STIMULATING INDUSTRIAL INNOVATION FOR SUSTAINABILITY:
AN INTERNATIONAL SURVEY FOCUSED ON TECHNOLOGY

UNITED STATES

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1. INSTITUTIONAL CONTEXT/BACKGROUND

1.1. US NATIONAL INNOVATION SYSTEM

In recent years total R&D expenditures in the US have been increasing. In 1999 258 billion euros (247 billion US dollars) were spent on R&D (including the defense sector). This amounted to 2.79 percent of GDP in 1999, the highest since 1967 (NSF, 1999). Figure 1 shows the trend in R&D investment as a percent of GDP since 1981.

![Figure 1-1: Historical R&D Expenditures as a Percent of GDP](image)

Industry by far is the largest provider of R&D in the US. It also is the largest performer of R&D. In 1999 industry funded nearly Euro 173 billion worth of research\(^1\) (USD 166 billion and 68.5 percent of the total) to the federal government’s billion 69 billion euros (66 billion US dollars). Industry also performed close to 194 billion euros’ worth of the research (75 percent). The top four industrial sectors’ investment in R&D in 1998 were the electrical equipment at 25 billion (24.4 billion US), chemicals and allied products at 22 billion (21.3 billion US), transportation 20 billion (18.9 billion US) and machinery 15 billion (14.8 billion US) sectors (out of $145.0 billion US provided by all of industry) (NSF, 1998). (Note to Erik and Jim, I can plot out all the sectors by SIC if you wish) Figure 2 shows the distribution of industrial funds for 1998 by size of firm as determined by the number of employees.

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\(^{1}\) US Dollars were converted to euros using the average of the monthly conversion rates for the period January 1999 to April 2000 reported by the Federal Reserve Board of Governors, accessed at [http://www.stls.frb.org/fred/data/exchange.html](http://www.stls.frb.org/fred/data/exchange.html). The value is 1.0441.
Other institutions involved in R&D in the US are the federal and state governments, universities and colleges, national laboratories and other nonprofit institutions (such as RAND). Figure 2 shows the R&D investments provided by these institutions for the last several years (note, industry surpassed government R&D spending around 1980).

In 1999 the top three federal government agencies funding R&D were the Department of Defense (40.1 billion euro/$38.4 billion), Department of Health and Human Services (15.1 billion euro $14.5 billion), National Aeronautics and Space Administration (9.8 billion euro/$9.4 billion) and the Department of Energy (6.4 billion euro/$6.1 billion). The Environmental Protection Agency has a small portion of federal R&D dollars, 0.6 billion euro/$0.6 billion in FY 99 (RAND, 2000).

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2 Numbers represent estimated fiscal year 99 budget authority for the conduct of R&D (excludes facilities and
Universities are considered important contributors to the US innovation system because they focus on longer term research and because these institutions train the next generation of scientists and engineers. Funding for university based research comes from the federal government, state government and industry. Industrial funding of R&D at universities is rising. To foster collaboration with industry, universities, often with the help of state governments, are establishing centers of excellence. For example the State University of New York has centers in the areas of hazardous waste, waste management, Great Lakes research, and coastal resource management. State governments are important to the innovation system because they fund universities. In some cases states also provide considerable funds for specific technology areas (e.g. California’s Energy Commission funds research and provides other services through its Public Interest Energy Research Program (PIER), Ohio’s Clean Coal Program and New York State’s Energy Research and Development Agency (NYSERDA)).

National laboratories are increasingly applying their expertise to industrial productivity and energy and environmental issues and devising institutions to enhance technology transfer, often with universities. The laboratories have a consortium called the Federal Laboratory Consortium for Technology Transfer, of 600 members to promote the rapid transfer of federally held technology into the market.

Small firms, especially high-technology start ups, provide alternative solutions to problems that the large, established firms may not seek. As wellsprings of ideas some policy specifically designed to encourage these firms.

1.1.2. Environmental technology innovation
Environmental technology policy in the US seeks to reduce the costs of environmental compliance, encourage greater levels of environmental protection, achieve more efficient resource use and create jobs in a vibrant industry. Environmental technology policy in the US addresses the needs of the companies that develop and sell environmental technologies and services as well as those firms that provide other products and services and must meet US environmental requirements. The environmental technology sector (the providers) is not tracked separately by the Bureau of the Census but private data suggests that this sector is an important revenue generator and employer.3 Figure 4 shows the revenue of the environmental technology companies as compared to other large US industries.

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3 Some believe these numbers could be greater because these data emphasize the traditional waste treatment and control firms and do not include all the pollution prevention companies and energy technology companies.
However, only about half of these companies invest in R&D and the rate of investment is low, less than three percent of revenues (ELI, 1997).

In 1991 US industry spent nearly 7.7 billion euro/$7.4 billion on pollution control and abatement investments and operating expenses (DOC, 1993). The industrial sectors with the largest expenses included the chemicals, petroleum refining, primary metals, paper and food industries. Not surprisingly, little is known about how much these firms invest in environmental technologies. Because universally accepted definitions of environmental technologies do not exist, estimates of these investments are quite variable. An Industrial Research Institute (IRI) survey of members performed in 1991 found that respondents were spending approximately 13 percent of their R&D investments on environmental technologies. However, the author of the IRI study cautions that rigorous definitions were not imposed and that the sample was not completely representative of all of industry (Rushton, 1993 and 1998). Moreover, since the IRI survey was performed around the time of Clean Air Act Amendments of 1990, the number from a survey today may be lower. An Office of Technology Assessment (OTA) study reviewed the IRI study along with NSF data and select data from the petroleum and pulp and paper industries. OTA reports that a more likely estimate for investments in pollution-control technologies, only one component of all environmental technologies, is between 1 percent and 2 percent of overall R&D funds.4 Another study, performed by the European Industrial Research Management Association (EIRMA) in 1992 took a different look at environmental R&D. The results of this study reported that nearly half of all R&D projects have a significant environment and safety component (Rich, 1993, pp. 16–23). While performed in similar time periods, each of these studies had different definitions of environmental technologies and, as a result, came to variable conclusions regarding the amount industry invests in environmental technologies. Case studies of Intel, DuPont, Monsanto and Xerox suggest that while R&D investments done exclusively for environmental purposes are small, most of their R&D investments have some environmental component (Resetar, 1999).

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4This figure refers to the regulated industries, which OTA estimates support half of all US investments in pollution-control technology R&D (OTA, 1994, pp. 308–310).
2. POLICY FRAMEWORK

2.1. KEY INSTITUTIONS

Environmental policy and technology programs in the US are dispersed across several agencies and state and local governments. No one institution has responsibility for environmental issues or sustainability in the US. Key organizations involved in advising the president on policies for promoting environmental technologies within the executive branch are the White House Office of Science and Technology Policy, the National Science and Technology Council Committee on Environment and Natural Resources (a federal R&D coordinating committee), the President’s Council of Advisors on Science and Technology (PCAST), the Council on Environmental Quality and the Interagency Environmental Technology Office. When it was in operation the President’s Council on Sustainable Development played a role to a lesser extent.

The previous organizations generally play advisory roles to the president while the federal agencies are responsible for creating and implementing the initiatives. Important agencies to environmental technologies and their foci are shown in Table 1.

