Energy Technology Innovation at the State Level: Review of State Energy Research, Development, and Demonstration (RD&D) Programs

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ACRONYMS

ABSC	Applied Building Science Center
ACEEE	American Council for an Energy-Efficient Economy
ASDs	adjustable speed drives
ASERTTI	Association of State Energy Research and Technology Transfer Institutions
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
BIA	Bus Industries of America
BNL	Brookhaven National Laboratory
BPA	Bonneville Power Administration
CALBO	California Building Officials
CalETC	California Electric Transportation Coalition
CARB	The California Air Resources Board
CEC	California Energy Commission
CHEERS	California Home Energy Efficiency Rating System
CIEE	California Institute for Energy Efficiency
CPUC	California Public Utilities Commission
CRADA	Cooperative Research and Development Agreement
DBEDT	Hawaii Department of Business Economic Development and Tourism
DCA	Florida Department of Community Affairs
DHCR	Division of Housing and Community Renewal
DMACC	Des Moines Area Community College
DNR	Department of Natural Resources
DOE	U.S. Department of Energy
DOER	Massachusetts Division of Energy Resources
DOS	New York State Department of State
DPU	Department of Public Utilities
DSM	Demand-Side Management
ECW	Energy Center of Wisconsin
EEMs	Energy Efficient Mortgages
EEMs	energy-efficient motors
EEP	Energy Emergency Preparedness
EF	Efficiency Factor
EIERA	Missouri Environmental Improvement and Energy Resources Authority
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
ERS	Energy Resource Station
ERT	Energy Branch of the Energy, Resources, and Technology
ESEERCO	Empire State Electric Energy Research Corporation
EV	Electric Vehicle

ACRONYMS (CONT'D)

FERC	Federal Energy Regulatory Commission
FPL	Forest Products Laboratory
FSEC	Florida Solar Energy Center
GM	General Motors
GRI	Gas Research Institute
GWh	Gigawatt hours
HE	hybrid-electric
HERS	Home Energy Rating System
HEV	Hybrid Electric Vehicle
HP	horsepower
HVAC	heating, air conditioning and ventilation
IEC	Iowa Energy Center
IEL	Industrial Energy Laboratory
IOUs	investor-owned utilities
IRP	Integrated Resource Planning
ISU	Iowa State University
KEURP	Kansas Electric Utilities Research Program
kWh	kilowatt hours
LBNL	Lawrence Berkeley National Laboratory
LEAP	Leadership in Environmental Action Projects
LIHEAP	Low Income Heating and Energy Assistance Program
LRC	Lighting Research Center
MERP	Missouri Energy Resources Project
MMDP	Missouri Market Development Program
MnBRC	Minnesota Building Research Center
MTA	Metropolitan Transit Authority
MW	Megawatt
NASEO	National Association of State Energy Officials
NEEA	Northwest Energy Efficiency Alliance
NEMA	National Electrical Manufacturer's Association
NET	New Energy Technology
NLPIP	National Lighting Product Information Program
NREL	National Renewable Energy Laboratory
NYPA	New York Power Authority
NYSDPS	New York State Department of Public Service
NYSEO	New York State Energy Office
NYSERDA	New York State Energy Research & Development Authority
OPM	Connecticut State Office of Policy and Management
ORNL	Oak Ridge National Laboratory

ACRONYMS (CONT'D)

PNL	Pacific Northwest National Laboratory
POS	Performance Optimization Service
PSC	Public Service Commission
PV	photovoltaic
R&D	research and development
RD&D	research, development, and demonstration
REEDS	Residential Energy Efficient Distribution Systems
RFPs	requests for proposals
RPI	Rensselaer Polytechnic Institute
RPM	Responsible Power Management
SCAQMD	South Coast Air Quality Management District
SEED	School Energy Efficiency Development
SMUD	Sacramento Municipal Utility District
SoCAB	South Coast Air Basin
SRCC	Solar Rating and Certification Corporation
SWAP	Solar Weatherization Assistance Program's
TIPS	Targeted Investment Protocol System
UCLA	University of California at Los Angeles
USDA	United States Department of Agriculture
VIEO	Virgin Islands Energy Office
WAP	Weatherization Assistance Program
WAPA	Western Area Power Authority
WCDSR	Wisconsin Center for Demand-Side Research
WDSD	Wisconsin Demand-Side Demonstration

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EXECUTIVE SUMMARY

State energy research, development, and demonstration (RD&D) institutions have made valuable contributions to the energy balance, economic development, and environmental integrity of their states and the nation. They have helped companies develop and introduce new products and manufacturing techniques that protect the environment, enhance business revenues, create jobs, and save consumers hundreds of millions of dollars annually through lower energy bills. Despite their success, future prospects are uncertain given the dependency of many programs on oil-overcharge funding or utility contributions or surcharges in an era of utility restructuring, steady depletion of oil-overcharge funds, and broad-based declines in energy research and development (R&D) in the private, utility, and public sectors.

The study includes case studies on a dozen of the more successful ASERTTI programs, a discussion of relevant restructuring issues, recommendations on the role of state energy RD&D institutions in a more competitive utility environment, and profiles on 15 ASERTTI members. The objectives of the study are to:

- Inform policymakers, energy professionals, and the public regarding the status, funding mechanisms, achievements, and rationale for state energy RD&D organizations;
- Address the state energy RD&D role given a more competitive utility industry; and
- Evaluate different approaches to energy RD&D and technology transfer, which could help organizations design future programs and help states considering starting an energy RD&D organization.

An advisory panel with energy experts from ASERTTI, DOE, a national laboratory, an energy service company, a university, and a state utility regulatory commission provided input on project design, selection of case studies, and the draft report.

State Energy RD&D Institutions and the Association of State Energy Research and Technology Transfer Institutions (ASERTTI)

In 1990, several state energy RD&D institutions established ASERTTI in response to the increasing need for state initiatives in energy R&D, and technology transfer. ASERTTI is a confederation of state and regional organizations focused on enhancing energy research and technology transfer on a

Mission: "To increase the effectiveness of energy research efforts in contributing to energy security, environmental quality, and economic growth."

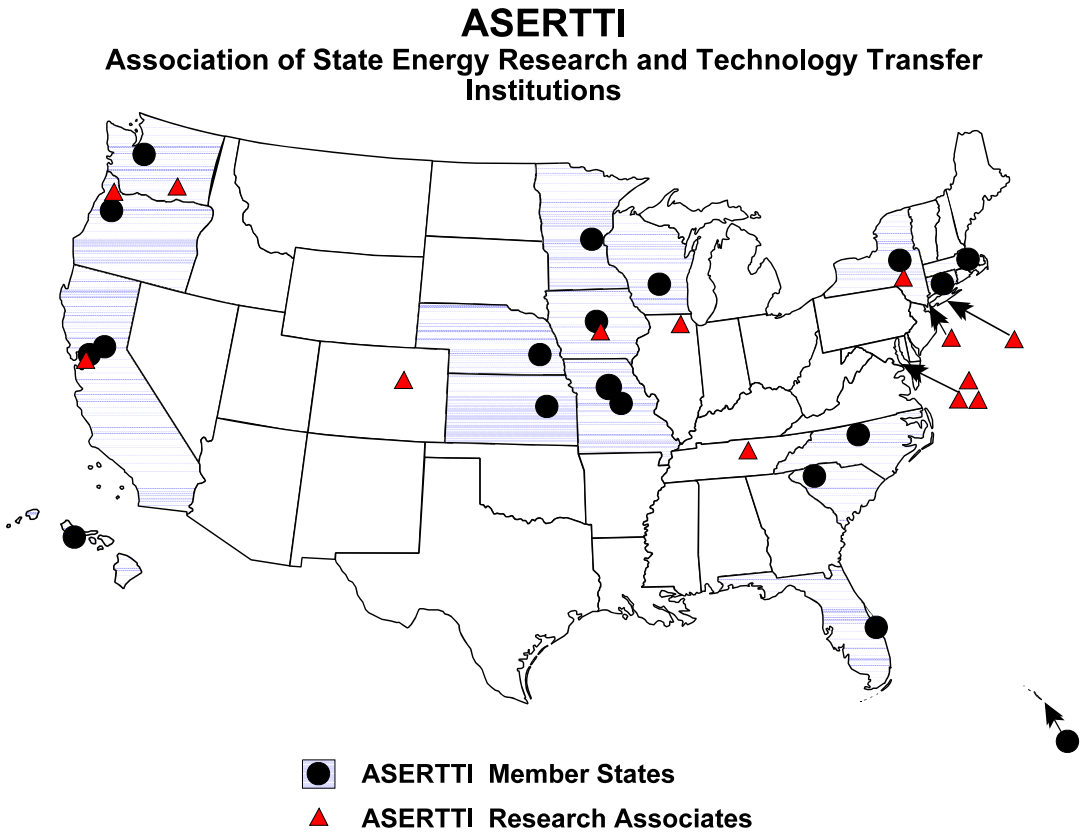
statewide and regional basis to promote collaboration and eliminate duplication. As of July 1997, 19 ASERTTI members represent 16 states and the Virgin Islands:

ASERTTI Members

California Energy Commission (CEC)
California Institute for Energy Efficiency (CIEE)
Connecticut Office of Policy & Management
Energy Center of Wisconsin (ECW)
Energy Systems and Resources Program, University of Missouri
Florida Solar Energy Center (FSEC)
Hawaii Department of Business, Economic Development, and Tourism (DBEDT)
Iowa Energy Center (IEC)
Kansas Electric Utilities Research Program (KEURP)
Massachusetts Division of Energy Resources (Mass DOER)
Minnesota Building Research Center (MnBRC)
Missouri Environmental Improvement and Energy Resources Authority (EIERA)
Nebraska Energy Office
New York State Energy Research and Development Authority (NYSERDA)
North Carolina Advanced Energy Corporation
Oregon Department of Energy
South Carolina Energy Research and Development Center
Virgin Islands Energy Office (VIEO)
Washington State University Energy Program

These institutions develop and promote energy efficiency and renewable energy technologies. ASERTTI members vary significantly in terms of type, funding levels, and funding sources. Table E-1 summarizes some key data for the 15 members that responded to our request for information.

ASERTTI members managed more than $170 million in 1995/96 for energy research. This amount includes a $65 million state RD&D institution budget and $109 million in project co-funding for the ASERTTI members who provided funding data. Compared to efforts of utilities, the federal government, Electric Power Research Institute (EPRI), and Gas Research Institute (GRI), who together spent more than a billion dollars on energy-related R&D in 1996, state energy R&D efforts are small. Despite relatively small funding levels, state energy RD&D institutions have sponsored public-benefit programs that have had nation-wide impact, and have been particularly effective in addressing state and local priorities.



Achievements and Lessons Learned from State Energy RD&D Case Studies

This paper includes 12 case studies of some of the more successful and innovative ASERTTI-collaborative and ASERTTI-member projects. The case studies reflect the innovative approaches that state energy RD&D institutions are taking—approaches that integrate technology development and deployment to advance state-of-the-art technical knowledge to address real-world needs and opportunities. These projects are not confined to a single piece of hardware; instead, they define technology more broadly to include energy systems and services. Table E-2 summarizes case study highlights.

State energy RD&D institutions have historically built on research by others and filled in gaps when a significant state need was not being met. The state energy RD&D institutions build on the more basic research capabilities of the federal government and university systems and focus on technologies and services with potential for timely commercialization and use. Many ASERTTI members have worked collaboratively with utilities to plan and manage programs. Most ASERTTI members work extensively with energy end-users and technology developers

Table E-2. Case Study Highlights

Residential Thermal Distribution Systems—develops and commercializes residential duct technologies.

- Savings potential for California consumers: $300-600 million per year. Reduces costs for sealing ducts in existing homes by half.

National Lighting Product Information Program (NLPIP)—publishes and distributes publications on innovative lighting products and subjects.

- Over 160,000 publications distributed to date.
- Country's primary source of *objective* information on efficient lighting.
- Serves as model for IEC's HVAC program.

Hybrid Electric Vehicle (HEV) Program—develops and demonstrates HEV technologies.

- Developed the first hybrid electric bus, and facilitated business partnership to produce 100 of these buses.

Residential and Commercial Heating Program—provides funding to heating-equipment manufacturers to develop innovative products:

- Pulse-combustion space-heating boiler saves 20 percent of energy and halves emissions.
- Condensing, gas-fired boiler cost effectively achieves 20 percent energy savings.

Low-Income Housing and Weatherization—develops and demonstrates technologies, processes, and strategies to save energy in low-income households.

- Targeted Investment Protocol System (TIPS) has helped low-income households cut energy bills more than 25 percent on average.
- Serves as model for other states.

Energy-Efficient Wastewater Treatment and Sludge Management Technologies—provides co-funding for municipalities and businesses to test, demonstrate, and implement technologies that save or produce energy.

- Savings for 6 recent projects: 19-65 percent energy savings; 18-86 percent cost savings.
- Non-energy benefits: reduction in residue disposal saves landfill space.

Biopulping—new technology that reduces energy and cost of making high-quality paper.

- Savings: 30 percent reduction in pulp grinder's electricity consumption.
- Non-energy benefits: increases throughput and produces stronger paper.

Responsible Power Management (RPM) High-Efficiency Motors Program—provides information and tools to motor distributors.

- Increased share of energy-efficient motors sold in Wisconsin to 37 percent in 1996.
- Coordinated utility programs and simplified rebate process across state.
- Serves as model for nationwide program.

Performance Optimization Service—uses *systems* approach to optimize entire motor system.

- Energy savings: 20-50 percent for systems identified as good candidates for POS.
- Average project payback: less than 2 years.

Reducing Cooling Loads and Smog Through Urban Heat Islands Control—measured energy savings of shade trees and light-colored roofs.

- Energy savings: approximately 30 percent (air-conditioning savings) from either strategically planted shade trees or reflective roofs.
- Doubling albedo of roofs and pavements decreases ozone levels by as much as 11 percent during peak afternoon hours.

California Building Code Project for Electric Vehicle Chargers—developed, adopted and trained building officials on building codes that ensure safe, effective installation of electric vehicle charging systems.

- Coordinated wide range of stakeholders with disparate agendas.
- Serves as model for other states.

Low-Cost Water-Heating Systems—promotes use of cost-effective, solar water heating.

- 460,000 solar water-heating systems installed in Florida, saving consumers $83 million/year.

in their respective states. The state energy RD&D institutions have developed many successful approaches to make public-interest RD&D efforts more effective:

- *Collaborating with a variety of partners* brings a diverse range of expertise to their projects, stretches research dollars, makes the technologies developed more marketable, and creates closer contacts with constituents.

- *Getting stakeholder input from the beginning of the process* allows for agreement on project design.

- Putting effort into *building strong partnerships* is part of what places state energy RD&D institutions in a unique position to involve a wide range of partners.

- Approaching projects as *objective service providers* strengthens their credibility.

- Taking *marketing and technology transfer* into account in initial project stages shapes research to accommodate commercialization and maximize effectiveness.

- *Understanding customers and marketplace dynamics* is key to successful marketing of new products or services.

- *Focusing efforts* is important and can be facilitated by structuring requests for proposals (RFPs) so that they solicit multiple complementary projects that address a topic area that has been identified as "ripe for action."

- *Being flexibile* allows organizations to act quickly to pick up "hot" projects, and fosters project expansion by being open to identifing opportunities throughout the entire project.

- *Being patient* is required because it often takes time to get the attention of manufacturers, develop a productive relationship with them, conduct R&D, and get to the commercialization phase.

State energy RD&D institutions have evolved over the years, learning lessons such as these not only from successes, but also from failures. Emphasizing project evaluation would further strengthen credibility, as most projects are not well-evaluated. Evaluation criteria should be identified early in the planning stage. Certain institutions have struggled with cumbersome administrative bureaucracies. Others are still working on maximizing the number of the "public" who can benefit from their public-benefit RD&D (i.e., doing good work *and* getting the message out—through marketing, publications, workshops, etc.). "Marketing" their prod-uct" could only be enhanced by further evaluation of their programs, so the public can better understand the magnitude of the return on the investment in energy efficiency and their contibution toward public-benefit RD&D.

State Energy RD&D Institutions as Providers of Public-Benefit RD&D

Public-benefit RD&D involves goods and services that benefit society, but for which private interests cannot capture enough revenues to recover the cost (plus a profit) of providing the goods and services (e.g., space exploration). In addition to providing a variety of services to promote the creation, development, and commercialization of new technologies for energy efficiency, public-benefit RD&D can address myriad market failures that persist in the energy services marketplace.

Public-benefit RD&D performed by state energy RD&D institutions is gaining in importance because fewer organizations are providing it as a result of electric utility industry restructuring, decreasing federal budgets, and businesses focusing more on near-term profits. Public-benefit RD&D that reduces energy use and pollution can also enhance business competitiveness by reducing the energy and waste content of their products.

In order for a market to function, good information is needed and state energy RD&D institutions have proven their ability to disseminate information well. By supporting development of renewable energy sources by local businesses, state energy RD&D institutions can diversify the states' energy resource mix.

State energy RD&D institutions can also reduce the economic and environmental costs of predicted growth in transportation energy demand, and help fiscally stressed municipalities meet environmental requirements.

