

- Implement exchange programs for EPA staff and industrial personnel so that each has a better idea of the other's outlook and experience.

- Strengthen programs that provide technical information to governmental personnel and make them readily available to rule writers, permit writers, and compliance staffs.

- Provide the flexibility to change career paths between Agency divisions.

- Create a reward system to recognize improved technical competence (and risk taking associated with the encouragement of innovative solutions, including pollution prevention).

- Create a system for detailing ORD staff into programs that write rules, issue permits, and perform compliance functions to provide technical support and to raise their level of technical competence.

- Establish and strengthen technical and industrial criteria for employment and continuing training of rule writers, permit writers, and compliance staffs.

- Work with the Pollution Prevention Education Committee of NACEPT to establish standards for technical education and criteria for evaluation at the K-12 grade levels and beyond to increase the pool of technically competent personnel.

- Provide environmentally oriented education for scientists and engineers.

Recommendation 3: Clearly define and map the process required to obtain permits for testing and demonstration, and for operation (for compliance purposes) of innovative technology.

Commentary: The risks faced by investors, developers, and users of innovative environmental technology are amplified by the lack of general availability of knowledge about permitting processes. The unpredictability of these processes compounds these risks. This situation is not in the public interest, because it stifles the development and availability of innovative technology for environmental purposes. Further, it weakens the domestic environmental industry by increasing the cost of innovation. By making the permitting process explicit, this risk would become more predictable, would be reduced, and development would be encouraged.

Actions:

- Each EPA program should map its permit processes and make the "maps" widely available.

- Improve the clarity of permit processes and more clearly state the information required of the permittees.

- Clarify the roles/responsibilities of all parties.

- Analyze the processes to streamline them and make them more predictable. Consider the TIE Committee's recommendation of a "two-tiered" permit process when innovative technologies, and (therefore) greater risk, are involved in a permit application.

- Build into the process encouragement to choose from among the widest range possible of applicable technologies, including innovative technology and pollution prevention solutions.

- Assign high priority to permit applications involving innovative technologies.

- Establish a program to encourage and facilitate "benchmarking" among regional, state, and local permit programs.

- Assign responsibility within EPA to one group to track the progress of EPA in implementation of the 1991 NACEPT recommendations on permitting and compliance policy.

Recommendation 4: Adopt policies in EPA research and other programs that ensure that EPA resources devoted to enhancing the nation's technology base for environmental purposes will gain leverage from private and other supporters of technology innovation, will be targeted more frequently to technologies **that** are successfully **commercialized, and will more frequently achieve significant market impact.**

Commentary: EPA's resources supporting technology innovation represent only a small portion (perhaps 5%) of the total national investment for this purpose. Within the federal government alone, EPA is only the third largest financing source. These scarce funds should be applied more effectively by EPA to leverage private sector funds. Improving the "bang for the buck" is a management issue of significant dimension to EPA: the (lack of) availability and cost of performance characteristics of some available technologies limit the nation's ability to meet its declared environmental objectives, and increasingly the international environmental marketplace represents a "lost opportunity." Serious consideration should be given to a mandatory leveraging requirement for a significant portion of EPA's annual investment in technology-related RD&D. The trend for EPA to support university-based consortia, combining the efforts of government, industry, and academia to develop and commercialize environmentally beneficial technology, has been an important development over the past several years. This trend should continue, because it encourages cooperation and leveraging. The leveraging effect also could be created with federal investment support for the testing, development, and demonstration of innovative environmental technologies (perhaps in the form of a public-private investment fund), with required matching non-governmental sources in each case. This approach might require new resources, however. It should be noted that it is important to recognize in any management design that mandates leveraging to distinguish between the risk levels associated with stage of development (i.e., to recognize that early stage technologies are the most risky).

Actions:

- Establish mandatory leveraging requirements for a substantial portion (e.g., 25 percent) of EPA's technology related spending.

- Institute planning processes for EPA technology programs that involve industry, university-based consortia, and other technology experts who are concerned about commercialization and market impact.

- Assure data compatibility between EPA, DOE, and DOD environmental technology RD&D products to enhance the efficiency of federal environmental management efforts and to speed the availability of innovative solutions developed in whole or in part with federal support for private applications.

- Increase the technology market and commercialization expertise within EPA and introduce an evaluation of commercialization potential as one criterion in RD&D funding decisions.

- Study investment fund experience of other governmental entities, and consider establishing a public-private investment fund.

- Assure that EPA policies involving CRADAS seek that greatest reasonable degree of commercialization, assure confidentiality, and properly handle intellectual property, patents, licenses, and royalties.

Recommendation 5: Establish an industrial user facility program at specialized EPA facilities.

Commentary: Establishing a mechanism for the private sector or other outside organizations to avail themselves of the cost-effective use of specialized EPA facilities is a strong opportunity for government/industry cooperation. EPA has built and operated several unique and/or specialized facilities that other organizations might find useful for research, for developing performance data, or for other purposes. These potential outside users might be willing to pay user fees for the opportunity to conduct trials at these facilities, of course within the constraints that a reasonable person might impose (e.g., limiting outside use to times and types of activity that do not interfere with EPA's programmatic use of the facility). Their use could also be subsidized as part of EPA's support mission.

Actions:

- Study how other government agencies operate such programs.

- Establish EPA/ industry team to study EPA facilities, especially those in ORD, to determine usefulness and availability for industrial use.

- Develop necessary procedures and management systems to guide such activity.

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13. ABSTRACT ***(Maximum 200 words)***

The United States' potential to improve the environment is directly related to our ability to produce and **apply technological** solutions. The Technology Innovation and Economics (TIE) Committee, a standing committee of EPA's National Advisory Council for Environmental Policy and Technology (NACEPT), concluded that the environmental regulatory system could expand environmental progress and improve economic competitiveness if processes that diffuse environmentally beneficial technologies are used to effectively complement regulations. Enhanced EPA technology diffusion programs, especially those involving pollution prevention technologies and techniques, are essential to the achievement of EPA's mission. Federal, state and local regulators, technology developers, technology users, the financial community, environmental groups, and academia together identified and assessed potentially practical approaches. In this report, the Committee analyzes several critical policy issues affecting EPA's essential diffusion roles and makes five major policy recommendations, including:

1.- Making technology diffusion a major supporting mission for EPA.

2.- Building a stronger partnership with technology diffusion providers and users.

3.- Making diffusion and incentives the emphases of EPA's pollution prevention programs.

4.- Expanding support for the international diffusion of environmental technologies to help meet U.S. environmental and competitiveness objectives.

5.- Increasing the support of diffusion provided by EPA's environmental technology research programs.

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14. SUBJECT TERMS (Key Words) continued: information management and transfer, training, education, environmental publications, R&D process, environmental technology research and development (R&D), pollution prevention, environmental permits, compliance, environmental enforcement, environmental incentives, non-regulatory environmental approaches, environment, environmental management system, environmental regulations, technology advocate, environmental partnerships, multi-media, competitiveness, environmental technology markets, environmental technology imports and exports, technology commercialization, Federal Technology Transfer Act (FTTA), licensing and royalty policies, cooperative research and development agreements (CRDAs), environmentally beneficial technologies, environmental business data, public private partnerships, leveraging, state and local environmental agencies, research consortia, coordinating environmental technology research and development (R&D), industrial user facility program, Environmental Protection Agency (EPA), environmental stakeholders