Table 2-1: Federal Agencies Involved with Environmental Technologies and their Focus

<table>
<thead>
<tr>
<th>Department of Energy</th>
<th>Alternative energy sources, energy efficiency and nuclear waste disposal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Defense</td>
<td>Environmental technologies to support the operations of military installations and weapon systems.</td>
</tr>
<tr>
<td>Department of Commerce</td>
<td>Environmental technology industry competitiveness and exports. Environmentally preferred manufacturing technologies. Monitoring technologies.</td>
</tr>
<tr>
<td>Department of Interior</td>
<td>Natural resource management, abandoned mine reclamation and material flows.</td>
</tr>
<tr>
<td>US Department of Agriculture</td>
<td>Environmental technologies related to food production, water management, forestry and biobased products.</td>
</tr>
<tr>
<td>Department of State</td>
<td>Foreign assistance/development and export promotion.</td>
</tr>
<tr>
<td>Environmental Protection Agency</td>
<td>Voluntary programs with industry and consumers. Regulatory change. Verification.</td>
</tr>
<tr>
<td>Housing and Urban Development</td>
<td>Building construction technologies and technologies for sustainable communities.</td>
</tr>
<tr>
<td>National Aeronautics and Space Administration</td>
<td>Monitoring technologies, especially remote sensing.</td>
</tr>
<tr>
<td>Small Business Administration</td>
<td>Assistance to technology developers that are small businesses.</td>
</tr>
<tr>
<td>Department of Transportation</td>
<td>Mass transit, airplane noise and oil pollution.</td>
</tr>
<tr>
<td>National Science Foundation</td>
<td>Basic research into the scientific disciplines and environmental technology and industrial ecology.</td>
</tr>
</tbody>
</table>

The legislative branch of government (Congress) affects environmental technology innovation because of its role in passing environmental regulations, which depending on how they are crafted can stimulate or limit innovation. The Congress also oversees the activities of the various executive branch’s federal agencies because of its judiciary role and can
influence specific initiatives through the budget process. The judicial branch touches on environmental technology innovation primarily through product liability laws and through its oversight of anti-trust activity (which places limits on how much companies within an industry can cooperate with each other).

In the early 1990s several initiatives aimed at addressing environmental technology innovation began to surface (OTA, 1994). Technology innovation for two types of business was sought, those firms that develop and market environmental technologies and services as well as those firms that must meet US environmental requirements. US policy makers use a broad definition of environmental technology. An environmental technology is a technology that advances sustainable development by reducing risk [of harm to human health or the environment], enhancing cost-effectiveness [of achieving environmental protection], improving process efficiency, and creating products and processes that are environmentally beneficial or benign. The word “technology” is intended to include hardware, software, systems, and services. The categories of environmental technologies are:

- **Avoidance.** Avoidance technologies avoid the production of environmentally hazardous substances or alter human activities in ways that minimize damage to the environment.
- **Monitoring and assessment.** Monitoring and assessment technologies are used to establish and monitor the condition of the environment, including releases of pollutants and other natural or anthropogenic materials of a harmful nature.
- **Control.** Control technologies render hazardous substances harmless before they enter the environment.
- **Remediation and Restoration.** Remediation technologies are those that render harmful or hazardous substances harmless after they enter the environment. Restoration technologies embody methods designed to improve ecosystems that have declined due to naturally induced or anthropogenic effects (NSTC, 1994)

During 1993 to 1995 there was a major effort to develop a national environmental technology strategy. During this time policy makers gathered stakeholder input on policy priorities and coordinated federal (and to a lesser extent state government) initiatives. The strategy, *Bridge to a Sustainable Future*, was published in 1995 by the National Science and Technology Council and the White House Office of Science and Technology Policy.

As a nation, we seek long-term economic growth that creates jobs while improving and sustaining the environment. Achieving these goals requires an environmental technology strategy that addresses the need to remediate past environmental damage while helping us shift from waste management to pollution prevention and more efficient use of valuable resources.

Goals identified in the strategy are:

1. **Achieve continuous improvement of the environmental performance and US industries using the most advanced technologies and cost-effective means possible, by strengthening incentives for innovation within the regulatory system.**
2. **Increase the overall productivity of our nations energy, food, manufacturing, transportation, construction and service sectors through environmental technologies and practices that significantly reduce the use of energy, materials and other inputs.** Environmental technologies are needed to improve understanding of atmospheric, terrestrial and aquatic systems and to remediate and restore environmental damage in a cost-effective manner.
3. **Accelerate and facilitate the demonstration of promising environmental technologies while reducing costs.**
4. **Develop through the federal government and the states working together credible performance information for precommercial environmental technologies.**
5. Ensure that adequate investment capital is available for the development, commercialization, and use of environmental technologies, both for entry into the domestic market and to support an active export industry.
6. Increase US environmental technologies exports to support and create new, high-paying US jobs and to contribute to the achievement of sustainable development.
7. Build a foundation for environmental stewardship and sustainable development internationally implementing a coordinated set of activities to facilitate avoidance of environmental harm and remediation through the development, adaptation, and use of environmental technologies.
8. Develop and implement sustainability plans in many US communities and make significant progress toward achieving sustainable communities over the next 25 years, increasing the quality of urban, suburban, and rural life, and reducing our use of energy and natural resources.
9. Ensure that the federal government becomes a more accessible partner with the private sector in advancing the development of environmental technologies.
10. Build an integrated, interdisciplinary environmental education and training system for students at all levels over the next decade.
11. Improve the nation’s environmental monitoring data and information systems substantially over the next five years through public-private partnerships designed to maximize opportunities for developing and sharing information essential for achieving sustainable development (NSTC, 1995).

No assessment of progress toward these goals developed in the strategy has been performed. The NSTC’s Committee on the Environment and Natural Resources (CENR) was created to integrate the previously fragmented research agendas in each of the agencies. Various subcommittees, some of which are more active than others, coordinate science and technology initiatives and investments. The issue subcommittees are global change, biodiversity and ecosystems, resources use and management, toxic substances and solid and hazardous waste, air quality, water resources/coastal and marine and natural disaster reduction. The cross-cutting subcommittees are risk assessment, environmental technology and social and economic science.

The President’s Council for Sustainable Development has made policy recommendations and issued reports on eco-efficiency; energy and transportation; public linkages, dialogue and education; sustainable agriculture; and sustainable communities; natural resource management and protection; and population and consumption. It’s period of operation has expired.

State governments are important because they implement federal environmental regulations and in some cases states have special programs to promote their state’s environmental technology industry. Those active in this area are California, Massachusetts and New Jersey among many others.

2.2. INITIATIVES AND POLICY MECHANISMS

The US has many initiatives at both the federal- and state-levels specifically designed to promote the development and deployment of environmental and energy technologies. Policy instruments to promote environmental technology innovation include direct federal or state investment, public-private research partnerships, federal support for high-risk technology demonstrations, use of federal laboratories’ capabilities and resources, research and experimentation tax credits, production tax credits, federal-state collaboration on research efforts, environmental regulations, product liability laws, green labeling programs, technology verification and streamlined certification programs, business planning and capital assistance, loans and equity financing, federal and state procurement practices, executive orders, foreign aid and technology assistance, export promotion, education and training.
investments, and programs to provide technical assistance, collect and disseminate
environmental information.\(^5\)

A table showing a sample of initiatives by policy instrument and the innovation phase is shown below (some initiatives cover more than one cell so this is a simplification of its coverage). This is just a sampling of the programs in the US, most are federally sponsored programs but some state initiatives are shown as well. Of special note is the interagency environmental technology office (IETO), which is a central office for outreach to the environmental technology industry and coordination among federal agencies.