While substantial and useful RD&D can be included in broader public-benefit programs, a valuable role exists for statewide, dedicated RD&D. The benefits of working at a statewide level, compared to federal RD&D, include:

- Focus on state and regional needs and opportunities provides RD&D that is not addressed by national programs (e.g., ECW's work with the paper industry and FSEC's promotion of solar water heaters);

- Closer ties with local industries and consumers make RD&D more "customer driven" (e.g., NYSERDA's work with New York businesses and CEC's work on building codes for electric vehicle chargers); and

- Closer ties with state and local RD&D expertise enriches the value of the RD&D (e.g., CIEE and University of California and LBNL).

Benefits also accrue from working at the statewide level as compared to individual company RD&D:

- Greater resources can be brought to bear and more coordination is possible than if individual companies and utilities operate their own public-benefit RD&D programs. For this reason, many utilities have voluntarily chosen in the past to channel a portion of their R&D funds through statewide organizations (e.g., NC Advanced Energy Corporation and ECW);

- A dedicated statewide R&D fund has greater visibility than more dispersed efforts;and

- State institutions are in a better position to leverage federal resources.

State energy RD&D institutions effectively fill a need for RD&D that can focus on state and local needs and coordinate a range of resources from across the state. The biggest issue currently on the minds of state energy RD&D institutions is the uncertainty of future funding sources as the electric utility industry restructures.

Electric Utility Industry Restructuring and the Future of State Energy RD&D Institutions

Utility restructuring will probably alter the mix of RD&D and may add new functions to state energy RD&D institutions' activities. In all five states that have ASERTTI members and where some restructuring decisions have been made, it appears that the R&D institutions will continue, some with their traditional funding sources and some with funding from a small charge on distribution service. In some cases, the role of ASERTTI members will expand, as has already happened with the California Energy Commission (CEC) and could happen possibly with Energy Center of Wisconsin (ECW) and New York State Energy Research and Development Authority (NYSERDA). A future role is not ensured in the case of California Institute for Energy Efficiency (CIEE), although given CIEE's expertise and experience, it is likely that it will partner with the CEC in planning, funding, and managing a major component of the public-benefit RD&D program. On the other hand, thus far, none of the other states that have made restructuring decisions have existing state R&D institutions, and in most cases are including public-benefit R&D as part of broader energy efficiency and renewable energy efforts. As the roles of state energy RD&D institutions change and expand, ASERTII's coordinating role will grow in importance.

While state RD&D institutions are likely to continue in many states following restructuring, this is only part of the picture. Utility R&D funding exceeds ASERTTI R&D funding by more than a factor of five. Even in states with large state R&D organizations such as New York, California and Florida, utility R&D funding exceeds state R&D organization funding to a substantial degree. As shown in many of the case studies in this report, ASERTTI members often work closely with local utilities to fund projects jointly, thereby leveraging ASERTTI members' funds. While some utility R&D funding will continue following restructuring, unless specific provisions are made by policy-makers, utility investments in end-use R&D are likely to fall precipitously. Such funding cuts will directly reduce benefits from these investments, and can

also adversely affect state R&D efforts because there will be less utility funding for state R&D institutions to leverage.

From our review of restructuring in California and other states, a number of R&D issues emerge that all states will need to grapple with as they make decisions on restructuring. Among these questions are the following:

- What is *public-benefit* RD&D, versus RD&D that can and should be funded by private entrepreneurs or regulated distribution companies?
- Is a dedicated RD&D fund needed, versus funding RD&D out of designated funds for such public purposes as energy efficiency and renewable energy?
- To what purposes should public-benefit RD&D be focused—energy efficiency, renewable energy, environmental research, environmentally preferred advanced generation, system reliability, others?
- Who should administer public-benefit RD&D funds—state agencies, utilities, state boards?
- How much funding should be provided?
- How should funds be allocated?
- To what extent should strategic planning guide decisions about allocation of public-benefit R&D funds?
- Should RD&D programs stop at the point of demonstration, or is there a useful and appropriate technology transfer role for R&D institutions including commercialization and promotion of new technologies in the marketplace?
- How can public-benefit R&D be made more effective?

Suggested answers to these questions are discussed in the Recommendations section of the full report. Briefly, we conclude:

- There is an important role for public-benefit R&D—not all good and socially beneficial ideas will be developed by the private market. Given past cutbacks in private and federal R&D that will be difficult to reverse, it is very important that steps be taken to minimize reductions in state and utility public-benefit spending.

- At least a portion of these funds should be in dedicated, statewide or regional R&D funds to permit a statewide or regional approach to R&D, rather than having to coordinate multiple utility-based efforts. Also, state institutions are probably in a better position to leverage federal resources than individual utilities.

- The R&D organization reponsible for administering programs must be not only a good administrator, but also technically competent and widely perceived as objective. The administrator should have a strategic vision of what it seeks to accomplish and have good ties with private companies and other researchers throughout the state and region. Administrators need the contacts and ability to involve other stakeholders in their planning, prioritization, and funding processes. The administrator also needs to be flexible and independent.

- State public-benfit R&D, including both statewide and utility-supported funds, is currently funded at approximately $2 per capita annually in the states that are leaders in energy innovation. This funding level may be a reasonable level to consider nationwide.

- Priority areas should be established to guide the allocation of funds, so that efforts are focused rather than scattered. For example, priorities can be established and used as the basis for a series of RFPs, one or more for each priority area.

- RD&D institutions should be broad in scope, with the ability to pursue technology transfer and deployment efforts to the extent other players are not adequately addressing these needs. RD&D institutions should plan for and be involved in commercialization activities, with the role of the RD&D institution gradually lessening as deployment proceeds.

State-sponsored RD&D emphasizing energy efficiency and renewable energy sources is a forward-looking investment that can pay off substantially in the long run given national and global challenges such as climate change, urban air pollution, and global economic competition. The states that nurture local production of technologies such as fuel cells, PV systems, hybrid electric vehicles, and super-efficient appliances, etc. *today* are likely to be the states that will be major suppliers of these key technologies of the 21st century.

INTRODUCTION

State energy research, development, and demonstration (RD&D) institutions have made valuable contributions to the energy balance, economic development, and environmental integrity of their states and the nation. They have helped companies develop and introduce new products and manufacturing techniques that protect the environment, enhance business revenues, create jobs, and save consumers hundreds of millions of dollars annually through lower energy bills. Despite their success, future prospects are uncertain given the dependency of many programs on oil-overcharge funding or utility contributions or surcharges in an era of utility restructuring, steady depletion of oil-overcharge funds, and a broad-based decline in energy R&D in the private, utility, and public sectors.

In 1990, several state energy RD&D institutions established the Association of State Energy Research and Technology Transfer Institutions (ASERTTI) in response to the increasing need for state initiatives in energy research and development, and technology transfer. ASERTTI is an informal organization focused on enhancing energy research and technology transfer on a statewide and regional basis to promote collaboration and eliminate duplication. Sixteen states and the Virgin Islands have state energy RD&D and technology transfer institutions that are members of ASERTTI. These institutions develop and promote energy efficiency and renewable energy technologies.

ASERTTI members managed more than $170 million in 1995/96 for energy research. This amount includes a $65 million state RD&D institution budget and $109 million in project co-funding for the ASERTTI members who provided funding data (missing data are from smaller members, so inclusion of these data would increase the above figures only marginally).

To put this spending in perspective, in Table 1 we compare these figures to estimates of energy R&D overall, to electricity R&D, and to energy efficiency and renewable energy R&D. As can be seen, state energy R&D efforts are small compared to total energy R&D, which includes such activities as research on nuclear energy and large R&D investments by major oil companies. However, state energy R&D expenditures become more significant when compared to electricity-related R&D, and even more significant when we look just at R&D on energy efficiency and renewable energy.

Despite relatively small funding levels, state energy RD&D institutions have sponsored public-benefit programs that have had nation-wide impact, and have been particularly effective in addressing state and local priorities. These institutions are particularly active in public-benefit RD&D. Public-benefit RD&D involves goods and services that benefit society but for which private interests can not capture enough revenues to recover the cost—plus a profit (e.g., space exploration). In addition to providing a variety of services to promote the creation, development, and commercialization of new technologies for energy efficiency, public-benefit

Table 1. Energy R&D Expenditures by Source and Year (in millions of 1995 $)

Source	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
All Energy R&D										
Private sector[1]	3583	3536	3580	3680	2997	2524	2414			
Public sector [1]	2643	2880	3428	3248	3323	2803	2951			
State R&D institutions (incl. in above)[2]									65+	
Total[1]	6226	6415	7008	6929	6320	5327	5365			
Electricity-Related R&D										
DOE[3]						1116	1148	1285	1029	
Utilities[3]						708			476	
EPRI (included in above)[1]	474	436	442	490	533	534	479	442	429	
Equipment manufacturers[3]	200									
Efficiency/ Renewable R&D										
Private sector[1]	392	497	318	527	509	322	290			
EPRI (included in above)[4]				33						11
GRI (included in above)[5]										13
Public sector[1]	350	339	321	407	470	518	611			
State R&D institutions (incl. in above)[2]									50+	
Total[1]	742	836	639	934	979	840	901			

Sources:

1. Dooley 1996. Figures represent best available data but are subject to several qualifications noted in the source report. In particular, the private sector efficiency/renewable numbers are conservative as they do not include the energy R&D investments of companies with R&D budgets under $1 million.
2. ACEEE estimates for this study.
3. GAO 1996.
4. Birk and Cugozzi 1997; Moskovitz, Nadel, and Geller 1991.
5. GRI 1997.

RD&D can address myriad market failures that persist in the energy services marketplace (Hanson 1996a).

More specifically, GRI, in a recent filing with the Federal Energy Regulatory Commission (FERC), proposed that public-benefit R&D meet the following screening criteria (GRI 1997):

- Benefits must flow predominantly to consumers;
- Benefits must be dispersed broadly among consumers;
- The project must provide least-cost energy service, increase efficiency, enhance safely, enhance environmental quality, increase system reliability or integrity, increase energy supply, or represent a fundamental breakthrough in technology;
- Benefits to existing classes of ratepayers must outweigh RD&D costs and demand-induced price increases; and
- It must be highly unlikely that the project would be adequately funded absent public funding.

Public-benefit RD&D performed by state energy RD&D institutions is gaining in importance because fewer organizations are providing it as a result of electric utility industry restructuring, decreasing federal budgets, and businesses focusing more on near-term profits. Public-benefit RD&D that reduces energy use and pollution can also enhance business competitiveness by reducing the energy and waste content of their products. In order for a market to function, good information is needed and state energy RD&D institutions have proven their ability to disseminate information well. By supporting development of renewable energy sources by local businesses, state energy RD&D institutions can diversify the states' energy resource mix. State energy RD&D institutions can also reduce the economic and environmental costs of predicted growth in transportation energy demand, and help fiscally stressed municipalities meet environmental requirements.

State energy RD&D organizations currently confront a number of challenges as well as opportunities. The major challenges include:

- budgetary pressures at the state level;
- limited interest in energy issues in general among policymakers and the public;
- declining utility support for energy efficiency programs and uncertainties concerning utility restructuring; and

- broad attacks on public sector RD&D spending by some politicians.

These challenges, notably the changing utility environment, have resulted in budget cuts or even threatened the existence of some state energy RD&D institutions in recent years, putting RD&D in the position of potentially becoming a "stranded benefit."

Major opportunities also exist for state energy RD&D institutions:

- the decline in utility support for efficiency and renewable energy programs presents new opportunities for state programs that could be funded by a wires charge on electric service;

- many companies have cut their internal R&D efforts and are more interested in partnering with public sector R&D organizations; and

- other funders (e.g., DOE or state energy offices) are experiencing budget cuts and are more interested in partnering to leverage their limited resources.

As the roles of state energy RD&D institutions change and expand, ASERTTI's role will grow in importance.

This study has several objectives:

- Inform policymakers, energy professionals, and the public regarding the status, funding mechanisms, achievements, and rationale for state energy RD&D organizations;

- Address the state energy RD&D role given a more competitive utility industry; and

- Evaluate different approaches to energy RD&D and technology transfer, which could help organizations design future programs and help states considering starting an energy RD&D organization.

Following a discussion of the methodology, the study includes case studies on a dozen of the more successful ASERTTI programs, a discussion of keys to success and lessons learned and relevant restructuring issues, recommendations on the role of state energy RD&D institutions in a more competitive environment, and profiles of 15 ASERTTI members that responded to our request for information.

METHODOLOGY

An advisory panel consisting of representatives of ASERTTI, DOE, a national laboratory, an energy service company, a university energy expert, and a representative of a state utility regulatory commission provided input on the project design, selection of case studies, and draft report.

ACEEE requested information from each ASERTTI member on: budgets, funding mechanisms, mission, scope and major approaches. Emphasis was given to energy efficiency activities, but renewable energy programs were also covered. Particular attention was given to the issue of utility restructuring and the role for continued/new state energy RD&D efforts in an increasingly competitive utility industry environment. Also, commonalities and differences among the ASERTTI members were explored through these information requests.

ACEEE also collected information and prepared case studies of particularly noteworthy projects and programs. The case studies were drawn from states that cosponsored this study (California, Wisconsin, New York, and Florida), with the assistance of the advisory panel, and were selected to cover a variety of sectors, approaches, and technologies. We discuss the approaches used and the role of the state energy RD&D organization, economic and environmental impacts, and technology development and technology transfer/promotion efforts. The case studies were prepared by reviewing documents, visiting and interviewing program managers, and interviewing equipment manufacturers and adopters.

Along with preparing case studies of successful programs, we also review and discuss areas where ASERTTI members have been less successful based on a review of reports, site visits, and interviews. This discussion is broad in nature, generalizing across the organizations, rather then focussing on particular projects.

Based on these case studies and the general review of the efforts of ASERTTI members, we draw conclusions about which state energy RD&D and technology transfer strategies have been most successful and which have been less successful, including factors that contribute to success. We give particular attention to those strategies that may be especially effective in a more competitive utility environment. We also provide program design recommendations that can be used by both existing state energy RD&D organizations and those considering starting such an organization. Finally, we present recommendations to state and federal policymakers regarding how they can best support energy RD&D and technology transfer in the context of government budget cuts and utility restructuring.

OVERVIEW OF ASERTTI

ASERTTI was established in 1990 as a confederation of state and regional organizations in response to the increasing

Mission: "To increase the effectiveness of energy research efforts in contributing to energy security, environmental quality, and economic growth."

need for state initiatives in energy research and technology transfer. ASERTTI members manage more than $170 million a year for energy research. Its research agenda focuses on energy-efficient and renewable energy technologies and priority energy areas where additional research is needed. ASERTTI pursues its objectives by:

- collaborating on research projects with state, federal, and private-sector partners (including utilities, trade associations, manufacturers, etc.);
- sharing technical and operational information among members and associates; and
- speaking with "one voice" on energy R&D policy issues to national, state, and local decision makers.

ASERTTI is an informal organization, with membership open to any state or regional institution conducting energy research or technology transfer. As of the date of this report, ASERTTI has 19 members, representing 16 states and the Virgin Islands. In addition to these state members, ASERTTI works collaboratively with many public and private, national and regional organizations. A list of ASERTTI members and collaborators follows on the next page.

ASERTTI members vary significantly in terms of type, funding levels, and funding sources. Table 2 summarizes and the appendix contains profiles of 15 ASERTTI members that responded to our request for information.

Areas of Focus

Priority areas for collaborative research are reviewed by ASERTTI members and associates annually. ASERTTI and its members are interested in jointly planning and implementing energy efficiency and renewable energy programs in the areas shown in Table 3.

ASERTTI Members

California Energy Commission (CEC)
California Institute for Energy Efficiency (CIEE)
Connecticut Office of Policy & Management
Energy Center of Wisconsin (ECW)
Energy Systems and Resources Program, University of Missouri
Florida Solar Energy Center (FSEC)
Hawaii Department of Business, Economic Development, and Tourism (DBEDT)
Iowa Energy Center (IEC)
Kansas Electric Utilities Research Program (KEURP)
Massachusetts Division of Energy Resources (Mass DOER)
Minnesota Building Research Center (MnBRC)
Missouri Environmental Improvement and Energy Resources Authority (EIERA)
Nebraska Energy Office
New York State Energy Research and Development Authority (NYSERDA)
North Carolina Advanced Energy Corporation
Oregon Department of Energy
South Carolina Energy Research and Development Center
Virgin Islands Energy Office (VIEO)
Washington State University Energy Program

ASERTTI Collaborators

Bonneville Power Administration (BPA)
Brookhaven National Laboratory (BNL)
Electric Power Research Institute (EPRI)
Gas Research Institute (GRI)
Interstate Renewable Energy Council
Lawrence Berkeley National Laboratory (LBNL)
National Association of State Energy Officials (NASEO)
National Renewable Energy Laboratory (NREL)
Oak Ridge National Laboratory (ORNL)
Pacific Northwest National Laboratory (PNL)
U.S. Department of Energy (DOE)
U.S. Environmental Protection Agency (EPA)

Table 3. Priority Areas for ASERTTI Collaborative Research

Commercial and Residential Buildings
- *New construction and retrofit*
- *Thermal distribution*
- *Heating, ventilation, and cooling*
- *Super commissioning (systematic efficiency from design commissioning)*
- *Life-cycle performance monitoring/diagnostics*
- *Lighting applications and controls*

Renewable Energy
- *Infrastructure development, training, and certification*
- *PVs (remote/distributed applications including building applications), biomass, and wind*

Industrial
- *Cross-cutting technologies (e.g., motors, compressors)*
- *Industries of the Future*
- *Waste reduction and treatment*

Transportation
- *Alternative fuels*
- *Alternative-fueled vehicles*
- *Intelligent transportation systems*

Water Treatment
- *Drinking water*
- *Wastewater*

Distributed Energy Systems
- *Institutional issues*
- *Technologies*

Partnerships
-
Technology/problem assessment
- *Technology development and commercialization*
- *Field-testing and demonstration*
- *Deployment and market transformation*
- *Monitoring and performance evaluation.*

State energy RD&D institutions are involved with hundreds of projects that encompass a wide range of objectives and accomplishments, including: reducing the cost of energy for businesses, municipalities, and residents; minimizing environmental impacts; and helping create and retain jobs. Specific examples of the achievements of the state energy RD&D institutions and their collaborators are shown in the following case studies.