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Science</th>
<th>R&amp;D</th>
<th>Demonstration</th>
<th>Deployment</th>
</tr>
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<tbody>
<tr>
<td>R&amp;D investment</td>
<td>NSF and EPA Industrial Ecology-Environmental Technology Program</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Public-private partnerships</td>
<td>DOE’s Industries of the Future public-private partnership</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td></td>
<td>HUD and DOE’s Partnership for Advancing Technologies in Housing</td>
<td>X</td>
<td>X</td>
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<td></td>
<td>DOC’s and DOE’s Partnership for the New Generation Vehicle</td>
<td>X</td>
<td>X</td>
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<td></td>
<td>DOC’s Advanced Technology Program</td>
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<tr>
<td>Regulatory Reinvention</td>
<td>EPA’s Project eXcellence and Leadership</td>
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<td>6-State MOU for permit reciprocity</td>
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<td></td>
<td>State Pollution Prevention Planning Laws</td>
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<tr>
<td>Market Stimulation</td>
<td>Million Roofs Initiative</td>
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<td>Executive Orders for Energy Conservation at federal facilities</td>
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<td>EPA’s Energy Star</td>
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<td>EO on biobased products</td>
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<td></td>
<td>New York State’s Empire Development Corp. Office of Recycling &amp; Market Development</td>
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<tr>
<td>Fiscal and Tax Policy</td>
<td>Small Business Administration’s venture capital assistance ACE-Net</td>
<td>X</td>
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<td></td>
<td>The Energy Policy Act of 1992 provides a 10-year production tax credit</td>
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<td>Information Dissemination</td>
<td>EPA DFE program</td>
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<td></td>
<td>EPA-DOE</td>
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<td></td>
<td>Green Lights</td>
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<td></td>
<td>Climate Wise</td>
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<td></td>
<td>State technical assistance programs</td>
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<td></td>
<td>DOC MEP</td>
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<td></td>
<td>X</td>
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<tr>
<td></td>
<td>EPA ETV</td>
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Providing niche markets for new and developing technologies is also an area that is receiving attention at both the state- and federal-level. Demonstration programs, affirmative procurement of environmentally preferable goods and services, and changing regulation of the electricity market all contribute to this.

\(^5\)This is not an exhaustive list of potential federal policies, but it does provide an illustrative overview. For more specifics on federal policy options see NSTC (1994) or OTA (1994).
In some occasions programs have been developed to address the unique circumstances of small- to medium-sized firms. These include providing technical assistance on pollution prevention and assistance in identifying sources of venture capital to help speed the adoption and the development of new environmental technologies. Other activities toward improving regulatory practices and policies are attempting to provide incentives to practice pollution prevention and to incorporate new technologies.

Over the last 15 years changes in legislation in response to concerns regarding lagging US industrial competitiveness have facilitated closer cooperation between government and industry. As a result, new ways of working together are being explored through many initiatives. Public-private partnerships have been used to co-fund environmental and energy research, development and demonstrations to accomplish specific goals. Greater emphasis has been placed on transferring knowledge residing in federal laboratories to industrial needs and to improving processes and products from an environmental perspective. And federal facilities have been used extensively to demonstrate new technologies as well as to stimulate demand for these new technologies. Industrial input is important to environmental policy development. There are numerous efforts to encourage dialogue between industry and other stakeholders throughout the federal, state and local governments. Several public-private research partnerships have formal arrangements with the targeted industries to ensure that the programs address industry priorities. EPA has several initiatives with the industrial sector to discuss regulatory barriers to technology innovation. The DOC has completed a study of barriers to innovation in the environmental technology industry and OSTP funded studies on R&D investments by small environmental technology firms and large regulated firms. The PCSD has an industrial co-chair. The National Environmental Strategy was developed during numerous stakeholder events that included industrial participation. Most of the initiatives described in later sections are a direct result of discussions with the industry.

The next three sections describe several programs at both the federal and state levels that seek to aid innovation of environmental technologies. Each program addresses a different phase of the innovation process and uses different policy mechanisms for accomplishing their goal. All are considered novel and innovative either because they represent new ways of working with industry or because they attempt to reduce the negative social impacts of different market failures previously unaddressed by policy.
3. SPECIFIC EXAMPLE PROGRAM DESIGN CHARACTERISTICS

3.1. INDUSTRIES OF THE FUTURE

3.1.1. Program Purpose
The purpose of the Industries of the Future Program (IOF) is to improve the energy efficiency, environmental performance and productivity of energy-intensive industries through technology innovation. The program is entirely voluntary and any potential investments required to accomplish the goals ultimately will be evaluated in light of energy prices, individual companies’ financial status and general market conditions.

The IOF program works with the industrial sectors to help them:

- Improve energy efficiency by 25 percent and reduce emissions by 30 percent for the nine industries by 2010.
- Improve energy efficiency by 35 percent and reduce in emissions by 50 percent for the nine industries by 2020.
- Save close to 1 quadrillion Btu of energy in the year 2010 in the cross-cutting program.

These goals are considered ambitious.

The nine industries partnered with the program are the agriculture (agrichemicals focus), aluminum, chemicals, forest products, glass, metal casting, mining, petroleum refining and steel industries. Each sector signed a compact to work with the DOE. These industries have been targeted because of their energy-intensity. In total these industrial sectors consume 27 quadrillion Btu (74.5 percent of the total energy consumption by industry in the US).

The primary policy mechanism used by the IOF program is competitively awarded, cost shared R&D support for precompetitive research and development. Because of its organizational domain, OIT also targets funding to process and not end-use technologies. Technical assistance and information dissemination are also used in the program. The program’s activities are designed to seek improvement of existing products and processes, redesign of products and processes, function and system innovation. Market introduction is left to the private sector. (NOTE to Jim and Erik: In the US no program would say it operates at market introduction because it would be political suicide (vis a vis the Congress). As a result the program interviewee deleted activity area #4. But, one could argue that demonstrations serve a market introduction function in addition to furthering development.)

3.1.2. Why Industries of the Future was Developed
Because of concerns regarding lagging US industrial competitiveness over the last 15 years changes in legislation have facilitated closer cooperation between government and industry. Federal and state R&D policy makers began to recognize that much of the expertise and decision making regarding the commercial viability of new technologies resides in industry. In addition, in the post-cold war era there has been greater interest in applying the knowledge and capability held by the national laboratories to broader social goals such as energy efficiency, environment and industrial productivity. Moreover, it became clear that funding R&D alone will not ensure that potentially effective technologies will ultimately be commercialized. Therefore, policymakers began to explore ways to improve the cooperation between government and industry in the hopes of improving the likelihood that public R&D investments will generate commercially viable technologies that contribute to broad social goals such as economic well-being and environmental improvement.

In 1992 DOE personnel associated with this program specifically began to discuss new approaches for working with industry to address the social goals of energy efficiency,
environment and productivity improvement. Resulting from these discussions was the strategy of using industry visions and technology roadmaps to inform DOE program planning. A formal 50 percent cost-sharing of projects would also be required. It was felt that this approach would ensure the relevance of the research portfolio to industrial priorities and improve the rate and likelihood that new technologies developed through the program would be commercialized. Other features of the vision-roadmap strategy are it:

- leverages industrial R&D investment given relatively limited federal funds,
- draws additional private investment toward the program goals,
- targets federal research investments across agencies, and
- aligns resources among customers, manufacturers, suppliers, federal government, academia, national laboratories and state government.

As a result of these changes DOE has reported seeing better quality research proposals and more active, high-level industrial participation in the program. Industries such as agriculture (agrichecmicals) and mining, which previously have not worked with the DOE, are currently active participants with the program team.