For more information, visit the ASERTTI web page at:
www.energy.wsu.edu/org/asertti

CASE STUDIES

Residential Thermal Distribution Systems

Ducts are the most common residential thermal distribution system in most states. The following duct problems result in wasted energy and diminished comfort: leakage, excess heat conduction to unconditioned spaces, temperature imbalances, and excess air infiltration from inadequate return-air pathways. Significant heated or cooled air is lost through leaks from supply ducts into crawl spaces or attics, and leaks into return ducts draw hot or cold air from the attic into the system. Ducts are also less insulated than the house, so heat transfer through duct walls to and from the unconditioned spaces is a problem. Imbalance between the air flow in supply and return ducts can increase air infiltration and pollutants in the house. Poor ducts can also distribute air unevenly, leaving some rooms in the house significantly hotter or colder than others. In addition to wasting energy and diminishing comfort, problems with ducted distribution systems and their interactions with houses and air-conditioning heighten peak electricity demands.

Neither the construction industry nor the residential HVAC installation/service business currently address residential duct performance. In response to these needs, CIEE, with funding from DOE, selected LBNL, through a competitive solicitation process, to implement an integrated R&D and technology transfer program in residential air-distribution systems. The project:

- developed a patent-pending duct-sealing aerosol process that allows internal access, is less expensive and more convenient, and is being commercialized;
- developed a simplified diagnostic technique that facilitates leakage estimates in cases where building tightness is known through quality assessments or blower door measurements;
- developed improved modeling capabilities that quantify the thermosiphon effect as being responsible for 5 to 16 percent of total heating use, depending on the degree of duct insulation;
- gathered data on thermal performance and air leakage characteristics of air distribution systems in California homes;
- analyzed the principal mechanisms that reduce thermal energy distribution efficiency and increase energy use and electrical demand for space heating and cooling;
- developed new computer analysis tools that account for air-distribution system inefficiencies, including the interactions of ducts with the house and HVAC equipment;
- created and field-tested duct system retrofit protocols and detailed new-construction duct leakage measurement and commissioning procedures; and
- developed the now widely used direct duct-pressurization system for measuring leakage (Brown 1996; CIEE 1996; Modera 1996).

These activities were also supported through co-funding from DOE, EPA, and EPRI. Other ASERTTI members also provided support. For example, FSEC conducted independent studies and shared data and R&D products. The North Carolina duct training effort was based on FSEC and LBNL work and was conducted with technical assistance provided by FSEC. A mobile home component was conducted by ASERTTI members in North Carolina and New York and by ASERTTI collaborator Bonneville Power Administration (Cole 1997).

Results from the various ASERTTI collaborators were shared through the Residential Energy-Efficient Distribution Systems (REEDS). CIEE played a leadership role in forming REEDS in cooperation with ASERTTI, EPRI, GRI, DOE, and other private- and public-sector organizations. REEDS Consortium members have facilitated communication and cooperation among the organizations participating in residential duct R&D efforts, minimizing the overlap of activities and identifying areas that need attention and resources. The REEDS Consortium also developed a multiyear RD&D plan to guide the group's efforts, enhance technology transfer and minimize duplication of efforts. An investigation of residential homes with basements, sponsored by EPRI, NYSERDA, and ECW, was a direct outgrowth of the REEDS coordination effort (Cole 1997).

For example, REEDS planning determined that a comprehensive understanding of national impacts required the stock characterization efforts conducted by ECW, NYSERDA, and EPRI. REEDS coordination was also responsible for establishing a critical mass of resources and participation in the ASHRAE Standard 152 figure-of-merit performance characterization activities. Finally, a cooperative effort by CIEE, GRI, and EPRI published and distributed a Thermal Distribution Update in 1995 to inform the industry of trends and technology developments (Brown 1996; CIEE 1996; Modera 1996).

The REEDS collaborative process is essentially dormant because other ASERTTI members are not currently motivated to do much in their states. This may change as the Home Energy Rating System (HERS) and aerosol technology become available in their states for HVAC contractor field tests (Cole 1997).

Project Impact

This program is developing and commercializing the technologies needed (measurement techniques, diagnostic tools, sealing techniques, and duct hardware) to motivate widespread adoption of high-quality construction techniques and effective retrofit strategies for residential ducts. The savings potential for California consumers from retrofit performance improvements being investigated and developed under this project is $300-600 million per year (CIEE 1996).

Duct system improvements have real, understandable benefits for consumers. Field-monitoring of duct repair indicated an improvement in comfort—uniformity of heating throughout the house and a reduction in drafts. In addition, an analysis of duct insulation performance showed that

insulation levels could be increased without the consumer incurring higher first cost. Preliminary analysis shows that putting ducts inside the conditioned space can reduce the need for insulation. Increasing overall system capacity with the insulation also allows for downsized air-conditioning equipment, creating first-cost savings that offset the increased insulation costs. In this scenario, a consumer could save $30 to $40 in annual energy costs without spending more up front. These consumer attributes—increased comfort and energy savings without incremental cost—increase the opportunities for effectively marketing thermal distribution systems.

Many benefits have already been realized from this duct research. For example, the California Home Energy Efficiency Rating System (CHEERS) incorporated the simplified pressure diagnostic procedure for duct leakage into its rating system, resulting in important procedural improvements. ASHRAE anticipates standardizing the measurement protocol being developed by LBNL. Pacific Gas and Electric incorporated duct efficiency findings into its customer energy services program for high-performance residential air-conditioning.

This program also developed a cost-reducing technology that seals leaks in ducts by pressurizing the duct system with an aerosol that deposits on the leak edges. This technology is particularly useful for difficult-to-reach leaks. It may reduce total average costs for sealing ducts in existing homes by half, as well as substantially reduce the cost of creating tight duct installations in new construction (CIEE 1996).

Continued R&D and commercialization efforts in residential distribution technology will focus on:

- completing commercialization of the aerosol duct-sealing technology;
- developing standard procedures for evaluating longevity of duct seals;
- developing approaches for implementing ducts in conditioned spaces;
- developing retrofit approaches targeted at the failure of existing air-conditioning equipment, combining duct measures with right-sizing of new air-conditioning;
- continued improvement in diagnostic techniques;
- measuring the longevity of various duct seals; and
- expanded technology transfer efforts, including interactions with home energy raters and the California Residential HVAC System Quality Collaborative (Brown 1996; CIEE 1996; Modera 1996).

Lessons Learned

Technology transfer has been a part of this project's design from its initial stages, shaping the research to accommodate commercialization. One way technology transfer has been promoted is through collaborations with a wide range of partners, including the California Building Industry Association/Building Industry Institute, Natural Resources Defense Council, CEC, and ConSol (a major residential construction consulting firm). The collaborative brought a diverse

range of expertise to the project, stretched research dollars, and expanded the group that can claim ownership of its success. A representative from ConSol, in particular, noted that by bringing together practitioners with researchers, the technologies developed were more marketable. Although the university/government bureaucracy meant slower progress, ConSol believes this is a small price to pay for the expertise that comes out of the laboratory (Hammond 1997).

National Lighting Product Information Program

The National Lighting Product Information Program (NLPIP) is a national program operated by the Lighting Research Center (LRC) at Rensselaer Polytechnic Institute (RPI). LRC, which was started with research funding from NYSERDA in 1988, is the world's largest university-based research and educational institution dedicated to lighting. NLPIP was started in 1990 and is one of LRC's six program areas. NLPIP is a major source of objective information on efficient lighting products. The program is funded by several ASERTTI members, including NYSERDA, ECW, and IEC; EPA; DOE; and several electric utilities and utility organizations, who guide the direction of the program. Its goal is "to disseminate accurate, timely, manufacturer-specific information on energy-efficient lighting products, thus stimulating more widespread acceptance and more appropriate uses of these products." Prior to the inception of NLPIP, a reliable, independent source of lighting testing information did not exist (LRC 1996).

Lighting accounts for as much as 30 percent of the electricity consumed in New York State and 19 percent nationwide. At least a 20 percent reduction in this energy consumption is attainable through developing and commercializing of efficient lighting products. NLPIP is helping customers identify applications for energy-efficient lighting products in their facilities, homes, and offices by developing evaluation protocols, assembling product and manufacturers' data in useful formats, conducting tests, and producing and distributing the following publications:

- *Specifier Reports*—geared toward facilities managers, utilities, lighting designers, electrical contractors, and architects. They provide manufacturer-specific information on products such as power reducers, specular reflectors, parking lot luminaires, dimming systems for compact fluorescent lamps (CFLs), occupancy sensors, dimmable electronic ballasts, electronic ballasts, exit signs, and screw base CFLs.
- *Specifier Report Supplements*—provide updates on new products covered by previous Specifier Reports.
- *Specifier Report Abstracts*—geared toward non-technical people (e.g., chief financial officers) and trade shows. Available at no cost, they build sales for longer reports.
- *Lighting Answers*—tutorials on solutions to specific lighting problems for energy management systems and power quality of CFLs (e.g., electromagnetic interference involving fluorescent lighting systems, dimming systems for high-intensity discharge lamps, task lighting for offices, and multilayer polarizer panels).

Project Impact

LRC has printed more than 20 publications on different lighting products and subject areas, and has distributed more than 160,000 of these reports. The majority are distributed through EPA and other sponsors, while LRC sells about 25 percent. Performance information is used by specifiers and consumers. Based on EPA data, NYSERDA estimates that New York Green Lights Partners alone saved approximately $40 million through energy efficiency in 1996.

EPA is the largest single funder of NLPIP, contributing more than 20 percent of its budget in FY 1996/97. EPA's Green Lights Partners have found NLPIP's objective information to be the most valued part of EPA's Green Lights Program (Von Neida 1997). NLPIP has also enjoyed financial support from utilities, but their interest in sponsorship is waning because they no longer offer customer rebates through DSM programs, and utility restructuring efforts across the country have made utilities more focused on near-term cost-cutting.

NLPIP's work is valuable to a variety of end-users for many reasons. It is the country's primary source of *objective* information on efficient lighting, and end users highly value objectivity. Objectivity is supported by independent testing, outside technical reviews, and a focus on accuracy. End-users also value NLPIP because the information is manufacturer-specific, rather than solely theoretical, and uniform comparisons of products from different manufacturers facilitate decision-making processes. The information is kept current through updates to reflect changing technology, and publications are tailored for technical and non-technical audiences. These NLPIP characteristics were corroborated through discussions with several end-users (Hammer 1997; Olson 1997; VonNeida 1997).

NLPIP provides a model for product information programs for other technologies. For example, the IEC is creating a similar program for HVAC that will also be based on independent verification of manufacturers' data (Olson 1997). NLPIP received the 1994 Governor's Award for Energy Excellence in the Public and Private Colleges and Universities category.

Lessons Learned

LRC has found it is very important to involve stakeholders (e.g., manufacturers) from the beginning of the process to get both their input and their agreement on methodology. This may require spending more time upfront, but it saves time and improves the quality of the reports in the long run.

Another issue LRC deals with is the tradeoff between accuracy and timing—information is most valuable when it keeps up with quickly changing technology; however, accurate and thorough analyses take time. LRC invests time in checking the accuracy and completeness of the information it publishes, but because technology is continually changing, publications may not include new information that becomes available, so accompanying updates are published on an

on-going basis. LRC has built a reputation for having high quality standards, and has built a critical mass of talent in its interdisciplinary team (with specialists in architecture, engineering, communications, economics, human factors, lighting design, management, manufacturing, marketing, ophthalmology, optics, physics, psychology, and vision science) that analyzes human factors in addition to technical and design attributes of lighting.

Future NLPIP activities could be strengthened by documenting more results of impacts than are currently available. The value of NLPIP's work also could be increased by marketing information to a broader audience. This is recognized by LRC and its supporters. NLPIP is exploring new marketing vehicles, such as an NLPIP internet web site and targeted, direct mailings, to get its information to those who make decisions about lighting and can benefit from more efficient lighting technologies (Davis 1996; Leslie 1996).

Hybrid Electric Vehicle Program

New York's transportation sector consumes 39 percent of the state's energy, causes more than half of its air-quality problems, and is 99 percent dependent on out-of-state oil. Transportation energy use and its associated impacts are only expected to get worse over the next 20 years, with an anticipated 40 percent increase in transportation miles and a tripling in traffic congestion. NYSERDA has addressed these issues by developing and demonstrating technologies that not only mitigate energy and pollution problems, but also create opportunities for New York businesses in transportation industries (NYSERDA 1996a). One of the technologies NYSERDA is exploring is hybrid-electric vehicles (HEVs), in which the engine drives an electric generator that supplies power to electric motors that ultimately turn the wheels.

In 1988, NYSERDA began funding R&D in Hybrid-Electric Vehicle (HEV) technology to improve energy and environmental performance of future New York transportation choices and maximize New York State content of those products. The HEV program involves: heavy-duty vehicles, with a focus on municipal transit buses; medium-duty vehicles, with an emphasis on school buses and delivery trucks; and light-duty vehicles, with a focus on taxis (Drake 1996). The HEV program also includes component and subsystem product development projects, such as motors, generators, and controllers. NYSERDA is working closely with New York firms that are already producing similar products or have a logical self-interest in getting into these markets (Hudson 1996).

Project Impact

HEVs reduce emissions and fuel consumption by improving system operation efficiency, and provide range and performance competitive with conventional vehicles in urban settings. The program has demonstrated that HEVs save up to half the fuel and half the emissions of conventional vehicles. The manufacture of HEVs is expected to create high-technology jobs and make New York more competitive in product manufacturing. Sales of these hybrid-electric

transit buses, school buses, taxis, and delivery trucks are anticipated to generate $200 million in annual revenues in New York (Drake 1996).

One benefit of HEVs is regenerative braking, which means that when the vehicle stops or goes down hill, the motors act as brakes, generating electrical energy that is stored in batteries for subsequent use, resulting in energy savings and allowing a smaller engine. Also, because HEVs brake electrically, traditional brakes are used less. Since traditional brakes are a big repair item, reducing brake wear saves money in repairs. This feature is particularly advantageous in urban driving, where there is a lot of stop-and-go-traffic. HEVs are also quieter than conventional vehicles (Hudson 1996).

NYSERDA's various HEV projects have been geared toward vehicles that stop-and-go often, such as buses, taxis, and delivery trucks. These projects are in various stages of progress. NYSERDA is currently working with many partners in New York, mostly in the private sector, to develop, build, and demonstrate hybrid-electric (HE) products.

NYSERDA organized a project with Bus Industries of America (BIA) that designed, built, and tested a 26-foot-long natural-gas-powered HE transit bus—the first of its kind in North America. Because of this project's success, NYSERDA upgraded the bus and performed seven demonstrations for New York State transit authorities in 1995 and one university campus in 1996, resulting in production of the first hybrid-electric (natural-gas-powered) transit bus to operate in revenue service in North America. NYSERDA has since collaborated with the NY Power Authority to help the Metropolitan Transit Authority (MTA) get a $3-million grant from the Federal Transportation Authority, and formed a consortium that also included several utilities, Empire State Electric Energy Research Corp., BIA, and General Electric to develop a prototype diesel-powered 40-foot HE bus.

Hybrid-electric technology for medium-duty vehicles is similar to that for heavy-duty vehicles; however, the market for medium-duty vehicles is much more sensitive to first cost. Thus, the challenge was to develop a system that performed as well as, but was less than half the price of, heavy-duty HE vehicles. NYSERDA has worked with several New York companies to develop cost-effective technologies that will allow entrance into this market, including:

- Matthews Buses, Inc.—to develop and test a natural-gas-powered HE school bus;
- Lockheed Martin Control Systems—to develop and demonstrate a low-cost HE drive train for school buses; to develop a HE truck with Navistar;
- BFGoodrich Aerospace, Engine Electrical Systems Division—to develop a compact, lightweight generator for HE vehicles;
- Advanced DC Motors—to design, build, test, and demonstrate an improved DC motor and controller;
- General Electric—to design, build, and test ultracapacitor stacks and a controller;

- Mechanical Technology, Inc.—to develop an optimized flywheel rotor design for an electromechanical battery; and
- Clever Fellows Innovation Consortium, Inc.—to develop a cost-effective, low-emission, power-generation unit for HEVs (NYSERDA 1996a).

One outcome of these efforts was the development of a low-cost HE drive that was suitable not only for medium utility trucks, but also for heavy duty buses. In early 1997, Lockheed Martin and Orion Bus entered into a partnership to produce 100 HE 40-foot buses for commercial sale in 1997 and 1998. Orders for the first 15 buses were received within days of the first prototype production.

Taxis are an ideal candidate for HE technology because they are more sensitive to fuel and operating expenses than any other light-duty vehicle. Taxis also account for more urban air pollution than any other type of vehicle, consuming one-third as much fuel as a 40-foot transit bus. NYSERDA is working with a variety of partners, including: EDO Corp.; Mechanical Technology, Inc.; GSM Design Ltd.; Lockheed Martin Control Systems; and the New York City Taxi and Limousine Commission to develop a HE handicapped-accessible taxi, which will be made in New York. The project will produce a cost-effective, long-lived alternative to the conventional taxi. The taxi's design incorporates other NYSERDA-supported products, including BFGoodrich Aerospace generators.