3.1.3. How IOF is Structured: Government Role and Other Players

The IOF program is a public-private partnership. IOF co-funds precompetitive R&D with the nine energy intensive (and waste generating) industrial sectors. The specific investments are determined using input provided by the industrial sectors. Each sector creates its own long-term (20-25 year) vision of desired industrial performance. For example, the glass industry goals that include 1) operate with production costs at least 20% below 1995 levels and 2) recycle 100 percent of all glass products in the manufacturing process where consumption is greater than 5 lb/capita, 3) reduce process energy use from present facility levels by 50 percent towarded theoretical energy use limits and others.

In many cases this is the first time that these sectors have come together as an industry to identify common goals and research priorities. Technology roadmaps identify the technological options and research and development needs to move from today to the industry outlined in the vision. The industrial sectors are responsible for the development and content of these visions and roadmaps but IOF facilitates their creation.

IOF uses the visions and roadmaps to justify the program plan and to help determine what research projects it should fund. Because each industrial sector creates the documents that determine the priorities for program investment, the vision and roadmap, and because many sectors take an active role in the solicitation process, this program is described as an industry-driven public-private partnership.

There is significant variability among the different industries as to the processes they use to issue solicitations and to prioritize the submitted proposals. However, most of these processes involve active participation and coordination by the trade associations. In order to be funded by the IOF program a project must meet the following criteria:

- reduce energy use,
- minimize environmental impacts,
- improve productivity,
- involve pre-competitive research, and
- be process oriented (as opposed to end-use or product oriented).

In many cases the industry members organize technical working groups through the trade association to rank order the submitted proposals according to the industry’s priorities. Government personnel on the IOF teams assess the rankings in their selection process for potential energy efficiency and environmental gains. In many cases because the industrial
members evaluate proposals they do not receive DOE funds (this is not universally true however). The funds go to national laboratories or universities who partner with the industry members. The industry members then provide the cost-share portion through in-kind work. Generally the cost share for projects is 50% over the life of the project, although there is some variability by project type. It should be noted however that each sector has its own unique process for issuing solicitations, evaluating solicitations and determining who receives funds.

In addition to the sector-specific research and development activities under IOF there are cross-cutting programs geared toward technologies applicable to multiple industrial sectors. Technology areas funded in the cross-cutting programs include advanced materials, distributed generation systems, sensors and controls, power generation and combustion. The cross-cutting programs also disseminate best practices through technical assistance to facility level managers both domestically and internationally. Industrial assessment centers work with small and medium sized businesses to provide energy and waste audits. Financial assistance in the form of grants is provided for some plant demonstrations to speed the market introduction of new technologies. Some program funds are directed toward the states to leverage off state economic development activities and to address the energy efficiency and environmental issues of industries important to the participating states. In fiscal year 2001 there is also some budget set aside to support proposals received from suppliers to the vision industries.

The OIT Industries of the Future Program’s funding levels are very modest relative to the total industry R&D investments. Its overall funding for the sector-specific work (the nine sectors) has been approximately $60 million for the last couple of years (about $12m for forest products, $10m for steel, and $8m for aluminum). An additional $75 to $100 million has been spent on cross-cutting technologies. Table 1 presents the budget detail by fiscal year.

**Table 3-1: Budget Authority for the Industries of the Future Program (Millions of USD)**

<table>
<thead>
<tr>
<th></th>
<th>FY 93</th>
<th>FY 94</th>
<th>FY 95</th>
<th>FY 96</th>
<th>FY 97</th>
<th>FY 98</th>
<th>FY 99</th>
<th>FY 00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector Specific Programs</td>
<td>27.5</td>
<td>53.3</td>
<td>53.9</td>
<td>41.7</td>
<td>45.3</td>
<td>52.2</td>
<td>57.5</td>
<td>74.0</td>
</tr>
<tr>
<td>Cross Cutting Programs</td>
<td>27.5</td>
<td>29.6</td>
<td>71.0</td>
<td>64.0</td>
<td>63.2</td>
<td>74.1</td>
<td>100.1</td>
<td>87.6</td>
</tr>
<tr>
<td>Other</td>
<td>48.0</td>
<td>32.7</td>
<td>2.7</td>
<td>2.7</td>
<td>2.1</td>
<td>7.7</td>
<td>8.3</td>
<td>9.4</td>
</tr>
<tr>
<td>Total</td>
<td>103.0</td>
<td>115.6</td>
<td>127.6</td>
<td>107.2</td>
<td>110.6</td>
<td>133.9</td>
<td>165.9</td>
<td>171.0</td>
</tr>
</tbody>
</table>

Other includes management and planning operating expenses.

**3.1.4. Key Issues/Hurdles**

There are several factors that are important to the implementation of this program.

Active participation by high level industry partners is necessary to ensure that the visions and roadmaps reflect the industry’s strategic priorities as well as to develop consensus on these priorities. The quality of the visions and the roadmaps are critical factors because plans, funding levels and specific research projects are developed from them. The process of developing these documents has improved communication within the sectors leading to unforeseen benefits. For example, some of the roadmaps are used by universities to guide the engineering curriculum. Significantly, in others the process has improved information flow between primary producers and their suppliers.

Because of the cost-share requirement, the general focus of industry and the budget environment there are strong incentives to prioritize shorter term projects. These are
counterbalanced by the focus on precompetitive technologies, which often tend to be longer term, and the need to address the longer terms goals identified in the vision statements. A mix of shorter-, mid- and longer term projects will satisfy the various needs.

The DOE does not have regulatory authority over these industries so there is no threat of regulatory reprisals for non participation. As a result, quality research and development projects that improve energy efficiency and productivity are the sole motivating factor for industrial participation. The proposal evaluation process, frequently performed by the high level industry experts (chief technical officers) and the trade association, can be labor intensive.

3.2. ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

3.2.1. Program Purpose
The US Environmental Protection Agency’s (EPA) Environmental Technology Verification (ETV) Program seeks to provide objective, replicable, independent performance data for new commercial ready environmental technologies to help reduce the time it takes to gain market acceptance. It is entirely voluntary. The program does not certify (guarantee) performance for regulatory purposes, nor does it seek to establish performance standards for new environmental technologies. Technologies must be commercial ready, funds for technology R&D are not provided.

Environmental technologies addressed by the program cover a broad spectrum including avoidance, control, monitoring and remediation technologies for air, soil and water. This program addresses market introduction of new technologies that may improve existing products and processes, redesign of products and processes or address function and system innovation.

3.2.2. Why ETV was Developed
Consistent, independently provided information on new environmental technologies does not exist. This information is especially important to have for environmental technologies because of the associated health and environmental risks. For certain classes of environmental technology the regulated marketplace segments markets, adds uncertainty and lengthens the time to new technology acceptance. Yet prior to the mid-1990s there were no verification programs aimed at the environmental technology market.

Because of this the program was developed to improve the information available to early adopters of new environmental technologies so that uncertainty surrounding the technology’s performance is reduced. The questions a new purchaser is likely to ask is:

- Is this technology going to work as advertised?
- How do technologies A, B, and C compare for a consistent set of parameters?

The program was also developed to increase information available to state permitters, who generally speaking, may not have the resources or the incentives to quickly evaluate new technologies. A state permitter is going to ask:

- Does this technology do what the permit requires it to do?

The financial community could also use the information provided by the program to improve financial risk calculations. By providing third party, objective, comprehensive and scientifically sound technical information the program hopes to improve the time-to-market of new environmental technologies, to increase the supply of innovative technologies to the
user-industry so that greater levels of environmental protection may be achieved at lower cost.

Because the goal of the program is to increase the number of innovative technologies available to the largest market possible, high data quality and relevance are the major contributing factors to a successful program outcome. Links to users of these data—permittees and purchasers—can ensure relevance and improve confidence in the data.