Another key impact of NYSERDA's HEV program is that it allows New York firms to play a larger role in federal HEV programs.

Lessons Learned

NYSERDA has found success with this program by working with partners that show evidence of commitment and have logical self-interest. They have also found it valuable to be flexible in writing contracts, taking into account the private sector's need for potentially large returns to take risks with new technologies. NYSERDA comes to the table with technical expertise, which is particularly valuable to small firms that don't have large technical staffs or financial resources to buy expertise. However, even large firms have benefited from NYSERDA's technical support (Hudson 1996).

BFGoodrich Aerospace noted that NYSERDA was not only a financial partner but also a business ally, referring potential customers to BFGoodrich Aerospace (Eddy 1997). Lockheed Martin Control Systems indicated that NYSERDA's role as an organizational/networking facilitator was critical in bringing together the right people and getting answers to pertinent questions to move this work forward (Smart 1997).

NYSERDA has sponsored transportation projects for several years; however, it did not establish a formal transportation R&D program until 1993. NYSERDA was reluctant to establish a

transportation program under the belief that transportation R&D was an inherently national issue. With the passing of the Clean Air Act, the National Energy Policy Act, and the Intermodal Surface Transportation and Efficiency Act in the early 1990s, the need for improvements in the transportation sector increased. In just a few years, NYSERDA has demonstrated that a state can develop "homegrown" solutions to its unique transportation problems through an innovative transportation R&D program. NYSERDA's transportation program has focused on addressing urban driving cycles, congestion, and smog, building on the technical and business strengths of some of New York's non-traditional transportation suppliers. Other states may also find that homegrown solutions to their transportation problems are needed and indeed best for their state (Joseph 1997).

Residential and Commercial Heating Program

Over the past 10 years, NYSERDA has provided funding to many New York manufacturers of heating equipment through its Residential and Commercial Heating Research Program. The program has funded projects that developed products such as high-efficiency hydronic steam boilers; low-emissions gas and oil-fired burners; and combustion, monitoring, and safety controls. The program's goal is to bring projects to commercialization, so the program funds not only R&D but also marketing and plant equipment, depending on what an individual project needs to achieve commercialization. Achieving commercialization is not only good for energy efficiency, the environment, and the manufacturer's business, but also allows the manufacturer to repay NYSERDA's investment through royalties (Albrecht 1996b).

To assure commitment, NYSERDA requires partners to share half the costs of each project, either financially or through in-kind services. NYSERDA also makes a strong effort to find additional funding for projects (e.g., federal agencies or utilities). This added support strengthens the relationship between NYSERDA and the manufacturers, making NYSERDA more of an advocate rather than just another government agency. Most projects involve a team effort that includes two or more manufacturers of complementary equipment (e.g., manufacturers of burners and boilers) (Albrecht 1996b).

Approximately 20 companies in New York manufacture heating equipment, including boilers, compressors, controls, and burners. NYSERDA has supported product development at 10 New York companies. Collectively, participating manufacturers have heating sales of about $125 million annually, and account for 90 percent of boiler production in New York and 30 percent of production nationwide (Albrecht 1996b; Joseph 1997).

Project Impact

One particularly successful project was with Fulton Boiler Works, Inc. NYSERDA, Brooklyn Union, and Niagara Mohawk Power Corporation have been funding Fulton's work on developing a pulse-combustion space-heating boiler that reduces energy use by 20 percent and

cuts emissions by half. The new boilers can be used in multifamily buildings, institutional and commercial buildings, and industrial processes. Within the last five years, the pulse-combustion boiler has helped make Fulton one of the top 10 boiler manufacturers in the United States. Fulton has developed an R&D engineering staff, and built an R&D facility with funding from Niagara Mohawk. In addition, the boiler has improved Fulton's competitiveness in the world market, with 30 percent of its boilers being sold overseas. This project won a 1994 DOE National Award for Energy Efficiency and Renewable Energy, as well as a 1994 Governor's Award for Energy Excellence. These honors were awarded not only for Fulton's accomplishments, but also for its ongoing commitment to including product R&D as a permanent part of its business strategy (Albrecht 1996b; NYSERDA 1996d).

Another successful project NYSERDA coordinated is the development of the Quantum Leap™ condensing, gas-fired boiler with Dunkirk Radiator Corporation. The project was also supported by Brooklyn Union, Consolidated Edison Co., National Fuel Gas Distribution Co., and the New York Gas Group. The product is an ultra-low-emission, high-efficiency, condensing, gas-fired hydronic boiler for residential and commercial buildings. This boiler achieves 20 percent energy savings over conventional atmospheric gas-fired boilers, and is a cost-effective approach to reducing energy consumption. The product is now in limited production, with anticipated annual sales of $15 million after five to ten years. Dunkirk Radiator Corp. expects to double its size as a result of the Quantum Leap boiler (Albrecht 1996a).

Lessons Learned

The Commercial and Residential Heating Program has found that working directly with business partners, especially manufacturers, has been the most successful strategy. The program has found that building a strong relationship with partners involves more than just giving them funding. For example, NYSERDA has established itself as an advocate with its partners by helping to raise additional funding and being more flexible than other funders by allowing funding to support costs beyond R&D, such as marketing. The most successful projects have involved manufacturers with a strong commitment.

The ultimate success of a new product depends less on whether it is efficient or environmentally friendly, and more on cost-effectiveness, especially first cost. Program management addresses this marketplace reality by factoring into product development that the final product should be not only more efficient and environmentally friendly, quieter, more reliable, less-labor intensive, and more productive, but also less expensive. Successful marketing of a new product requires NYSERDA's project manager to understand not only the technology, but also the customers and marketplace dynamics.

Patience is also required for successful product development. It often takes time to get the manufacturers' attention and then develop a productive relationship with them. It can take several years of R&D to get to the commercialization phase. Once a prototype is being tested

in the field under a controlled situation, new problems often arise that need further time and attention (Albrecht 1996b). It can take years to introduce a new product and figure out a successful marketing strategy. Thus, funders need to take a long-term perspective and not expect results overnight.

Low-Income Housing and Weatherization

On average, low-income households pay between 12 percent and 26 percent of their incomes for energy—three to seven times the percentage that the median-income household pays (3.8 percent). The low-income sector's high energy burden creates a constant threat of termination of utility service, and a higher incidence of illness and deaths due to inadequate heating and cooling (NCLC 1995). New York State has more than 1.5 million households eligible to receive weatherization services (NYSDHCR 1997). Although New York spends about $800 million annually to assist low-income households, effective energy efficiency measures have been hard to implement because of financing difficulties and barriers that result from *owners* not wanting to invest in measures that save the *tenants* money. Potential energy savings in the public-housing and low-income sector are estimated to range from 12 to more than 30 percent (NYSERDA 1996b).

NYSERDA's Low-Income Multifamily Buildings Program's current goals are to:

- Develop and demonstrate technologies, processes, and strategies, including auditing and investment protocols, to achieve energy efficiency in low-income multifamily buildings;
- Evaluate and demonstrate new technologies appropriate for improving the energy efficiency of electrically heated multifamily buildings;
- Assess the feasibility of developing public- and assisted-housing cooperatives for the purchase of energy-efficient appliances; and
- Develop and demonstrate financing strategies and models for implementing energy efficiency measures in public and publicly assessed housing.

Project Impact

NYSERDA's greatest success in its low-income program has been its contribution to the development of the Targeted Investment Protocol System (TIPS) for low-income weatherization. NYSERDA began developing TIPS with the New York State Department of State (DOS) and Synertech Systems Corporation (the project contractor) in 1986, with the objective of investigating the benefits of and strategies for incorporating instrumented audit technology into local weatherization operations. For the past four years, TIPS has helped low-income New Yorkers cut home energy bills by more than 25 percent on average (based on project evaluations). This level of savings is significantly higher than traditional weatherization programs, which average about 15 percent energy savings. All 60 weatherization agencies in the state have been trained to use TIPS, which has been used in more than 25,000 low-income

households. Based on data in New York's 1997 Weatherization Assistance Program State Plan, TIPS has saved more than $30 million in energy costs to date (Joseph 1997).

TIPS characterizes the needs of each home, enabling Weatherization Assistance Program (WAP) technicians to determine the optimum level of investment for cost-effectively reducing energy use. Thus, TIPS allows a higher investment in some homes and a lower one in others. Although TIPS involves computerized software, its successful use depends on a protocol of interactive components, which involves training weatherization staff to make sound energy efficiency decisions. The NYSERDA/DOS/Synertech collaboration has produced several essential resources for using TIPS:

- Professional video *Weatherization: Doing It Right in the 90s* that explains TIPS and shows it being used in an actual weatherization job;
- Training notebook for optimizing weatherization;
- TIPS decision tree that guides the user to ask the most relevant questions that drive the process; and
- TIPS computer software, which satisfies all current DOE criteria, calculates fuel analysis, and computes savings and investment ratios for proposed retrofit packages.

The Weatherization Director at the State's Division of Housing and Community Renewal (DHCR)—Energy Services Bureau indicated that NYSERDA's role was critical in guiding the early development work and in directing the independent evaluation of the TIPS process (Gerardi 1996).

The program has been so successful that several other states and Canadian provinces are modeling their weatherization programs after New York's. Efforts are also underway to develop a TIPS approach appropriate for multifamily buildings and beyond the low-income sector. For example, banks may be more willing to negotiate on mortgage terms because TIPS provides an accurate way to measure savings. The project won an Energy Conservation Award from the National Center for Appropriate Technology (Gerardi 1996; Karins 1996; NYSERDA 1996a; NYSERDA 1993b; Rizzuto 1996).

The increased sophistication that TIPS and related processes have brought to the energy efficiency field has contributed to the creation of the Buildings Performance Institute (BPI). This newly created, non-profit organization will establish an infrastructure that will promote voluntary standards and best practices for building performance practitioners, which will bring uniformity to delivery mechanisms, product installation, quality control, and attention to health and safety issues. BPI will provide assessments leading to certification of competency for residential building performance practitioners. NYSERDA is collaborating on BPI with DHCR, DOE, and the Vermont Office of Economic Opportunity, in an effort to increase public confidence in the skills of energy efficiency practitioners. Fourteen other states have expressed interest in affiliating with this project. This effort will create jobs, reduce residential energy

costs, improve health and safety, and increase comfort and durability (Gerardi 1996; Karins 1996; Rizzuto 1996).

Lessons Learned

NYSERDA has played a critical role in this project by providing the resources necessary to make it happen—resources not available to DOS. NYSERDA brought together partners that have made progress that they most likely would not have achieved working independently. The collaboration has not only advanced cost-effective energy efficiency progress for the low-income sector in New York, but also has shown how the same methods can be advantageous for other customer sectors and in other states and countries. The depth and potential breadth of this work results from a comprehensive approach that looked beyond traditional measures of performance (e.g., number of measures installed, number of households weatherized) to include more quantitative measures, such as energy saved and cost per unit of energy saved (Gerardi 1996; Wojcik 1997).

Energy-Efficient Wastewater Treatment and Sludge Management Technologies

Municipal wastewater and sludge treatment in New York uses six million kWh of electricity daily (two to three percent of the state's generation, and enough energy for 300,000 homes), and is expected to rise due to the need to meet more stringent effluent limits, control toxics, remove nutrients, treat storm water and control air pollution (NYSERDA 1996b). High energy costs have made operating expenses for wastewater treatment plants one of the largest expenses for many communities. NYSERDA's Energy-Efficient Wastewater Treatment and Sludge Management Technologies Program provides co-funding for municipalities and businesses who want to test, demonstrate, and implement innovative technologies and management techniques that save or produce energy (Pakenas 1996). The program's objectives are to:

- Develop and demonstrate methods to control treatment processes, pretreat wastewater, treat industrial wastes and storm water, increase plant treatment capacity, remove nutrients and toxics, and minimize sludge production;
- Develop and demonstrate low-cost, innovative technologies to treat wastewater and manage septage from small communities;
- Determine and demonstrate technologies to reduce energy use and control air emissions from sludge incinerators, dewatering and drying equipment, composting, and other methods to manage and safely use sludge products;
- Develop and commercialize innovative products and systems to treat wastewater and manage sludge; and
- Participate in the Community Environmental Center (cosponsored by EPRI, Con Edison, NYSERDA, and others) to develop and promote new, energy-efficient technologies for municipal water and wastewater treatment, sludge management, and hospital wastes (NYSERDA 1996b).

Project Impact

Since 1984, NYSERDA has provided almost $6 million for more than 50 wastewater treatment and sludge management projects in New York State. A recent analysis of six projects showed energy savings from 19 to 65 percent, resulting in cost savings of 18 to 86 percent (Pakenas 1997). NYSERDA will fund up to 75 percent of total project costs, with the locality's share either in cash or in-kind services. Industrial projects can obtain up to 50 percent of funding from NYSERDA with a recoupment provision for successful projects. Municipalities are encouraged to find necessary expertise by establishing project teams, including subcontractors (NYSERDA 1993a). NYSERDA works with a variety of co-funders, including utilities (electrotechnologies), manufacturers of energy-efficient equipment, and EPA.

One success story is from the city of Geneva. The city of Geneva's Wastewater Treatment Plant replaced surface agitators with energy-efficient aeration panels, reducing energy use by about 40 percent. This modification also allows the plant to accept and treat more diverse and stronger waste streams. Thus, local industries also save money because they have to pre-process wastewater to a lesser extent. Although the local industrial economic effects have not been quantified, the enhancement of the wastewater treatment plant has bolstered Geneva's economic development. For example, the plant's enhanced capabilities saved a local shampoo manufacturer hundreds of thousands of dollars in wastewater treatment costs and facilitated the siting of a $120-million glass plant. Geneva wastewater treatment plant management were very pleased with the opportunities and guidance that NYSERDA provided them throughout this project, which would not have happened without NYSERDA's involvement (Eddington 1997).

Additional successes include NYSERDA's work with the following:

- The city of Buffalo installed a sludge dryer at a wastewater treatment facility that reduces by 50 percent the need to run the incinerator with expensive auxiliary fuel;
- Binghamton-Johnson City designed, installed, and tested a 200-kW cogeneration system that saves $89,000 in energy annually, yielding a six-year payback; and
- Canandaigua Wineries installed and is operating an anaerobic expanded-bed system in place of conventional aerobic technology to pre-treat wastewater prior to discharge in a municipal sewer.

Many projects also have non-energy-related benefits, such as reduction in residue disposal, which saves landfill space (NYSERDA 1996d). An example is a project with Suffolk County that is demonstrating the use of sludge incinerator ash as an aggregate for pavement and concrete products (Joseph 1997).

Lessons Learned

NYSERDA Program management believes that a key to its success is the competitive solicitation process, which it lets the market determine which projects are worth pursuing. The process is end-user driven, requiring an operator's commitment to make the project a success; proposals must include an estimate of the time the operator will commit, as well as the level of co-funding. The process also involves setting objectives that reach beyond energy efficiency to a wider range of problems. Solicitations are structured to get operators to quantify their definition of success, including what they are looking to improve and how they will measure it. Proposals undergo review by: (1) an internal/external technical team; (2) the NYSERDA (program management, legal, and contracts staff); and (3) NYSERDA senior management, and can be vetoed at any of the three levels. Sometimes NYSERDA conducts extensive meetings with potential program participants before accepting a proposal; this helps operators focus on goals (Pakenas 1996).

NYSERDA's senior management has pushed to "raise the bar," getting better projects and helping the program evolve by making the proposal format more end-user driven and by doing better marketing. Staff go out in the field to facilitate communication, understand motivation, find the right people, and build relationships to enhance their efforts to achieve their goals. Municipalities often take a long time to make a decision and take little initiative to promote new technologies, so, in many ways, they are more difficult partners to work with than private industry (Pakenas 1996). Additional quantitative analysis of energy and cost savings could strengthen the argument for pursuing more projects in this area. Such projects also lend themselves well to replication, and efforts to duplicate successful results should be exploited.

Biopulping

Biopulping is a new technology that could reduce the energy and cost required to make high-quality paper. A fungus common to Wisconsin's forests, *Ceriporiopsis subvermispora,* has the natural ability to digest wood without breaking up the cellulose. Letting the fungus grow on wood chips reduces the amount of mechanical grinding required to produce a high-quality pulp with extra-long cellulose fibers, which makes the paper stronger. The fungus also removes pitch, an unwanted component of the wood (Kohler 1996a).

Biopulping is the product of $5-10 million in research conducted over nine years by the United States Department of Agriculture's (USDA) Forest Products Laboratory (FPL) and its colleagues in the Biopulping Consortium (the University of Wisconsin-Madison Biotechnology Center, the University of Minnesota, and members of the pulp and paper industry). The Energy Center of Wisconsin (ECW) became involved with biopulping at a point when the Biopulping Consortium hit a roadblock in terms of moving to the next step of development: larger-scale testing. Wisconsin's utilities have been particularly interested in this project because the paper industry uses three to four times more energy than any other industry in the state; however, the magnitude of the project was too great for any one utility to fund, so they were supportive of ECW's involvement. ECW provided $150,000 in capital needed to fund large-scale experiments to allow

researchers to document energy savings and fine-tune the process while demonstrating how biopulping might work in an industrial setting. Although ECW's investment was small compared to the time and money already invested in the development of biopulping, its involvement came at a critical time, when no one else was willing or able to fund the technology's next step toward commercialization (Shipley 1996).