3.2.3. How ETV is structured: Government Role and Other Players

Originally the ETV program was part of a package of initiatives under the Environmental Technology Initiative (ETI). The ETI was a roughly $120 million initiative that contained plans to reduce regulatory and market barriers to environmental technology innovation including R&D investment. All planned activities under the ETI program, with the exception of ETV, were canceled by the Congress in 1995.

The ETV program is structured to be a two-phased ten year program. The pilot phase, lasting from 1995 to 2000 is purposely structured to experiment with a variety of partners and procedures. As a result there is a lot of diversity in this program. At the end of this year the ETV program will report to Congress and recommend a future structure for the program. Unless the experimental phase suggests otherwise, the program will eventually be privately funded and operated with minimal, yet crucial, EPA participation at a target of $3 to 4 million per year. EPA will always provide quality assurance. The program was developed at EPA because of the agency’s scientific expertise and mission to protect the environment.

The ETV program covers a broad range of technology areas from remediation to pollution prevention across the three media. Twelve pilots covering 16 technology areas have been developed in this phase (Table 1). They were selected based on an assessment of their contribution to environmental protection and potential market opportunities with special attention given to high priority areas such as pollution prevention and those that anticipate regulatory requirements. Each pilot has differences from the others.
Table 3-2: ETV Pilots

<table>
<thead>
<tr>
<th>Pilot Focus</th>
<th>EPA Funding through FY99</th>
<th>Date Established</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Monitoring Systems</td>
<td>4.2</td>
<td>Oct 1997</td>
</tr>
<tr>
<td>Air Pollution Control Technology</td>
<td>4.0</td>
<td>Oct 1997</td>
</tr>
<tr>
<td>Drinking Water Systems</td>
<td>4.2</td>
<td>Oct 1995</td>
</tr>
<tr>
<td>Greenhouse Gas Technology</td>
<td>4.0</td>
<td>Dec 1997</td>
</tr>
<tr>
<td>Indoor Air Products</td>
<td>2.0</td>
<td>Dec 1995</td>
</tr>
<tr>
<td>Pollution Prevention Coatings and Coating Equipment</td>
<td>2.8</td>
<td>Oct 1996</td>
</tr>
<tr>
<td>Pollution Prevention Metal Finishing Technologies</td>
<td>2.8</td>
<td>Jun 1998</td>
</tr>
<tr>
<td>Pollution Prevention Recycling and Waste Treatment Technologies</td>
<td>1.7</td>
<td>July 1995</td>
</tr>
<tr>
<td>Site Characterization and Monitoring Technologies</td>
<td>4.0</td>
<td>Oct 1994</td>
</tr>
<tr>
<td>Source Water Protection</td>
<td>3.0</td>
<td>May 1998</td>
</tr>
<tr>
<td>Wet Weather Flow Technology</td>
<td>3.0</td>
<td>Jun 1998</td>
</tr>
<tr>
<td>Environmental Technology Evaluation Center</td>
<td>2.3</td>
<td>Oct 1996</td>
</tr>
</tbody>
</table>

The US EPA Office of Research and Development runs the program. It provides management, budget and scientific expertise (generally of an oversight nature). Initially EPA funded the protocol and test plan development as well as the tests themselves so program funding was relatively high (see Table 2 for the funding history). Now testing expenses are often shared and a company can pay anywhere between $5,000 and $100,000 depending on the scale of the test. Eventually the vendors will pay for the testing exclusively and federal funds will be used for logistical support for stakeholder meetings, generic protocol development and program outreach. The vendors will pay for the tests and laboratory data analysis. Combined funding will be used for quality assurance (EPA always plans to play a role here) and report writing and review. Generic protocols, test plans and test results are published on the ETV website.

Table 3-3: ETV Funding

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>7.0</td>
</tr>
<tr>
<td>1996</td>
<td>10.0</td>
</tr>
<tr>
<td>1997</td>
<td>10.0</td>
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<tr>
<td>1998</td>
<td>10.0</td>
</tr>
<tr>
<td>1999</td>
<td>7.8</td>
</tr>
<tr>
<td>2000</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>3.0-4.0</td>
</tr>
</tbody>
</table>

Note, not all of the funding went to the pilots identified in Table 1.

For each of the technology areas there are program partners. The program partners are responsible for developing a protocol and test procedures using stakeholder input and experts when required. The partners are also responsible for performing the test. Frequently the partners contract with experts to develop draft protocols and test plans. Partners can be independent, non-profit organizations, federal laboratories, or in one case a state government.
The EPA and its partners have cooperative agreements, not contracts. Cooperative agreements outline the areas of responsibility and lay out the program’s purpose. Funding is provided in yearly increments to the partner. These agreements give the partner more latitude to operate the pilot. One program objective is to allow the private sector, not EPA, to control the verification process because the results are for purchasers, permittees, etc. and they are not intended to be used by EPA for regulation development. While the partners have a lot of authority to run the pilot as necessary given the specific applications and market conditions, the terms of the cooperative agreement require them to meet the EPA standards for quality (one pilot, EvTEC, is completely independent and therefore may have different quality standards).

Stakeholder groups of vendors, purchasers, state representatives, consulting engineers, and the financial community provide input into the program on technology priorities, performance parameters required for decision making, test protocols, and information dissemination. The stakeholder input is considered critical to the program design. The make-up of the stakeholder groups vary by pilot and range in size from 16 to 179 members averaging 64 members. These groups provide class knowledge, improve the program’s credibility, and develop buy-in. The ultimate decisions on technology areas and protocols are made by the EPA with its partners based on the supply of technologies, estimated environmental benefits and practicality given time and budget constraints. In many areas--where one company has a large market share, where technologies are not sold or licensed, etc.--the market would not benefit from a verification program.

There are five operating principles for the program. These are:

- Testing will be available to and consistent for all vendors of commercial-ready technologies within defined categories.
- All ETV test will be conducted by objective, third party testing organizations having no financial or other interests in the technology.
- Pre-existing, publicly available test plans will be used throughout the program.
- Results of all ETV evaluations will be published in reports that are available to all interested parties.
- All ETV pilots will operate under a quality management plan and through quality assurance procedures that ensure the production of data of an acceptable level for verification.

During the pilot phase the ETV program office has collected a lot of data on the program such as the number of stakeholders, number of stakeholder meetings, number of verifications completed and in progress, cost and time to perform tests, test outcomes, uses of this information, website utilization, publications and vendor surveys. A management team of approximately 20 personnel communicate via biweekly via conference calls and periodic meetings to share lessons learned and revise procedures as needed. One of the most significant early surprises in the program was the lack of existing protocols and testing procedures that could be applied to the environmental technologies of interest.

While ETV is the largest, there are 10 other US verification programs. These are sponsored by the EPA (1), other federal agencies (5) and state government (4). There is also a verification program in Canada. These have been established for the same general purposes, to advance innovative environmental technologies more quickly into the market place, although the technology focus and the verification approaches vary. In the case of the other federal programs the verification initiatives cover technology areas related to the missions of those agencies. ETV has a memorandum of understanding to cooperative with the Department of Defense program, which is focused on remediation technologies. ETV also routinely coordinates with select others at both the federal and state levels to the extent practicable given staffing limitations and the experimental nature of the pilots.
3.2.4. Key Issues/Hurdles/Lessons Learned

The most important issue for the program is whether or not this activity adds value to the market place. The critical factors from the program’s point of view will be the confidence in the results, the cost and time it takes to test technologies and the contribution this information makes to purchasing and permitting decision making. EPA’s contribution of quality assurance address the first factor. Program management at EPA but primarily by the partners will determine the second. Careful consultation and stakeholder participation addresses the third. The benefits of any of these verification programs will be more fully realized if states and international governments accept the results. Currently in the US there are two efforts at the state level to increase coordination of requirements for permits and other regulatory requirements.

Each pilot has a unique approach and diverse groups of stakeholder involvement. These stakeholder boards drive the ETV process. They determine the technical focus and the testing protocols. Each stakeholder process is comprehensive and thorough. This process is laudable because it includes all the interested parties and those with in-depth technical expertise. It also helps to maintain high quality assurance throughout the verification process. Some would argue that such a process is needed for program acceptance and to ensure quality standards of the entire verification process. However, such a thorough process has high costs both in time and dollars.

In addition, the lack of existing protocols and test plans applicable to the environmental technologies of interest made the early stages of the program more challenging than anticipated. A large amount of time and money has been used to develop the program infrastructure, develop protocols, conduct testing, and issue the verification documents. EPA recognizes these costs and hopes as the program evolves and pilots learn from previous experience and their infrastructure is in place that timelines and costs can be reduced. EPA and the pilot partners are working hard to streamline the process and some improvements have already been realized because of learning from earlier pilot experiences.

3.3. VENTURE CAPITAL PROGRAMS

3.3.1. Background and Introduction

Many of the environmental technology firms in the US are small enterprises in need of capital.\(^6\) For a small enterprise, especially a start-up, it can be difficult to identify and raise the necessary capital for a host of reasons including management inexperience, lack of information, time and expense, etc. Compounding the unique difficulties a small enterprise faces is the trend in recent years for institutional investors to prefer larger transactions (1999 average was $13 m), which are generally greater than the amount required by many small enterprises (around $1 m). Moreover, consolidation in the banking industry has led to a greater reliance on automated credit scoring over personal knowledge of firm reputation, business focus, etc. for investment decision making. Environmental technology firms face additional burdens because of the poor financial performance of environmental technology companies in the past and greater uncertainty caused by environmental regulations. One study performed in the mid-1990s states that only five percent of U.S. venture capital firms actively invested in the environmental industry. Moreover, according to a 1993 Environmental Business Journal survey, venture capitalists prefer environmental technology companies in the early- to mid- revenue earnings phases and not in the pre-prototype phase (SBA, 1994).

\(^6\) The Small Business Administration’s standards for a small enterprise vary by North American Industry Classification System (NAICS) codes. Generally the standard is companies with fewer than 500 employees or with less than $5 million in sales (some companies classifications go to $20 m or higher) when sales is a more appropriate indicator.
For many environmental firms the cost of capital is a major determinant of the price that can be offered. For example, 80% of the cost of wind powered electricity is determined by the cost of capital investments. Because of the technological and market uncertainties, most wind providers are smaller, independent companies that acquire financing with higher-than-average rates. Most wind energy projects are financed by the manufacturer, institutional investors, or venture investment who require a rate of return higher than average because of the perceived risk and uncertainty of wind projects in the United States (Energy Information Agency, 1998).

This section describes several programs that seek to address the capitalization needs of new environmental technology companies. Example programs include those sponsored at both the federal and state level. Each targets slightly different kinds of businesses -- either those that are small, offer bio-based products, or provide environmental technologies. The mechanisms used to facilitate capitalization include information exchange, regulatory modifications, direct equity investment, and preferential treatment in public procurement decisions. The commonalities among these programs are that each seeks to improve the equity or venture capital available to firms that provide products or services where the environment is at least one of the social goals addressed. Each program also offers other services including business plan development assistance, incubator facilities, etc. These are no means the only, nor the largest programs that seek to improve capital availability to environmental technology firms in the U.S.

- Federal Programs
  - ACE-Net
  - Alternative Agricultural Research and Commercialization (AARC) Corporation
- State Program
  - Massachusetts Technology Development Corporation (MTDC)
- Other programs mentioned during the discussions that may be of interest are:
  - Kansas Technology Enterprise Corporation (KTEC), www.ktec.com
  - Small Business Innovation Research (SBIR), www.es.epa.gov/ncerqa/sbir
  - Agricultural Utilization Research Institute (AURI) (in Minnesota), www.auri.org

3.4. ACE-NET

3.4.1. ACE-Net Description and Purpose
The ACE-Net initiative by the US Small Business Administration (SBA) seeks to increase the small start-up company’s access to equity capital for deals in the range of $250,000 to $5 million. Its focus is small business and is not the more specific environmental start-up companies, although there is obvious overlap. It is a national, internet based listing service that allows accredited individual investors to view the prospectuses of newly established businesses anonymously. The initiative by the SBA is connected to regional development centers typically operated by a university or state-based organization. Through ACE-Net, small companies have low-cost access to potential investors nationwide.

3.4.2. Why it was Developed
ACE-Net resulted from the concerns expressed by small businesses at a 1995 conference on small business sponsored by the White House. A large portion of the recommendations generated at this conference dealt with capital formation. In particular, participants suggested that angel investors (wealthy private individuals) had considerable resources, in the range of $20 to $60 billion or more, that was underutilized. Because angel investors tend to take a personal interest in companies they often fund companies for reasons other than estimates of financial gains making them more inclined than institutional investors to invest in an
environmental technology company. And they generally rely on personal contacts to identify potential investments and to make investment decisions.

In addition, the regionalization of venture capital availability and the barriers created by state oversight, meant that some parts of the country did not have easy access to capital, while others were awash in it. The laws granting state oversight were originally promulgated because of concerns over the potential for interstate fraud. However, state oversight made it expensive from both time and monetary points of view for a company to seek equity capital in more than one state. In order to overcome the market fragmentation caused by regulations, the SBA Office of Advocacy sought and attained regulatory changes and coordinated application processes to improve the flow of capital across state lines.

3.4.3. How it Works
The SBA began working with several established developmental centers scattered throughout the county. The list of operators has grown to 50 (identified on the website as of July 2000). The operators are critical to the process because they provide outreach and guidance to both the investors and the companies and have the essential regional knowledge required to be effective. These operators are non-for-profit organizations typically associated with the state or a university. They provide a multitude of services such as business plan development assistance.

Venture capitalists, individual investors (angels) and institutional investors can view the prospectuses of companies seeking equity capital using a search engine. They can search on factors such as geography, technology type, investment size, stage of development, etc. They must first register with an operator and complete a form to certify that they satisfy the US Securities and Exchange Commission’s definition of an accredited investor.

Companies interested in obtaining capital can offer securities though ACE-Net submits the required information one of the operators. They must satisfy federal and state securities registration or exemption requirements. Fees to cover administrative costs are charged up to a maximum of $450. Fees are not related to transactions.

ACE-Net was begun in 1996 and will eventually will be spun off into a not-for-profit organization. Thus the federal role is to provide coordination among the state and regional level operator and to spearhead modification to securities regulatory processes such as common forms to facilitate interstate transactions.

3.5. ALTERNATIVE AGRICULTURAL RESEARCH AND COMMERCIALIZATION (AARC) CORPORATION

3.5.1. AARC Description and Purpose
The Alternative Agricultural Research and Commercialization (AARC) Corporation was a federally sponsored venture capital fund for new nonfood, nonfeed, products derived from agricultural materials, forestry materials, and animal by-products. Initial investments to support new product commercialization ranged from $40,000 to $1 million US, although most were closer to $100,000 (the average was about $400,000). It was created by the Food, Agriculture, Conservation and Trade Act of 1990 as a wholly owned corporation of the Federal Government within the US Department of Agriculture. AARC Corporation was first funded in fiscal year 1993 at approximately $7.5 million (US), its peak funding was $9.0 million (rough estimates of funding levels by fiscal year are shown in Table 3.1). While AARC was authorized to approximately $25 million per year, it was never funded to that level. AARC was canceled as of February 2000.