In addition to funding the pilots, ECW is cosponsoring a biopulping workshop for Wisconsin paper mills in the spring of 1997 to inform potential endusers of the technological and economic aspects of biopulping. This workshop is an important component of ECW's contribution to this project because many in the paper industry are aware of biopulping but are not aware of how advanced it is technologically and the economic benefits there may be for them (Hardiman 1997). ECW has also produced an educational video on biopulping to reach audiences beyond the workshop (Kohler 1996a; Shipley 1996).

Project Impact

Biopulping has the potential to transform the paper industry. Not only does the process produce stronger paper and remove unwanted pitch, the 50-ton demonstration exhibited a 30 percent reduction in the grinder's electricity consumption. For perspective, an average mechanical mill (600 tons of pulp per day) could recover the $3.5-million biopulping capital cost in 10 months through energy savings (assuming a $0.05 per kWh electricity cost). The pilot has also shown that biopulping gives the mill flexibility to increase the chip throughput by as much as 25 percent. Although this increased throughput reduces energy savings from 30 percent to 25 percent, because of increased production, capital costs can still be recovered in less than four months (Shipley 1997).

To date, biopulping research has been conducted for mechanical paper mills, which produce about 15 percent of all paper. Because paper from the biopulping process is stronger, it may attain greater importance compared to the current source of stronger paper, *kraft* mills, which use a chemical process. This would be advantageous because the kraft process is costlier, uses chemicals that damage the environment, and has a low yield (about 50 percent of the pulp is lost in the kraft process as compared to a seven percent loss in the mechanical biopulping process). In addition, further research and modifications could make biopulping work in kraft mills, which account for approximately 85 percent of paper production (Kohler 1996a). DOE and ECW may co-fund research on biopulping in kraft mills (Shipley 1996).

Adoption of biopulping by paper mills could have a significant impact on Wisconsin's economy. Paper mills are Wisconsin's largest industrial energy user and have an annual payroll exceeding $1.6 billion. Wisconsin is the largest producer of paper in the United States and successful biopulping would improve the State's competitive position. This technology is not, however, limited to Wisconsin; it has potential benefits for the paper industry, the worldwide economy, and the environment. Wisconsin would benefit from mills biopulping outside the State by

collecting royalties on the technology and perhaps becoming a supplier of the fungal inoculum and equipment necessary for biopulping, as well as implementing the technology at mills (ECW 1996f).

Masood Akhtar, the FPL scientist leading the project, has been speaking to paper companies around the world about this technology. Interest in the technology is higher in other countries than in the U.S. because U.S. paper-production plants are more capital-intensive and less labor-intensive (i.e., they are more automated), making any sort of production changes a bigger decision (Akhtar 1997). The extent of potential worldwide economic and environmental impacts has not been quantified; however, based on pilot-testing thus far, biopulping has the potential to save orders of magnitude more than the investment in its development.

From a paper company's perspective, this technology's success depends on overcoming certain perceived drawbacks of the process. One drawback is the change in the optical properties of the wood, which decreases the paper's brightness. Another issue stems from the time it takes to process wood chips, which has been reduced to one to two weeks, but would still require a paper producer to devote a significant amount of space to processing the chips. Weather also factors into the equation, as there's some uncertainty about whether processing adjustments would be needed to deal with extremely cold temperatures or heavy snowfall. Even with these reservations, Consolidated Papers, Inc. of Wisconsin Rapids, Wisconsin, sees potential in the technology and is investing about $25,000 to conduct the next 50-ton trial, for which FPL will provide the treated wood chips (Sanborn 1997).

Because the most difficult barrier is getting the first paper mill to adopt the new technology, ECW designed an agreement it hopes will motivate commercialization of the technology. The agreement, between Wisconsin Alumni Research Foundation (WARF), FPL, and ECW, encourages biopulping by halving the licensing fee paid by paper mills (that are ECW-member-utility customers) that adopt biopulping technologies within five years of commercialization[1]. During this same period, ECW receives half the royalties actually paid by the mills. These monies will support future research at FPL and the University of Wisconsin to improve biopulping technologies (MOU 1996; Shipley 1996).

Lessons Learned

This project demonstrated the importance of being flexible. ECW was able to act quickly, picking up the project mid-fiscal year, finding money in the budget, sole-sourcing the project to the only people able to do the work, and creating an innovative agreement.

[1] The licensing fee is paid to WARF, the owner of the biopulping technology. "Commercialization" is defined as starting when the first end-user begins using and paying royalties for the biopulping technology. The discount allowed to end-users has a ceiling of 50 percent of ECW's trial-test funding.

Responsible Power Management High-Efficiency Motors Program

Electric motors use more than half the nation's electricity. Responsible Power Management (RPM) is a collaborative effort of Wisconsin's electric utilities, coordinated and managed by the ECW. The RPM High-Efficiency Motors Program provides information and tools to motor distributors in Wisconsin to promote the sale of high-efficiency motors. RPM was created in January 1993 to reduce confusion stemming from utilities having a variety of motors programs. Motor vendors had complained that different rebates and program requirements had fragmented the motors market in Wisconsin, which made selling energy-efficient motors (EEMs) difficult. RPM's goals are to (1) accelerate the adoption of motors that meet the proposed 1997 federal minimum efficiency standards, (2) transform Wisconsin's electric motors market to higher efficiency levels, and (3) reduce the cost of utility-sponsored programs by leveraging distributor efforts (Hagler Bailly 1996).

RPM focuses on distributors; marketing to end-users is the responsibility of local utilities and motor vendors. The program has developed a coordinated set of sales support tools and training for distributors selling motors in Wisconsin:

- Program brochures, videos, and advertising emphasize the benefits of EEMs, especially cost savings. The quarterly newsletter updates distributors on RPM and the performance optimization of fan, pump, and blower systems (a detailed description of the Performance Optimization System follows);
- *MotoRater Plus* is a circular slide rule that can be used to evaluate the cost-effectiveness of high-efficiency motors, which helps determine when to repair a motor and when to replace it with a high-efficiency motor;
- *MotorMaster* software is a database of available motors and case studies produced by DOE and distributed by RPM;
- MotorFacts Form is a reference tool that helps distributors and customers calculate a high-efficiency motor's payback period;
- Annual breakfast meetings explain program features to distributors. A toll-free line is available for questions and comments.
- Presentations are made at trade shows and professional meetings.
- Motor Partners (similar to DOE's Motor Challenge Partners) invites companies purchasing motors to become a partner by agreeing to purchase high-efficiency motors. In return, Motor Partners receive the MotorMaster database and public recognition.

Project Impact

A recent evaluation found a high level of awareness of the program and the benefits of high-efficiency motors. While the evaluation found moderate to low levels of use of RPM's tools and information, some tools proved to be very helpful to the largest distributors in the state.

MotoRater and *MotorMaster* were found to be the most remembered tools, with the video being the least remembered (Hagler Bailly 1996).

The biggest factor influencing high-efficiency motor sales is rebates. In 1995, rebate levels were reduced and a statewide standardized rebate application form was introduced. In 1996, some utilities eliminated rebates, while remaining utilities dropped first-tier rebates (EPACT standards) and reduced second-tier rebates (premium efficiency) to 1995 first-tier levels. These declining rebate levels have been accompanied by declining sales of high-efficiency motors. In 1997, it is likely no rebates will be offered (Hagler Bailly 1996).

RPM's initial goal was very ambitious: to increase market share of three-phase 1-200 hp energy-efficient motors sold in Wisconsin to 80 percent by January 1997 (no baseline data are available). Based on a sample of 22 distributors, the share of energy-efficient motors increased to 52 percent in 1994 as a result of the combination of RPM program tools and motor rebates, but then fell to approximately 37 percent in 1996, most likely because of the reduction in rebates (Hagler Bailly 1996).

ECW was successful at coordinating utility programs and simplifying the rebate process for utilities, trade allies, and motor distributors across the state (Krajnak 1997). RPM is a model for a nationwide coordinated motor program developed by the Consortium for Energy Efficiency (CEE), including participants from Wisconsin, California, the Northwest, and the Northeast. These utilities represent about 11 percent of national electric sales (DeLaski 1997).

Lessons Learned

In a broad study, based on focus groups, the usefulness of RPM tools varied for different types of distributors. For example, distributors with big, long-standing accounts liked and used the tools because they have more of a customer-service relationship with their customers, who look for guidance and advice, thus giving the distributor time to use the tools to help the customer buy the most efficient motor. Other distributors sell motors more as a commodity, meaning the customer wants motors fast and at the lowest price, precluding the distributor form taking even a short amount of time to promote efficiency using RPM tools. Although this demonstration project was specifically aimed at distributors, it is possible some of the RPM tools may be better targeted at customers (Hagler Bailly 1996; Pigg 1997).

As the utility industry restructures, as the private business sector continues to become more competitive through downsizing, and as motor standards rise, informational programs such as RPM need to adjust to the changing environment. The Hagler Bailly (1996) evaluation makes several recommendations:

- Develop case studies for the most prevalent state industries;
- Continue newsletters, *MotoRater, MotorFacts*, and make them easy to reorder;

- Keep *MotorMaster*, and other tools with timely data, updated;
- Eliminate video distribution;
- Use breakfast meetings to give annual updates;
- Fine-tune the market for RPM tools, eliminating distributors who are not likely to make use of them;
- Expand beyond motor efficiency to include quality motor repair, motor systems, and OEM markets; and
- Continue to refine and improve tools.

Performance Optimization Service (POS), profiled below, is a part of RPM.

Performance Optimization Service

In 1993, several Wisconsin utilities and Wisconsin Demand-Side Demonstrations, Inc. began demonstrating the Performance Optimization Service (POS). In January 1995, the program was transferred to the ECW, which is working with DOE's Motor Challenge to refine training and develop new marketing materials. POS built on the work of the coordinated Canadian utilities' Performance Optimization program led by Ontario Hydro and begun in the late 1980s. Utilities in both Canada and Wisconsin had initially focused their efforts on identifying applications for adjustable-speed drives (ASDs). However, the utilities realized that this component focus proposed an answer before asking the question of which technologies make the most sense for each customer. Consequently, the POS concept uses a *systems* approach to optimize the entire motor-driven system (e.g., minimize system losses and match pump or fan output to system requirements).

Project Impact

The energy savings from fan, pump, or blower-system upgrades are estimated at 20-50 percent for systems identified as good candidates for POS. As of the fall of 1996, POS had 30 active pilot sites. For the 26 sites for which initial walkthrough data were available, the estimated payback on investments in efficiency ranged from a few months to four years, with an average payback of 2.3 years (ECW 1996d). Based on known and estimated costs and energy savings for
sites proceeding toward implementation, the average payback is 1.2 years, excluding POS program development costs ($918,000), and 1.8 years including those costs. These estimates do not account for productivity gains known to exist at some of the sites (Hanson 1997).

Utility customer service representatives identify candidates for POS feasibility studies. A POS engineer then offers the customer a quick, free, engineering "walkthrough" analysis of their systems. If substantial savings are projected, a feasibility study proposal is prepared to determine precisely what needs to be done to improve efficiency and performance, and how much money it will save the customer (Kohler 1996b). Once a proposal is accepted, a POS engineer performs

field performance testing to collect system-load and operating data. In coordination with the utility customer service representative, the engineer then prepares a feasibility study report that includes a recommended design strategy, and details the technical and economic impacts of the project.

A specialized technical background requiring experience in several elements (e.g., fluid dynamics, turbo machinery performance characteristics, motors and controls, sensors, and engineering economics) is required to carry out this assessment. The Wisconsin and Canadian programs recognized that few individuals or firms were expert in all elements, so they developed a training program with support materials for utility representatives, consulting engineers, trade allies, and end-users/consumers. This training is tailored for generalists and specialists according to their roles and responsibilities, and creates a pool of knowledgeable practitioners that can support the utilities' program (Wroblewski 1996).

In the past, POS offered two training courses. A three-day comprehensive course was geared toward engineers, and a one-day course, geared toward utility representatives, focused on identifying POS opportunities. Both courses had a heavy emphasis on promoting POS as a utility program. The training program has recently been redeveloped to be more customer-oriented, with a two-day, in-depth technical session focusing more on performance optimization as a technical concept rather than a utility program. This revised program, along with a one- or two-day module including a hands-on lab session at the boiler plant, forms the basis of training for engineers who will conduct feasibility studies. In addition, local engineers are paired with an expert mentor for on-the-job training, because ECW found that a three-day training course was not enough to get local engineers to the point where they could provide a high-quality product in a reasonable amount of time. ECW is also considering developing a one-day module that focuses on motor systems in general, and positions POS as one aspect of a comprehensive maintenance program. In addition, 30-60-minute mini-sessions on efficient motors and motor systems will be developed to promote the concepts at dinner meetings, trade shows, etc. (Wroblewski 1997).

The program has now trained enough engineers in the utility service territories where pilot installations are beginning to take place; marketing to customers began in 1996, with evaluation of program results to follow in the future (Prestil 1996). One of the first projects undertaken by this program was at the G. Heileman Brewing Company.

G. Heileman Brewing Company

The G. Heileman Brewing plant was experiencing problems with inadequate process cooling during the summer to meet production demands. The plant was looking at increasing either the chiller or pump capacity of its cooling system. The POS analysis traced the problem to a 150 HP pump that was heavily throttled, and recommended that the pump impeller be trimmed, which allowed the throttling valve to be opened. This measure reduced the losses resulting from the valve and allowed the pump to operate more efficiently. The flow could then be increased from 1,200 to 1,500 gallons per minute, while reducing energy consumption by half, which provided the cooling needed by the process. The plant is realizing annual energy savings of 490 MWh and cost savings in excess of $18,000. Thus, the company's $7,500 investment was recovered in just a few months (ECW 1996e).

Utilities have offered a range of incentives to encourage customers to undertake POS projects, including: partial reimbursement for feasibility studies, customized rebates based on projected energy savings, low-interest loans, and shared-savings contracts through an independent financing organization. Some utilities will continue to offer partial reimbursement for feasibility studies in 1997; however, few utilities still fund installation of equipment. Utilities would like to finance the studies and projects but large industrial customers do not seem to be interested in financing. Another issue is whether customers or utilities should pay for feasibility studies. Providing studies free of charge might increase their frequency; however, giving them away for free reduces the perceived value of the study.

Finding sites that will move forward is a difficult and long process. Of the approximately 50 sites contacted, nine have done feasibility studies and seven have proceeded toward implementation, of which three are complete. Although a higher success rate is certainly desired and sought, this 14 percent hit rate may be reasonable or even better than what can be expected when selling similar products or services to the industrial market.

Lessons Learned

POS has evolved over time, and now focuses on providing information and convenience for the customer. The greatest challenge is making it clear to customers and engineers that the concept works and is profitable. One way this is being done is by giving customers a comprehensive proposal right after the initial walkthrough, outlining what needs to be done, what it will cost and what it will save. This immediate feedback helps keep up the momentum and motivation. Another change to the program is to provide the services of a technical expert to the customer throughout the entire process. The expert’s involvement seems to be highly valued by the customers, and may be a key factor in building customer confidence in the technical approach and the program (Wroblewski 1997). The intent is that this expert will mentor a local engineer, who, in turn, will enhance the sustainability of the efficiency process in a market economy (Kohler 1996b). So far, experts teaming with local engineers hasn’t resulted in much business

for the engineers. This makes it difficult to keep their interest, as they do the feasibility studies free of charge and site visits can take a couple of days (Wroblewski 1996).

A utility partner praised the program for reaching beyond energy savings to look at overall process efficiency, but recognizes the potential barriers that must first be overcome. Both the utility collaborator and program management agreed that one barrier to achieving success with this program is the cost of the feasibility study. Many businesses are not willing to spend thousands of dollars to find out how much money they might be able to save through the project. One possible alternative is to conduct somewhat less rigorous, less expensive feasibility studies for smaller systems that require little capital outlay. This initial cost may be a stumbling block for industrial customers. One result of a less rigorous study would be that some energy savings may not be recognized and would therefore be excluded from upgrading. However, from a broader perspective, more energy efficiency measures may be implemented for a larger number of customers (Krajnak 1997; Wroblewski 1996).

Management attributes program success to being open to identify opportunities throughout the entire process. Identifying opportunities is facilitated by providing training to customers, so they are receptive to the message. An important lesson learned from this program is to do customer training in the first stage (instead of training local engineers first), while developing a local resource to get some solid successes up front. Proof of success provides the credibility needed to "sell" the program's services on a broader scale. Credibility is also enhanced by the service provider's objectivity. As the electric utility market restructures, utilities are losing perceived objectivity, which makes ECW's objectivity even more important (Wroblewski 1996).

Reducing Cooling Loads and Smog Through Urban Heat Islands Control

Elevated temperatures in urban areas, "urban heat islands," result from a high amount of dark surfaces (buildings and paved areas), and a low amount of vegetative cover. Air in a typical city can be approximately 5ºF warmer than surrounding rural areas on a clear summer afternoon. Higher temperatures lead to higher electricity consumption for air-conditioning. The additional air-conditioning contributes five to ten percent of peak electric demand at a direct cost of several billion dollars per year. Higher temperatures also accelerate formation of hazardous ozone and the evaporation of organic chemicals from vehicles, paints, fuels and chemical storage tanks. Combustion sources, such as vehicles, refineries and power plants, produce hydrocarbon and nitrogen oxide emissions that react in the sunlight to form smog. Thus, elevated temperatures and increased cooling needs have a compound effect on smog formation.

Many efforts have been made to reduce emissions in California, but until CIEE became involved, temperature reduction as a means to smog reduction was not investigated in depth. Although the theoretical advantages of reflective surfaces and trees are well known, their potential impact had not been quantified, nor were there any organizations whose missions included these strategies. CIEE initiated research to fill this void and was essentially the sole

funder of this work from 1991 through 1995. EPA and DOE then provided some support that has helped with technology transfer (Cole 1997).

CIEE issued a competitive solicitation in 1990 to investigate the effects of increased urban albedo (solar reflectivity) and tree cover. Lawrence Berkeley National Laboratory (LBNL) won the bid to do the research, which focused both on building energy end-use efficiency (direct effect) and city-scale atmospheric cooling and reduced smog formation (indirect effect). LBNL collaborated with many research partners, including: UCLA, Sacramento Municipal Utility District (SMUD), and DOE. CIEE funded these complementary projects from 1990 through 1993 (Akbari 1996; CIEE 1996; Taha 1996a).

The LBNL Heat Island Group conducted a controlled experiment that measured and analyzed energy savings of shade trees and light-colored roofs on selected residences and public buildings in Sacramento. The Group also performed numerical building energy simulations, modifying the DOE-2.1.E building energy computer model to analyze energy savings of high albedo and shade trees. They then validated the accuracy of the model using field data. To determine how much tree planting and increased albedo was needed to reduce ozone levels and improve urban air quality, LBNL modified and used pollutant and biogenic emission inventories and meteorological and air-quality computer simulation models used by the South Coast Air Quality Management District (SCAQMD), EPA, and other state and federal environmental agencies.

Project Impact

In terms of direct effects, the project determined that increasing the albedo of urban surfaces and planting urban trees extensively could limit and possibly reverse the heat island effect, and also possibly reduce ozone concentrations by reducing chemical reactivity and evaporative emissions. Researchers found that shade trees and solar-reflective coatings on roofs and walls can cost-effectively reduce peak electrical demand and air-conditioning energy use. Reflecting, rather than absorbing, energy lowers building cooling loads by decreasing the surface and air temperatures near the building. Shade trees reduce cooling loads by blocking the heat from the sun and by promoting evaporative cooling. One experiment showed air-conditioning energy savings of around 30 percent from either strategically planted shade trees or reflective roofs, especially in buildings with inadequately insulated roofs and walls.

LBNL's modifications to the DOE-2.1.E building energy computer model has improved the model so it can now be used to determine energy savings for different types of buildings in various climate regions that use shade trees and solar-reflective roofs and walls, as compared to other energy efficiency measures.

This research on direct effects has had a wide range of impacts:

- Data on reflectivity are the basis of national efforts (by industry leaders and researchers) under way to label paints, roofing materials, and road-surfacing materials with information about their energy impacts;
- A patent is pending on coatings that reflect both solar radiation and heat, saving energy and exhibiting fire-retardant properties;
- Southern California Gas has minimized energy use at its new Energy Resource Center by using white surfaces and trees; and
- SMUD is considering a follow-up project to analyze the potential of high-albedo roofs to reduce energy use in commercial and multifamily buildings, and single-family homes.

In terms of indirect effects, simulations indicate that in the South Coast Air Basin (SoCAB), if the albedo of roofs and pavements were doubled, ozone levels would decrease by as much as 11 percent during peak afternoon hours. Increased urban vegetation was shown to lower ozone levels if the additional trees are low emitters of hydrocarbons. Adding two low-emitting trees to each house in the SoCAB would lower ozone levels by as much as 14 percent during peak afternoon hours. Increasing both albedo and vegetation cover was found to decrease ozone by up to 20 percent during an August day (LBNL 1997; Taha 1996b).

These improvements in air quality are similar to those from implementing other major strategies such as vehicle emission control. For perspective, lowering the temperature by 5°F in the LA basin is equivalent to switching all vehicles to electric power. Savings from this magnitude of temperature reduction are estimated at $500 million per year as a result of reduced smog and electricity use. About $300 million of these savings are related to improved health from reduced smog. These impacts are the most important but are also the most difficult to measure. Independent reviews of LBNL's simulation models are under way by Applied Modeling, Inc.; however, even if the models were overstating impacts by 90 percent, temperature-lowering impacts would still be significant (Akbari 1996; Taha 1996a).

Additional impacts from indirect-effects research include:

- Identifying tree species that can worsen air quality through emission of relatively high levels of isoprene (e.g., eucalyptus). A 40 percent reduction in smog is estimated simply from switching tree species to those with low emissions;
- Developing a state-of-the-art inventory of vegetative cover and albedo in the SoCAB and a detailed database of tree characteristics that policymakers can use to determine the benefits of programs aimed at reducing basin temperatures through tree planting and surface lightening; and
- SCAQMD has conceptually included high-albedo materials and urban vegetation in its 1994 Air Quality Management Plan as a strategy for lowering ground-level ozone concentrations, and has expressed interest in collaborating with LBNL to perform more extensive computer analysis studies for the SoCAB and establish mechanisms that will

permit solar-reflective surfaces and tree planting to qualify for market incentives that exist under SCAQMD's Regional Clean Air Incentives Market program.

This project has proven to have substantial potential in California, but the modeling capabilities can be applied to any urban area. The calculations of effects on pollution and temperature will vary according to the characteristics of the each urban area, but the analytical techniques are readily transferable. Pursuing this line of pollution prevention is estimated to have annual savings potential of $10 billion by 2015, assuming an adoption rate of five percent of homes and buildings by that date (Akbari 1996; CIEE 1996; Taha 1996a). Program collaborators (SCAQMD and DOE) agree this program has resulted in a foundation of valuable research, but that more time and funding are needed to maximize benefits from these efforts (DeCot 1997; Hogo 1997).

Lessons Learned

CIEE had the vision to pursue this approach to energy savings, fulfilling a previously neglected opportunity. By being open to all possibilities and asking a lot of questions along the way, the scope of the project expanded beyond energy efficiency to include smog reduction and health benefits. CIEE and LBNL were well-positioned to collaborate with others to build on their expertise, such as modifying simulation models already in existence (Akbari 1996; CIEE 1996; Taha 1996a). Program management believes that better models, more accurate input data, and validation of simulations with extensive field data would have enhanced their work (Taha 1997).

California Building Code Project for Electric Vehicle Chargers

The California Air Resources Board (CARB) adopted a mandate to require California's seven largest automobile sellers to produce EVs beginning in 1998. CEC is taking a two-pronged approach to support electric vehicles: technology R&D and infrastructure development. The goal of the California Building Code Project for Electric Vehicle Chargers is to develop, get adopted, and train building officials on the new building codes necessary to ensure safe and effective installation of EV charging systems in commercial and residential buildings. Establishing an infrastructure to support the EV technology (e.g., refueling, financing, insurance, safety standards, and maintenance) is one of the greatest challenges to commercializing a new transportation technology (Fong 1996; Kateley 1996).

To complement CARB's regulatory approach to commercializing EVs, CEC is working to provide positive market signals to consumers, automakers, and fuel suppliers. Part of this approach involves CEC's facilitating demonstration programs to learn about infrastructure and customer needs, and to communicate what is learned to stakeholders. CEC is well-positioned to understand how the actions of the public sector affect the private sector because of its experience in new technology development and commercialization (Fong 1996; Kateley 1996).

CEC research found that the resolution of infrastructure barriers was lagging behind the EV mandate, so it initiated work in 1994 to revise California's State Building Code to include health and safety requirements for EV charging systems. CEC worked in partnership with General Motors (GM), Hughes Power Control Systems, the California Electric Transportation Coalition (CalETC represents the major California electricity providers), CARB, and California Building Officials (CALBO are experts in code development and enforcement within the building industry community). CEC had only $10,000 in its budget to start this project, but leveraged its resources 6:1 through the partnerships it established. CEC facilitated an open consensus process designed to provide equal and thorough evaluation of issues by a wide range of concerned parties. Code changes were adopted in November 1995 and took effect statewide in August 1996 (Fong 1996; Kateley 1996).

Project Impact

The project itself does not save energy or reduce pollution. However, without the infrastructure this project supports, commercialization of EVs and the resulting benefits could not be realized. This project ensures public health and safety, provides code consistency among local building departments, precedes the expected increase in EVs in California, prepares local jurisdictions for new vehicle technologies, allows time for industry to comply with codes, simplifies the permitting process, reduces the cost of complying with regulations through consistent interpretation and enforcement, and builds confidence among consumers and safety enforcement professionals in new technology (Fong 1996; Kateley 1996).

In 1996, more than 200 building officials and inspectors received training. Three additional training classes are scheduled for the summer of 1997, although more may be given as needed or requested by a particular community. CEC, CALBO, and CalETC are now managing additional statewide training through local groups and the CALBO Training Institute. Training will be an ongoing process and will eventually be integrated with other building code training (e.g., plumbing, etc.). CEC is managing a similar project with the State Fire Marshal to provide training on proper response personnel (e.g., law enforcement, fire, and medical). Feedback mechanisms allow for continual determination of effectiveness and corrections as needed (Fong 1996; Kateley 1996).

Another benefit of this program is that it is nationally transferable. CEC has been able to help other states get started on their development of an infrastructure to support EVs.

Lessons Learned

All stakeholders agreed that a smooth and clear regulatory framework for EV charging is a key element in the success of this project and the ultimate success of the market introduction of EVs. CEC, because of its long history with building code professionals, was well-networked and in a unique position to access and include a wide range of partners in the code-making process.

In addition to the funding partners listed above, numerous others participated, including (but not limited to): California State Fire Marshal, California Building Industry Association, National EV Infrastructure Working Council/EPRI, National Electrical Manufacturer's Association (NEMA), and Underwriters Laboratories. Partners provided expertise and guidance that built professional credibility which, in turn, built support and increased endorsement. Through an open participatory process, CEC achieved consensus early in the process, rather than designing a code itself and imposing it upon stakeholders. Open consensus assured thorough evaluation of issues, giving stakeholders ownership in the resulting code. This successful collaboration could not have been possible without CEC staff commitment (Fong 1996; Kateley 1996).

Representatives from CalETC, CALBO, and GM agreed this project was the most successful collaboration among public and private sector entities they had ever seen, and that CEC played a valuable role facilitating the networking among parties, catalyzing the process, maintaining flexibility to respond to changing technology, and successfully passing the code, as well as supporting current training efforts (Martin 1997; Shelton 1997; Young 1997).

Low-Cost Water-Heating Systems

Solar water heating has many economic and environmental implications. Water heating is often the second largest user of energy in a home after space conditioning. This cost can be reduced by increasing the water heater Efficiency Factor (EF). For perspective, efficient electric water heaters should have an EF of at least 0.9, while solar water heaters have an EF ranging from above one to greater than ten (Harrison 1997). This level of efficiency translates into a savings of as much as $300 per year for a family of four (FSEC 1989). From a jobs perspective, solar water heater manufacturing has the highest ratio of employment per million dollars expended by any energy industry, drawing from fields such as engineering, control and optical material systems, piping, construction, plumbing, and pumps (DOE 1995).

FSEC's extensive involvement in promoting the use of solar water heating includes:

- Creating a low-cost solar collector manufacturing facility in consortium with Florida collector manufacturers;
- Undertaking the Manufacturing Support Initiative to improve solar collector and system component performance, reduce manufacturing costs, and simplify installation;
- Coordinating installation of solar water heaters in low-income households;
- Providing technical support for nationwide certification of solar collectors and water-heating systems;
- Evaluating certification applications and calculated performance ratings using detailed computer modeling; and
- Providing consultation and technical advice to utilities on solar water-heating programs (FSEC 1996).

As part of a statewide campaign to reduce consumption of non-renewable energy resources, FSEC is collaborating with DOE and the Florida Department of Community Affairs (DCA) in a three-year pilot to install low-cost solar water-heating systems in low-income households. The Solar Weatherization Assistance Program's (SWAP) goals are to (1) reduce energy consumption and lower energy bills for low-income households while promoting solar water heating, and, in the long run, (2) determine whether solar weatherization measures are feasible in DOE's national Weatherization Assistance Program (WAP). SWAP also provides an opportunity to prove the feasibility of the product, making it more marketable (Fairey 1996; Harrison 1996).

SWAP provides grants to local weatherization agencies to install a variety of simple, reliable, low-cost solar water heater systems on existing electric water heaters. FSEC established contractor and solar system qualifications and provides technical assistance, while DCA administers the program.

Another important component of FSEC's work on solar water heating is the technical support it provides to the Solar Rating and Certification Corporation (SRCC), an independent, non-profit organization that certifies and rates the performance of solar energy equipment. With DOE funding, FSEC does all the testing for the country. SRCC fulfills an important function in promoting the marketability of solar water heating by providing reliable and comparable data for solar water-heating collectors and systems (SRCC 1996).

Project Impact

Due in part to FSEC's strong support for the state's solar industry, 460,000 solar water-heating systems have been installed in Florida in the past 15 years, producing an energy equivalent of 980 GWh, and saving consumers $83 million annually (FSEC 1995).

Of SWAP's 800-unit goal, more than 500 systems have been installed, with additional units on the way (Harrison 1997). Through system monitoring, FSEC will analyze the cost-effectiveness of the solar water-heating systems used in the program by monitoring pre- and post-program hot water usage and costs at 35 sites (hard monitoring) and weather-adjusted utility bills for an additional 200 sites (soft monitoring). These data are not yet available (Harrison 1996). SWAP is controlling costs by downsizing the solar water-heating systems to accommodate existing 40- and 52-gallon electric water heaters, rather than installing systems with 80- or 120-gallon solar tanks, which provide a greater volume of hot water. The average system costs around $1,500 installed and is expected to reduce water-heating bills by half, saving a household more than $150 annually (Emrich and Block 1996).

Lessons Learned

FSEC has learned that to further a new technology, building a reliable industry is important. It has promoted this through contractor licensing, equipment certification, product improvements,

and training installers and inspectors. Through its efforts to simplify code systems, FSEC has made solar water heating look like a standard appliance. Another way to further new technologies is to make the marketing/installation process as painless and inexpensive as possible. Through SWAP, FSEC has tried to do this by finding customers for dealers to reduce their marketing costs (Harrison 1996).

Many barriers to widespread market acceptance of solar water heating still exist. For example, it is difficult to finance this equipment. Companies that provide their own financing have been most successful, but it would be helpful if such measures could be included in a mortgage (Harrison 1996).

KEYS TO SUCCESS/LESSONS LEARNED

A *collaborative process* was used in each of the case studies profiled and was the most often cited reason for project success by state energy RD&D institutions. Since the RD&D is for the public benefit, it makes sense to include a broad spectrum of interested parties. Many of the state energy RD&D institutions have been successful in bringing a diversity of stakeholders into the process of identifying, funding, and implementing RD&D work. The collaborative effort brings a diverse range of expertise to the project and stretches research dollars, as well as expanding the group that can claim ownership to its success. By bringing together practitioners with researchers, the technologies developed are more marketable.

It is very important to *get stakeholder input from the beginning of the process* and get them to agree on project design. It is also important to involve partners that show evidence of commitment and have logical self-interest. ECW has found that providing monthly budget-tracking information on contracting, expenditures, and percent of project complete allows interested parties to follow activities. Collaboration may require spending more time up front, but saves time and improves the quality of the project in the long run. Most state energy RD&D institutions are well-networked and therefore well-positioned to collaborate with others to build on their expertise. State energy RD&D institutions have often played a critical role tying together in-state, regional, and national efforts (e.g., ECW's RPM, CEC's EV chargers, the LRC, and ductwork). The RD&D institutions have also been successful at using existing tools when they can, rather than reinventing the wheel (e.g., adapting DOE models for the heat island project, and using Motor Master for RPM).

Part of what puts these state energy RD&D institutions in a unique position to access and include a wide range of partners in their projects is the effort they themselves put into *building strong partnerships*. For example, NYSERDA has established itself as a business ally, providing technical expertise, referring potential customers to project partners, getting answers to pertinent questions, helping to raise additional funding, and being more flexible than other funders by allowing funding to support costs beyond R&D, such as marketing. State energy RD&D

institutions are also often more able to devote time and resources to address problems others are unable to handle (e.g., New York's weatherization program work).

Partnerships are strengthened by credibility, which is enhanced by the *objectivity of the service provider*. Using outside technical experts to peer review the projects and entire research process strengthens the credibility of the work of these institutions. As the electric utility market restructures, utilities are losing perceived objectivity, which makes the state energy RD&D institutions' objectivity even more important. The objectivity of state energy RD&D institutions has allowed them to build an infrastructure that creates a reliable industry for new technologies, which, in turn, promotes technology transfer. FSEC, for example, has set up a system for contractor licensing, equipment certification, product improvements, and training of installers and inspectors.

Credibility could be further strengthened by better *project evaluation*. Evaluation criteria should be identified early in the planning stage. Longer-term project success is difficult to document because it is affected by a wide range of variables (e.g., RPM and solar water heaters in Florida). Reasonable, carefully defined goals are often easier to achieve and document (e.g., NY boilers, EV charging stations).

The strength of the partnerships that state energy RD&D institutions have developed has had financial ramifications. The institutions have been able to *leverage their budgets with co-funding from project partners*. For example, NYSERDA averages co-funding at a level three times its own budget and KEURP has a 5:1 leveraging ratio. Co-funding not only allows state energy RD&D institutions to stretch financial resources, but also strengthens partners' commitment.