Table 3-4: Approximate Funding Levels for AARC (Millions of US Dollars)
<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>7.3</td>
</tr>
<tr>
<td>1994</td>
<td>9.0</td>
</tr>
<tr>
<td>1995</td>
<td>6.8</td>
</tr>
<tr>
<td>1996</td>
<td>6.5</td>
</tr>
<tr>
<td>1997</td>
<td>7.0</td>
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<tr>
<td>1998</td>
<td>7.0</td>
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<tr>
<td>1999</td>
<td>7.0</td>
</tr>
<tr>
<td>2000</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Source: Ron Buchalt

The primary motivation for establishing this fund was to help generate economic benefits to rural communities. In addition, these products were considered to be environmentally friendly because they were often bio-degradable and they were based on renewable resources that frequently substituted for petroleum based products. They also held the potential for making more efficient uses of resources because many of the products were considered agricultural waste.

Other state level programs considered good models by some interviewees are Kansas Technology Enterprise Corporation (KTEC) and Agricultural Utilization Research Institute (AURI) in Minnesota.

3.5.2. Why AARC was Developed
AARC was developed for many of the same reasons as ACE-Net (described in the previous discussion). An additional reason for AARC’s need is the specific failure of rural banks during the period of restructuring in the banking industry.

3.5.3. How AARC Worked
AARC was a venture capital fund, owned by the federal government. It made investments in companies seeking to commercialize new products (non-feed or non-food) from agriculturally-based sources. Initial investments ranged from under $100,000 to $1 million US. Most investments were closer to $100,000 while very few were $1 million. In practice, because AARC invested in companies very early in the development process, it continued to invest in some companies for two to three rounds. As a result, for three or four companies AARC investment totaled $2-3 million each. Companies seeking financial assistance were required to have matching funds from the private sector on at least a one-to-one ratio. In actuality, AARC literature states that the ratio overall was four-to-one private to public investment.

The primary policy mechanism was direct equity investment requiring payback. While AARC mechanism was direct investment, it built off the long history the United States Department of Agriculture (USDA) had in research. The USDA’s research laboratories were created in the first half of the 20th century to find new uses for farm products. The 1996 Farm Bill also gave federal procurement preference, in the form of set-asides, to AARC supported companies. In the end, however the AARC portfolio companies did not receive procurement preference because of the time it takes to change the procurement process and because contract personnel still often make decisions on initial prices over life cycle cost. In many of these cases, there is an initial purchase price premium while life cycle cost was lower.

The fund was established to fill a void in capital availability for riskier, rural businesses. Investments were made based on estimates of the number of jobs created, potential economic impact in rural communities, the amount of agricultural material used, and financial returns. Because the aforementioned social goals were part of the investment decision criteria, the
fund did not anticipate rates of return usually associated with venture capital (and based solely on financial prospects). The full list of considerations identified in AARC literature is shown in Table 3.2. Congressional testimony over the years offered program measures including return-on-investment, multiplier of private capital attracted, expanded capacity of acreage of agricultural land, and jobs created (Armstrong, 1999; Gain, 1998; and Crain, 1997).

Table 3-5: AARC Applicant Considerations

| Demonstrated management, technical, marketing, and financial expertise |
| Availability of matching funds |
| Economic viability |
| Private financial participation |
| Potential market size |
| Potential job creation and rural development |
| State or local government participation |
| Likelihood of reducing Federal commodity support |
| Likely impact on resource conservation |
| Likely impact on the environment |
| Lack of private capital |
| Broad applicability |
| Biodiversity |
| Long term viability without assistance |
| Ability to repay |


Outreach to potential companies was done through standard government solicitation methods (the Commerce Business Daily and other methods). Once the portfolio was largely established for the given funding levels this became unnecessary and the AARC website became the primary means to attract companies seeking capital. Congress initially funded the Corporation with annual appropriations (shown in Table X above). Eventually AARC was to become self-sustaining as the initial investments paid off, although there was no set time frame for this to occur. Investment decisions were made by a board, composed predominately of private sector personnel. Administrative expenses were limited to a maximum of 15% of funding levels.

Funding for the AARC Corporation was zeroed out by Congress for fiscal year 2000. The Corporation and the fund will eventually be dissolved. The next subsection discusses some of the lessons learned from this experience.

3.5.4. Lessons Learned

Because the federal government had no precedent for a venture capital fund, all organizational issues and processes had to be developed from scratch adding time, complexity and a certain amount of confusion. For example, contracts, applications, review processes, etc. all had to be created and there was a steep learning curve. The debate over accounting practices exemplifies some of the difficulties and confusion faced by AARC. Because it was new, AARC staff used modified grant applications and contract agreements for its investments. Technically, recipients did not have to provide annually audited financial statements. However, federal grant recipients do. Because grant situations were the model used for AARC, AARC contracts included this requirement (with one exception). Yet this requirement was not always enforced by AARC because in some cases the staff felt the costs of providing an audited statement might have been onerous for the firm. Yet an Inspector General Report criticized the program for not doing so. In other areas, especially financial, grants may not have been an appropriate model because they typically do not have the kind of involvement that equity investments require. This confusion over what
constitutes sound operating principles and legal requirements may not have occurred if this type of program existed previously in the federal government.

The cap on administrative costs, at 15 percent was constraining under these circumstances, limiting access to outside expertise. Moreover, as the values in Table 3.1 show, annual funding was volatile. As a result the amount that could be spent on administrative activities was uncertain and unstable. Interviewees were mixed on whether or not changes in leadership added instability to the program. They were also mixed on the effectiveness of the Board of Directors, particularly in fiduciary matters. The Board of Directors was chosen for its expertise in business (to include venture capital, science, and agriculture). Nine members were from the private sector and three were from within the Dept. (2 Undersecretaries and 1 lawyer). The private sector members really set the tone. After a few years of "apprenticeship" at the elbow of some of the Board members, some staff members felt adept at structuring investments. A Board with business experience--including VC, but also actual manufacturing experience--as well as scientific/technical experience--would help a program. Based on the AARC experience a Board's optimum size is in the 9-11 member range. The AARC Board of Directors was criticized in a USDA Inspector General report for not providing stronger leadership on fiduciary matters and for staying on the Board longer than they should have.7

Political pressures also tended to push for smaller amounts invested in a larger number of companies, an emphasis on small companies over large, and geographic dispersion. These pressures do not necessary improve the measures identified in Table X earlier and this may have led to an investment portfolio that was spread too thin across too many companies, allowing them to survive perhaps but not to expand.

Developing consensus on appropriate operating and investment strategies and evaluating AARC was vastly complicated by the fact that this was a public organization performing a private sector function. Within government (Congress and the USDA Inspector General) there was a tendency to evaluate AARC using standards established for public operations. However, AARC was not the traditional public operation and it needed greater flexibility to perform its mission. For example, issues such as the appropriate rates of return and values for other measures of success were also confused because while the private sector may have large financial returns, it provides less social goods. So AARC was established to invest in riskier businesses, generally earlier in the development cycle and with potentially lower rates of returns than the archetype private venture capital firm and yet in evaluators’ minds private sector payback periods and rates of returns were often used to benchmark its success. It is perhaps an example of a creative policy tool that in practice was constrained by mindsets and existing operating procedures.