Marketing is important to technology transfer at several levels: marketing the state energy RD&D institution's services to potential partners, and marketing project products (e.g., new technologies or processes, services, publications) to those who can benefit. Including a technology transfer plan in the initial project stages is critical if research is to be shaped to accommodate commercialization (e.g., residential thermal distribution systems). Effective technology transfer/marketing involves understanding customer motivation. Most often, the strongest motivation is money—businesses want to pursue projects that make them more profitable and consumers want to buy products that provide valued services or save them money. This marketplace reality should be factored into product development so the final product not only has a variety of attractive features (e.g., more reliable, less labor-intensive, and more productive), but is also less expensive (e.g., aerosol duct-sealing). This requires more documented results of cost/benefit impacts than currently available.

Successful marketing of a new product or service requires project management to understand not only the technology, but also the customers and marketplace dynamics. This knowledge allows project management to provide relevant information and convenience for distributors and customers by combining research with publicity/user education. During the project, the

marketing /installation process should be made as painless and inexpensive as possible (e.g., solar water heaters). Working as partners with private companies that sell the products tends to lead to more marketable new technologies (e.g., NYSERDA's residential and commercial heating program).

Another way of incorporating market factors into a project is through the *competitive solicitation process,* which lets the market determine which projects are worth pursuing. NYSERDA and CIEE have had good experience with requests for proposals (RFPs) that define a focused activity area and solicit specific projects within the defined area. Structuring RFPs in this way can help direct strategic planning and vision so efforts are focused rather than scattered, and allows for multiple complementary projects addressing a topic area that seems ripe for action. The process is end-user-driven, requiring the end-user's commitment to make the project a success. Solicitations should be structured to get those who propose the project to quantify their definition of success, including what they are looking to improve and how they will measure it. Prior experience with letting state legislatures specify projects proved unsuccessful at targeting worthwhile research, with legislators favoring projects based on whether or not they favored business in their district.

Flexibility is noted by many as a key to success. For example, ECW was able to act quickly to pick up the biopulping project mid-fiscal year, finding money in the budget, sole-sourcing the project to the only people able to do the work, and creating an innovative agreement. Flexibility is also important in terms of being open to opportunities throughout the entire project. Being open to all possibilities and asking a lot of questions along the way often expands the scope of the project beyond energy efficiency to include other benefits such as process efficiencies and pollution prevention, which can prove critical to the long-term commercial success of the products developed.

Patience is also a required component to successful product R&D and commercialization. It often takes many years to get the attention of manufacturers and then develop a productive relationship with them. Several years of R&D may be needed to get to the commercialization phase. Once a prototype is being tested in the field under a controlled situation, new problems often arise that need further time and attention to resolve. For example, NYSERDA has been working on developing hybrid-electric vehicles for a decade and is just now getting commercial projects.

State energy RD&D institutions have been particularly successful at *playing to in-state needs and strengths*. NYSERDA has made an economic contribution to New York through its development of more efficient boilers. FSEC, CIEE, and CEC have developed technologies that take advantage of their states' solar resources. And, ECW has furthered energy efficiency for Wisconsin's largest industrial user of energy—paper production.

As with life in general, many lessons learned are from failure. Some project failures result from factors beyond an RD&D institution's control, while others stem from causes that can be controlled, altered, or remedied.

For example, companies that are project partners may get bought out and have to drop projects, or the price of energy may drop and reduce the benefit/cost advantages of energy efficiency projects or renewable technologies. Sometimes, however, organizations have learned how to make the best out of a turn in events. For example, NYSERDA was formed in response to the energy crisis, but has remained vital by changing with the times by addressing important environmental needs in the 1980s and focusing on economic development as a primary goal.

In some situations, after a project fails, 20/20 hindsight makes clear what might have been done differently to avoid mistakes. Some generic mistakes include:

- Doing good work without getting the message out—through marketing, publications, workshops, *etc*.—limits the impact of RD&D;
- Getting carried away with enthusiasm for the concept, an inventor, or a project partner can result in a lack of due diligence;
- Having outsiders decide what research to do, which can result in end products that are not marketworthy;
- Putting all the "eggs" in one "basket", such as not having a contingency plan for unexpected events (e.g., death of an inventor);
- Collaborating with partners whose motivations are questionable (e.g., those that just want to "get the environmentalists off [their] back"); and
- Not getting full representation by the affected community on committees and boards of directors, which can limit project acceptance.

State energy RD&D institutions continue to evolve, learning from both their successes and their failures.

STATE RD&D INSTITUTITONS & ELECTRIC UTILITY INDUSTRY RESTRUCTURING

As of this writing, 13 states have made formal policy statements on utility industry restructuring, including seven that have enacted legislation (California, Maine, Montana, New Hampshire, Oklahoma, Pennsylvania, and Rhode Island); three that have adopted final regulatory decisions

or recommendations (Massachusetts, Vermont and Wisconsin); and three that have adopted draft regulatory decisions (Arizona, New Jersey, and New York). In addition, in the Northwest, a panel appointed by the region's four governors have developed policy recommendations that were largely adopted in Montana and are now being considered by the legislature in the other three states. Many more states are holding hearings or taking other actions to consider restructuring. In addition, Congress is considering national restructuring legislation. As of 1998, approximately half a dozen states will allow some or all of their electricity users to choose their own electricity supplier. Additional states have already committed to follow suit, and national legislation may mandate retail access in the early years of the new century.

In response to the onset of restructuring and the increased competition restructuring will cause, many utilities have reduced their expenditures on R&D. For example, a recent study by the General Accounting Office estimated that utility R&D declined from about $708 million in 1993 to about $476 million in 1995, a drop of one-third (GAO 1996). In some cases these cutbacks are directly affecting ASERTTI members. For example, at the end of 1994, Pacific Gas & Electric and Southern California Edison announced that they would no longer be able to fund CIEE due to significant reductions in utility R&D funds and changes in R&D priorities in anticipation of restructuring (CIEE 1996).

Restructuring also presents opportunities to ASERTTI members. For example, in both New York and Wisconsin, among the options on the table are for ASERTTI members to play an expanded role in technology transfer by operating large-scale programs to assist end-users in adopting new energy-saving and renewable technologies and practices. In California, the state legislature established a dedicated R&D fund to continue public benefit R&D following restructuring, funded by a small charge on all distribution service in the state. In other states, restructuring may even lead to the development of new RD&D institutions.

The following paragraphs summarize the current status of restructuring, and the impacts of restructuring on state RD&D centers in the five states with both restructuring policy decisions and ASERTTI members—California, Massachusetts, New York, Washington and Wisconsin. Key points from this discussion are summarized in Table 4. Following that is a discussion of some of the key issues that have emerged in these states, and that are likely to emerge in other states, as the role of public benefit R&D in a restructured utility industry is debated.

California

In September 1996, restructuring legislation was passed that called for all customers to be able to choose their electricity provider as of January 1, 1998. The law was crafted by legislative leaders with the active participation of all interested parties, and the resulting package was a carefully constructed compromise that had the support of nearly all major stakeholders in the California electricity industry, including traditional utilities, large customers, representatives of small customers, energy service companies, independent power and renewable energy providers,

environmental groups, low-income customer advocates, and many state agencies (California Assembly 1996).

As part of this legislation, CEC was specifically required to fund certain public-benefit RD&D efforts that will advance science or technology not adequately provided by the competitive and regulated markets, pursuant to "administration and expenditure" criteria established by the legislature. The legislation specifically set aside $62.5 million annually for public-benefit RD&D, funded by a statewide "wires charge" of approximately 0.38 mills per kWh (one mill is a tenth of a cent). This level of funding is equal to approximately 0.3 percent of electricity expenditures in the state. In developing the legislation, it was envisioned that additional RD&D would be funded by private companies trying to develop new products for the competitive market and by distribution utilities as part of their regulated activities to provide distribution service.

CEC is developing a strategic plan for implementing the public-benefit RD&D provisions of the legislation, and is also developing recommendations to the legislature regarding the appropriate administration and expenditure criteria for this RD&D program. CEC is being assisted by an ad hoc RD&D advisory group made up of most organizations and individuals with an interest in the RD&D provisions. The advisory group has recommended to CEC that public-benefit RD&D be focused on end-use energy efficiency, environmentally preferred advanced generation, renewable technologies, and environmental research. The advisory group also recommended that funds be distributed through a formal application and review process including unsolicited proposals, and proposals in response to either an open or targeted competitive solicitation (Public Interest RD&D Advisory Group 1997).

CEC is reviewing the advisory committee's recommendation. It is hoped this new process can begin in 1998, although achieving this may be ambitious. California has two ASERTTI members—CEC and CIEE. Clearly CEC's role is growing enormously under restructuring. CIEE's role has been less clear. In the 1990-1994 period, CIEE received an average of more

Table 4. Summary of Restructuring Decisions in ASERTTI Member States.

State	Policy status	Role of public benefits programs	Role of public benefit RD&D
California	Legislation enacted	Systems benefit charge of 3 mills/kWh to fund energy efficiency, renewable energy, low-income, and RD&D programs	$62.5 million annually allocated for public interest RD&D administered by CEC; CIEE likely to play a significant role

Massachusetts	Final DPU decision, legislation pending	Systems benefit charge to fund energy efficiency and renewable energy programs; charge 4 mils for largest utility; in addition, low-income programs funded thru rates	DOER will continue to use state and federal money for RD&D; RD&D on efficiency and renewables can be funded out of systems benefit charge
New York	General PSC decision; additional specific decisions pending	Systems benefit charge to fund energy efficiency, environmental, low-income, and RD&D programs; level and administration to be determined	NYSERDA programs and existing utility assessment for RD&D to continue; systems benefit charge for additional RD&D likely to be available; NYSERDA and others being considered to administer additional programs
Washington	Regional recommenda-tions, legislation pending	Regional recommendation is for a systems benefit charge of 3% of revenues to fund energy efficiency, renewable energy, low-income and RD&D programs	WA Energy Ext. Service will continue current federally funded efforts; likely to be additional RD&D and tech. transfer funds from systems benefit charge
Wisconsin	Final PSC recommend-dation, legislation being drafted	Systems benefit charge to fund energy efficiency, renewable energy, low-income, and RD&D programs	RD&D included in systems benefit charge; ECW and others being considered to administer RD&D and technology transfer programs

than $3 million annually from California's utilities. In 1995, this funding largely ended as utilities cut costs to prepare for restructuring (CIEE 1996). Current thinking is that under restructuring, CEC may seek CIEE's assistance in planning, funding, and managing a major component of the public-benefit R&D program as part of a partnership with the University of California, which has overall management responsibility for CIEE (Cole 1997).

Massachusetts

In December 1996, the Massachusetts Department of Public Utilities (DPU) issued final model rules on how it proposes to restructure the electric industry. Legislation based on these rules is likely to pass in 1997. The rules call for retail customer choice of power supplier starting January 1, 1998, and establish a special fund, funded by a wires charge, for public-benefit energy

efficiency and renewable energy programs. In addition, under the rules, low-income rates are subsidized at current levels, with the subsidies funded through rates (Massachusetts DPU 1996).

In a settlement agreement between the State Attorney General, Division of Energy Resources, and the state's largest utility, the wires charge is established at approximately 4 mills per kWh initially, gradually declining over the four years of the program. This settlement is providing a strong precedent for settlement negotiations with the state's other utilities. After four years, the DPU will decide whether to continue the program or not. While much of the public-benefit fund will go for energy efficiency programs and renewable energy procurement, RD&D efforts will also be covered by the fund. Under the rules, each distribution utility must prepare an efficiency and renewable plan and present it to the DPU for approval. Coordination among the state's utilities is strongly encouraged (NEES 1996).

Under this system, DOER, the Massachusetts ASERTTI member, is unlikely to receive funds directly from the utilities. However, as a major player in the restructuring rulemaking and all other major DPU cases, DOER is in an excellent position to work with the distribution utilities to coordinate their RD&D efforts with its own and those of other utilities. For example, DOER has taken the lead in convening a collaborative of the state's gas utilities to work together on joint planning for gas energy efficiency programs.

New York

In May 1996, the Public Service Commission (PSC) issued a decision that calls for all retail customers to be able to choose their electricity supplier by early 1998 (NYSPSC 1996). The decision also made a commitment to continue "environmental and public policy programs" at approximately "current" levels, funded by a small charge on distribution service referred to as a system-benefits charge. The types of programs covered include public-benefit R&D, energy efficiency, environmental, and low-income.

In February 1997, the PSC established a separate proceeding to address the "levels of the system benefits charge in the first few years, management, and timing of the transition to market funding of such programs" (NYSPSC 1997). A range of options for delivering and funding the public benefit programs have been discussed by the parties in the proceeding. Both utility and non-utility administration of the programs has been discussed. Several different interpretations of "current" funding levels have been offered by parties in the proceeding, ranging from 1995 to 1997 funding levels. According to New York State Department of Public Service (NYSDPS) staff estimates, electric investor-owned utilities in the state spent $140 million ($1.3 mills per kWh) on public-benefits programs in 1995: $107 million for energy efficiency (1 mill per kWh); $18 million for public-benefit R&D (0.17 mills per kWh), excluding NYSERDA's R&D assessment; and $14 million for low-income programs (0.13 mills per kWh) (NYSDPS 1997). If capped at a total level of one mill per kWh level, as proposed by NYSDPS staff, this would equate to funding levels on the order of $13 million (0.12 mills per kWh) for public benefit R&D

(excluding NYSERDA's assessment) and a total of $98 million for all public-benefit programs. The PSC is expected to decide on system-benefits charge issues in the summer of 1997 (Joseph 1997).

NYSERDA's budget is funded through a small surcharge on electric and gas sales in the state. This separate allocation is likely to continue, perhaps with some modifications incorporated into restructuring legislation. Another possibility is that NYSERDA's budget will be incorporated into the pool of public policy programs funded through a new wires charge. Some parties in the proceeding have suggested that NYSERDA play an expanded role in helping to administer some of the public-benefit programs. Thus, NYSERDA's core programs are likely to continue, and could possibly expand to include greater technology transfer activities.

Washington

In the Pacific Northwest, electricity service is provided through a patchwork of public agencies (i.e., the Bonneville Power Administration and more than 100 municipal utilities) and investor-owned utilities. The region is now grappling with such questions as how to introduce increased competition to the region's electric supply while maintaining reliable service and paying off bonds Bonneville issued to build a series of nuclear power plants, many of which have since been canceled or mothballed. To address these problems, the region's governors (i.e., Idaho, Montana, Oregon, and Washington) set up a taskforce to prepare a "Comprehensive Review of the Northwest Energy System." The taskforce recommended that retail competition begin in the region as of mid-1999. The recommendations also suggest that 3 percent of revenues be set aside to fund public-benefit programs, including R&D, energy efficiency, renewable energy, and special services for low-income households (NWPPC 1996). In Washington, this works out to a charge of approximately one mill per kWh (ACEEE calculation based on 1993 sales and expenditure data).

In 1995, the region's utilities spent approximately $6 million on R&D, plus approximately $174 million on energy efficiency and renewable energy promotion programs. The general intent is to continue public-benefit programs at approximately 1995 levels. These recommendations are guidelines, with decisions on implementation left to each state's utility commission and legislature (Watson 1997).

As of this writing, a bill to largely implement the taskforce recommendations was passed by the Montana legislature, but bills in Idaho, Oregon, and Washington are still under consideration and will likely be enacted in 1998. A bill pending in the Washington legislature provides funding for public-benefit programs along the lines of the regional recommendations, but changes may occur as it is still early in the legislative process (Watson 1997). The Washington State ASERTTI member (formerly the Washington State Energy Office, now the Washington State University Cooperative Extension Energy Program) receives funds from the federal government and has frequently received funds from the Bonneville Power Administration for energy efficiency and

renewable energy activities. The federal funding, which is given to all states, is likely to continue. The Bonneville funding is now being replaced by funding for specific projects from the Northwest Energy Efficiency Alliance (NEEA—a consortium of public and private utilities, public agencies, and public interest groups in the four-state region). The extent to which the Washington Cooperative Extension Energy Program participates in NEEA programs and receives funding from NEEA remains to be seen.

Wisconsin

In Wisconsin, the Public Service Commission has been working on restructuring issues since 1994. In early 1996, the PSC endorsed a 32-step plan that will ultimately lead to retail competition, perhaps as early as 2000. In March 1997, the PSC made final decisions on restructuring recommendations to forward to the state legislature. The plan includes establishing two public-benefits funds—one for low-income programs under the jurisdiction of the Department of Administration, with recommended annual funding of $105 million, and a second for energy efficiency, renewable energy, environmental and R&D programs under the jurisdiction of the PSC, with recommended annual funding of $107 million. These programs will be funded by a small wires charge (Wisconsin PSC 1997). The Energy Center of Wisconsin may receive R&D funds through this wires charge. Some parties have suggested that ECW also take on a broader role overseeing implementation of efficiency services, with service providers chosen on a competitive basis. Other state organizations and agencies are also being considered for this role. Thus, while many details remain to be worked out, it appears that ECW is likely to continue, and perhaps expand, under restructuring. In the interim, utility support for ECW is scheduled to continue through the fall of 1999, with some additional funding likely to be made available to during the transition to a public-benefit fund (York 1997).