The program budget was zeroed out in part because AARC was not self-sustaining as quickly as Congress thought it should (for comparison, the Massachusetts Technology Development Fund was self-sustaining after 10 years). A counter argument is that because AARC invested in early-development phase technology and riskier technology it should take longer than one might expect from private sector experience. An interviewee felt that after another 3 to 4 years the fund would have been self-sustaining. However, from its inception AARC invested $41.2 million and as of March 2000 received $1.1 million in returns.

Congressional support was limited and as a result the AARC funding often become a political bargaining chip. Broader support could have provided for greater funding and program stability.

7 The report was issued sometime in the 1996 to 1997 time frame.
Advice for others considering this kind of program is to ensure that staff have the requisite technical skills for the program. This includes scientific, manufacturing and financial expertise. Board members should actively monitor activities of staff and investees. Also, contracts and agreements should ensure that the investor (AARC) retains financial control (e.g., not allow stock dilution without permission), require authoritative standards be met, and require financial audits of the entity and not just the project funded. Language in these agreements should also be promptly enforced. Common terms and conditions should be used if possible to minimize confusion. And royalties should be applied to gross, versus net, sales (unless limits can be placed on expenses such as salaries, travel, etc.). Much of this advice has to do with the amount of financial control the investor maintains in the firm and suggest that AARC could have retained more.

Finally, this analysis is not in-depth enough to determine whether or not AARC may or may not have been a “good” program. And in the end that really doesn’t matter. Because it was a first-of-a-kind, the issues of operating procedures, program constraints, outside perceptions and evaluation techniques all had to be addressed for the first time (and created from incomplete models). There are several lessons here for novel programs in the future.

3.6. MASSACHUSETTS STEP, TECHNOLOGY DEVELOPMENT CORPORATION AND EMERGING TECHNOLOGY FUND

Massachusetts has a portfolio of programs to aid economic development are perhaps one of the most comprehensive state level development programs geared to environmental technologies. There are 3 technology-related programs in the state of Massachusetts that seek to aid environmental technology companies to promote economic development.

- The Industry Specialist Program provides a single point of contact for firms in each specific high technology areas such as software, telecommunications, biotechnology, and environmental technology, among others, who seek access to state programs promoting new development in their sector. The Strategic Environmental Technology Partnership (STEP), established in 1995 within the Industry Specialist Program, is geared to environmental start-up companies.
- The second relevant Massachusetts’ development program for environmental technology companies is the Massachusetts Technology Development Corporation. Established in 1978 this fund invests in technology-based companies in the early stages of development (for example, R&D into pilot phase).
- The Emerging Technology Fund, established in 1995, is a debt financing fund for companies seeking to expand operations, is also available to environmental technology companies.

Each of these programs will be described in more detail in the next few paragraphs.

3.6.1. Massachusetts Industry Specialist Program and the Strategic Environmental Technology Partnership (STEP).

The industry specialists link businesses with the appropriate state assistance programs and agencies. These programs cover job training, business planning (including marketing), export promotion, site location assistance, financing, and permitting. The specialist program aims to simplify the process required to identify and apply for state programs. It also seeks to improve state program outreach to businesses. And finally, the specialist program seeks feedback from companies and industry associations on state policies to aid high technology firms development and growth and to offer suggestions for unaddressed barriers or problems.

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Industry councils are considered an important element of the network. These include: MA Biotech Council, MA Telecommunications Council, New England Environmental Technology Council, and MA Software Council, MA Food Assoc., MA Specialty Food Assoc., MA Aquaculture Assoc., The Agriculture Council, and University of MA Medical Center.

The Strategic Environmental Technology Partnership (STEP) was established as a partnership between the state environmental agency, the state university system, and the business development office to assist environmental technology and energy efficiency startup firms. Assistance, based on the specific needs of the company, can include business plan review; technical assessments; technology research, testing, monitoring, demonstration, and purchasing; and permitting assistance. These services are provided free of charge to the company.

As part of this program the University of Massachusetts received approximately $1.5 million in 1995 to perform research, testing and technical assistance to companies. The University also edits a quarterly newsletter to facilitate technology transfer. As a result of feedback from industry representatives, the Office of Business Development and the Department of Environmental Protection are working together to formulate a special permitting process for innovative technologies. Early on cooperation with the environmental organizations, such as the Department of Environmental Protection Office of Innovative Technology, was informal. These agencies help by providing a “green stamp”. This “green stamp” does not satisfy any regulatory requirements but helps companies because it indicates that the new technology is technically sound enough to move through the permitting procedures. It improves the company’s track record and data availability so that start-ups can get additional financing for commercialization. They also have a lot of demonstration projects to pilot and prove technologies. These projects either take a prototype to full scale demonstration to collect data required for permits or they “showcase” a new technology for marketing purposes. The support for demonstrations is generally in the form of the use of state facilities. The Department of Environmental Protection Innovative Technology (IT) program is also the liaison to the Memorandum of Understanding for the Evaluation and Promotion of Environmental Technologies with California, New Jersey, Illinois, New York, and Pennsylvania.9

3.6.2. Massachusetts Technology Development Corporation

The Massachusetts Technology Development Corporation (MTDC) was established in 1978 with funds from both the state and federal governments. As mentioned, this fund was established to invest in technology-based companies in the early stages of development (ex., R&D into pilot phase) in the state of Massachusetts. In Massachusetts as elsewhere, there is limited venture capital for firms outside of software, telecommunications, and biotechnology industries. Four primary goals of the corporation are to create employment in the state, attract and leverage private investment in Massachusetts based companies, foster the applications of technological innovations, and support entrepreneurship as a means for long-term economic development in the state.

The fund provides equity-style loans ranging from $250,000 to $500,000 for limited time periods, seldom providing 100% of the required capital. This initial investment in a company is used to draw in other investors into the pool. Investment criteria include location in the state, technology-based business, potential job creation, demonstrated ability to secure sufficient capital on affordable terms to finance expansion, and rate of return.

Initially, the MTDC began with $3 million US from the federal government and state support for operating expenses. From fiscal year 1981 to 1987 the state contributed a total of $5.2

9 See http://www.state.ma.us/step/stepmand.htm for the MOU.
million and beginning in 1988 the fund has been self-supporting as a result of its initial investments. Measures used to show the contributions of this fund include jobs created in the state, state and federal tax revenues, private capital leveraged (5.8 to 1 cumulative ratio of private to public investment in companies),

Approximately 13 percent of the companies in the MTDC portfolio are classified as material science and environmental management companies.

3.7. EMERGING TECHNOLOGY FUND

The Emerging Technology Fund was established in 1995 to provide debt-financing for companies that seek to expand manufacturing. It is quasi-government, which means that it while it started with state funds, the fund is privately operated and must be self supporting. Since 1995 there has been limited loan experience to-date and specialists recall few loans to environmental purposes. The fund was restructured in 1997 to improve loan operations.

There is a state-wide Permit Streamlining Initiative. This initiative seeks a uniform process permitting for all kinds of permits. This process would have a single point-of-contact and uniform timelines for permits and review, consolidated meetings with state agencies, and combined public hearings. Finally, the development agencies actively market the state and its business services. Outreach is performed through regional centers located throughout the state as well as nationwide.
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5.2. INFORMATION SOURCES


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The author would like to acknowledge the following people for their assistance and clarification on the policies and programs discussed in this report:
Robert Armstrong
Terry Bibbins
Ron Buchalt
Kenneth Friedman
Penny Hansen
David Rejeski
David Scott Smith
David Suining