Other States

In addition to the five states discussed above, Arizona, Maine, Montana, New Hampshire, New Jersey, Pennsylvania, Rhode Island, and Vermont have issued final or draft decisions regarding restructuring.[2] In all these states, at least some types of public-benefit programs will be continued, funded either by a wires charge or by regulated distribution utilities. Some states, such as New Hampshire and Pennsylvania, will focus only on low-income programs (although New Hampshire is now considering whether to broaden its focus to include energy efficiency). Other states will also focus on energy efficiency (Arizona, Maine, New Jersey, Rhode Island, and Vermont) and renewable energy (Arizona, Maine and Rhode Island). None of these other states specifically identify R&D programs as a specific source of public-benefit funds, although

[2] In addition, Oklahoma passed restructuring legislation in May 1997, but most of the policy decisions are delegated to the Oklahoma Corporation Commission and will be worked out over the 1997-2000 period.

many have made it clear that R&D should be considered as part of an appropriate mix of energy efficiency and renewable energy programs.

Summary and Issues

In all five states with ASERTTI members where some restructuring decisions have been made, it appears the R&D centers will continue, sometimes with their traditional funding sources (e.g., Massachusetts, New York, Washington, and portions of the traditional CEC R&D program in California) and sometimes with a small share of public-benefit monies funded by a small charge on distribution service (e.g., CIEE, additional funds for CEC, and perhaps additional funds for NYSERDA and ECW). In some cases the role of the ASERTTI member will expand, as has already happened with CEC and may happen with NYSERDA and ECW. CIEE's future role is not ensured, although given CIEE's expertise and experience, after a rocky transition period, it is likely to receive a share of public-benefit R&D funds. On the other hand, none of the other states that have made restructuring decisions have so far set up an R&D center or mechanisms to ensure public-benefit R&D will continue, although in many cases public-benefit R&D is included as part of broader energy efficiency and renewable energy efforts.

While state R&D institutions are likely to continue in many states following restructuring, this is only part of the picture. In most states, utility R&D spending substantially exceeds ASERTTI member R&D. As shown in Table 1, utility R&D funding exceeds ASERTTI R&D funding by more than a factor of five. Even in states with large state R&D organizations such as New York, California, and Florida, utility R&D funding exceeds state R&D organization funding to a substantial degree. For example, utilities in California, Florida, and New York spent approximately $140 million on R&D in 1996 (GAO 1996), substantially more than was spent by state R&D organizations. As shown in many of the case studies earlier in this report, ASERTTI members often work closely with local utilities to jointly fund projects, thereby leveraging the ASERTTI member's funds. While some utility R&D funding will continue following restructuring, particularly for distribution and generation improvements (with investments by distribution and generation companies respectively), unless specific provisions are made by policy-makers, utility investments in end-use R&D are likely to fall precipitously. Such funding cuts will directly reduce the benefits accrued from these investments, and can also adversely affect state R&D efforts because there will be less utility money for state R&D institutions to leverage.

From our review of restructuring in California and other states, a number of RD&D issues emerge that all states will need to grapple with as they make decisions on restructuring. Among these questions are the following:

- What is *public-benefit* RD&D, versus RD&D that can and should be funded by private entrepreneurs or regulated distribution companies?

- Is a dedicated RD&D fund needed, versus funding RD&D out of designated funds for such public purposes as energy efficiency and renewable energy?

- To what purposes should public-benefit RD&D be focused—energy efficiency, renewable energy, environmental research, environmentally preferred advanced generation, system reliability, others?

- Who should administer public-benefit RD&D funds—state agencies, utilities, state boards?

- How much funding should be provided?

- How should funds be allocated?

- To what extent should strategic planning guide decisions about allocation of public-benefit R&D funds?

- Should RD&D programs stop at the point of demonstration, or is there a useful and appropriate role for R&D institutions in technology transfer, including commercialization and promotion of new technologies within the market?

- How can public-benefit R&D efforts be made more effective?

RECOMMENDATIONS

In developing recommendations based on our research, a good place to start is by attempting to answer the questions posed above. We then proceed to focus our recommendations on states that either have or do not have R&D institutions.

There is an important role for public-benefit R&D—not all good and socially beneficial ideas will be developed by the private market. Private industry is cutting back on R&D and emphasizing short-term goals. Government has traditionally emphasized longer-term R&D where risks and potential payoffs are greater (e.g., electric vehicles); market niches with substantial opportunities for public benefits but not profits (e.g., services targeted at low-income households); and areas where private R&D efforts are limited (e.g., duct-sealing). Public-benefit R&D can also help with local economic development—struggling industries rarely have money to invest in R&D, thereby making it less likely that they will develop new products necessary for their survival. Given past difficult-to-reverse cutbacks in private and federal R&D, steps must be taken to minimize reductions in state and utility public-benefit R&D funding.

While substantial and useful R&D can be included in broader public-benefit programs, there is also a useful role for a statewide, dedicated R&D fund. By working at a statewide level, greater resources can be brought to bear and more coordination is possible than if each distribution utility operates its own R&D program. For this reason, many utilities have voluntarily chosen in the past to channel a portion of their R&D funds through statewide organizations such as Advanced Energy and ECW. A dedicated statewide R&D fund has greater visibility than more dispersed efforts. It also has the ability to act quickly when there is a pressing need for funds, as with biopulping in Wisconsin. In addition, state institutions are probably in a better position to leverage federal resources. Thus, we recommend that a portion of public-benefit R&D funds be channeled through a central R&D institution, at the state or perhaps regional level. Likewise, where state-level programs exist, states should work with their neighbors on funding regional initiatives, as most R&D problems cross state lines.

The issue of who can best administer R&D funds is a complex one and the best answer may well vary from state to state. This entity not only must be a good administrator, but also must be technically competent and widely perceived as objective. This last criterion may make it difficult for integrated utilities to continue to administer public-interest R&D funds, as utilities that sell power in a competitive generation market are increasingly perceived as biased towards promoting power sales from their company. In addition, it is very useful if the administrator has a strategic vision of what it seeks to accomplish and has good ties with private companies and other researchers throughout the state or region. In particular, administrators need the contacts and ability to involve other stakeholders in their planning, prioritization, and funding processes, because it is through such collaboration that support is maintained and frequently the best results achieved. In some cases, distribution utilities will be scaled down and will lack broad interests and expertise, thereby making them less suitable to manage RD&D programs. The administrator also needs to be flexible and independent, and thus should not be buried in a large bureaucracy. However, the administrator can be affiliated with a large bureaucracy as long as it has substantial flexibility and independence and is outside of normal bureaucratic procedures and organizational politics.

As to funding level, NYSERDA is the largest state R&D institution, funded with a surcharge cap of approximately $0.0001 per kWh and $0.01 per 1,000 cubic feet natural gas sold in New York (which amounts to an average of $1 per capita annually). From our review of NYSERDA, the benefits it provides to the citizens of New York substantially exceed this cost; thus funding at this level per capita or per kWh appears reasonable for direct funding to state R&D institutions. In addition, other organizations in New York, such as utilities and Empire State Electric Energy Research Corporation (ESEERCO), have funded some public-benefit R&D, more than doubling public-benefit R&D spending in the state, so the NYSERDA budget should not be considered a ceiling. Thus, based on the New York example, a total budget of approximately $2 per capita is reasonable. Similarly, another way to look at the issue of a reasonable amount of public-interest R&D funding is to look at restructuring legislation in California, which set aside $62.5 million annually ($0.00038/kWh), which also is $2 per capita.

Allocation of funds is also a complex issue. It may be desirable for state or regional RD&D institutions to establish priority areas through analyses of market potential, local needs, gaps in private-sector efforts, etc., and then structure requests for proposals (RFPs) to help direct strategic planning and vision so efforts are focused rather than scattered. NYSERDA and CIEE have had good experience with RFPs that define a particular activity area and solicit specific projects within that area. This approach allows for multiple complementary projects addressing a topic area that seems ripe for action. Thus, a strategic vision is supported through a market-oriented, end-user-driven process.

In our view, it makes sense for state R&D institutions to be broad in scope, including technology transfer and deployment efforts. In general, we recommend that the lead on commercialization and deployment be left to others, such as private companies and other public-sector programs, but R&D institutions need to plan for and should be involved in commercialization activities, with the role of the R&D institution gradually lessening as deployment proceeds. This can increase the potential for new technologies to be commercialized and make an impact in the marketplace, as organizations such as NYSERDA and CIEE have proven.

As discussed in the Keys to Success/Lessons Learned section, the state energy RD&D institutions have developed many successful approaches to make public-interest R&D efforts more effective:

- The collaborative process brings a diverse range of expertise to the project, stretches research dollars, expands the group that can claim ownership, and makes the developed technologies more marketable. Stakeholders should be involved from the beginning and show evidence of commitment and logical self interest. State energy RD&D institutions can strengthen partnerships by establishing themselves as a business ally.

- Credibility is key to success, and is enhanced by the service provider's objectivity. Using outside technical experts to peer-review projects and the research process strengthens credibility. As the electric utility market restructures, utilities are perceived as losing objectivity, making the state energy RD&D institutions' objectivity even more important.

- More project evaluation would further strengthen credibility, because most projects are not well-evaluated. Evaluation criteria should be identified early in the planning stage. In particular, more documented results of cost/benefit impacts would provide businesses with critical decision-making input. Providing immediate feedback and technical expertise to the customer throughout the entire process helps keep up the momentum and motivation.

- Marketing is important to technology transfer at several levels: marketing services to potential partners, and marketing product (e.g., new technologies and processes, services,

publications) to those who can benefit. Developing a marketing plan in initial project stages is critical to shaping the research to accommodate commercialization and outreach efforts. Effective technology transfer/marketing involves understanding customer motivation. Most often the strongest motivation is money—businesses want to pursue projects that make them more profitable and consumers want to buy products that provide valued services or save money. This marketplace reality should be factored into product development so the final product is not only quieter, more reliable, less labor-intensive, and more productive, but also cost-effective (e.g., aerosol duct-sealing).

- Flexibility (e.g., minimal bureaucracy) is noted by many as a key to success. For example, ECW was able to act quickly to pick up the biopulping project mid-fiscal year, finding money in the budget, sole-sourcing the project to the only people able to do the work, and creating an innovative agreement. Flexibility is also important in terms of being open to opportunities throughout the entire project and modifying product design, goals, or partners mid-stream. Being open to all possibilities and asking a lot of questions along the way often expands the project scope beyond energy efficiency to include other benefits such as process efficiencies and further pollution prevention.

- Patience is also required. It often takes many years to get manufacturers' attention and develop a productive relationship with them. It can also take several years of R&D to get to the commercialization phase, and several more years to develop market niches.

States without energy R&D institutions might consider setting them up—such institutions can provide strategic planning and oversight to focus R&D efforts and make them more effective. The best way to set up a state energy R&D organization will vary, depending on the needs and resources of the state. However, certain basic characteristics, such as those discussed above, will contribute to such an organization’s success. In addition, regions with smaller or less populated states, or where there are strong common regional interests, might consider working together.

CONCLUSION

State energy RD&D organizations have made valuable contributions to the energy balance, economic development, and environmental integrity of their states as well as the nation as a whole. They have helped many companies develop and introduce new products and manufacturing techniques that protect the environment, enhance business revenues, create jobs, and save consumers hundreds of millions of dollars annually through lower energy bills. The state energy RD&D organizations have been particularly effective in addressing local priorities, but have also sponsored programs that have had nationwide impact, such as NLPIP. Certain programs yield potential benefits that exceed the cumulative annual budget for all the state energy RD&D institutions.

Public-benefit R&D performed by state energy RD&D institutions is more important than ever. Other funding for public-benefit R&D is declining as a result of the electric utility industry restructuring, federal budgets decreasing, and businesses focusing more on near-term profits. Public-benefit R&D will enhance business competitiveness by reducing the energy use, waste, and cost of their products. In order for a market to function, good information is needed and the state energy RD&D institutions have proven their ability to disseminate information well. By supporting development of renewable energy sources by local businesses, state energy RD&D institutions can diversify the states' energy resource mix. State energy RD&D institutions can also reduce the economic and environmental costs of the predicted growth in vehicle miles, and help fiscally stressed municipalities meet environmental requirements. Restructuring will probably alter the mix of RD&D and may add new functions, such as design, oversight, and evaluation, to state energy RD&D institutions' activities.

While substantial and useful R&D can be included in broader public-benefit programs, a statewide, dedicated R&D fund also has a useful role. Focus on state and regional needs provides RD&D that is not addressed by national programs (e.g., ECW's work with the paper industry and FSEC's promotion of solar water heaters) and benefits from closer ties with local industries, consumers, and R&D expertise (e.g., NYSERDA's work with New York businesses and CIEE's collaboration with the University of California and LBNL). In addition, by working at a statewide level greater resources can be brought to bear and more coordination is possible than if each distribution utility operates its own R&D program. For this reason, many utilities have voluntarily chosen in the past to channel a portion of their R&D funds through statewide organizations such as Advanced Energy and ECW. A dedicated statewide R&D fund has greater visibility than more dispersed efforts. It also has the ability to act quickly when there is a pressing need for funds, as with biopulping in Wisconsin. In addition, state institutions are probably in a better position to leverage federal resources.

Thus, we recommend that a portion of state public-benefit R&D funds be channeled through a central R&D institution. However, R&D need not be the exclusive domain of state institutions. Distribution utilities with a proven record in successfully administering R&D can also play a role and regional coordination among state institutions should be encouraged. Overall, the goal should be to at least maintain, if not expand, prior levels of public-benefit R&D, while striving to continually improve management of, and prioritization and coordination among, these different efforts. In these ways, utility-industry restructuring can actually be an opportunity to improve the effectiveness of public-benefit R&D efforts, and increase the benefits they bring. But if public-benefit R&D is ignored in the restructuring process, the public will lose.

State-sponsored RD&D emphasizing energy efficiency and renewable energy sources is a forward-looking investment that can pay off substantially in the long run given national and global challenges such as climate change, urban air pollution, and global economic competition. The states that nurture local production of technologies such as fuel cells, PV systems, hybrid

electric vehicles, and super-efficient appliances, etc. *today* are likely to be the states that will be major suppliers of these key technologies in the 21st century.

APPENDIX: PROFILES OF ASERTTI MEMBERS

California Energy Commission

Mission: "To ensure that California's energy needs are met in a manner that enhances the state's long-term economic competitiveness in balance with health, safety and environmental concerns. To promote cost-effective energy efficiency improvements. To research, develop and commercialize new and promising energy-related technologies. To ensure the construction of necessary and least-cost energy production and distribution facilities. To provide analytical support for policy and planning decisions affecting energy produc-tion, distribution and use. To reduce the impacts of unanticipated interruptions of energy supply on California's citizens and economy.

The California Energy Commission (CEC) came into existence on January 1, 1975, as the result of the passage of the Warren-Alquist State Energy Resources Conservation and Development Act. CEC is the state's primary energy planning and policy agency. Its formal title is the California Energy Resources Conservation and Development Commission.

The Commission has five legislative mandates: (1) develop and implement California's energy policy; (2) forecast future statewide energy needs and evaluate electricity resource acquisition plans; (3) site and license thermal 50 megawatt or larger power plants to meet statewide energy needs; (4) promote energy efficiency and a wide range of energy conservation programs and regulations; (5) research and develop alternative energy resources; and (6) plan for and direct state response to energy emergencies.

California's energy demand is expected to increase by 29 percent by 2011. To help provide for increased electricity and transportation needs, CEC's Energy Technology Development Division operates programs that research, develop, and demonstrate the feasibility and cost-effectiveness of advanced electricity generation, end-use efficiency, and transportation technologies that are less harmful to the environment and less expensive. The division approaches this task through its three offices:

- The Research and Development Office provides grants, research contracts, and loans to develop and commercialize advanced/renewable technologies; analyzes cost, environmental issues, and commercial status of generation, transmission, and distribution technologies; and facilitates collaboration among technology manufacturers, dealers, utilities, government agencies, and end-users to address market barriers to commercially available technologies.

- The Technology Evaluation Office directs specific R&D programs, and is responsible for a multiagency assessment of global climate change issues in California, and for helping California businesses market advanced energy technologies overseas.

- The Transportation Technology and Fuels Office analyzes and demonstrates the market potential of new transportation technologies and alternative fuels.

The Organization

CEC has an R&D budget of approximately $8 million in a typical year, funded primarily through a $0.0002/kWh electricity surcharge (about $1.44 per year for an average home). In addition, CEC manages federal dollars from a number of other sources, including the Petroleum Violation Escrow Account, DOE, and EPA. Co-funding ranges from three to five times CEC's investment, depending on the project. For certain projects, co-funding is legislatively mandated. CEC has a staff of about 540, around 100 of whom are in the Energy Technology Development Division.

The Process

CEC is governed by five commissioners with backgrounds in economics, environment, law, public policy, and engineering. An R&D Committee focuses on the R&D area, soliciting input from staff and the public. Staff annually propose a budget and workplan to the R&D Committee for approval. Staff conduct projects in R&D policy, technologies assessments, and RD&D solicitations. The full commission approves major policy and R&D contracts at public meetings.

CEC collaborates with a variety of partners, including DOE, EPA, WAPA, NREL, EPRI, Sandia Laboratory, California universities, and the California Air Resources Board. The majority of the research is done by the private sector, bid out on a competitive basis, although occasionally sole-sourced. CEC has found it easier to get work adopted/commercialized if the research is done by the private sector. The motivational aspect is enhanced by allowing inventors to retain patent rights to their inventions. If an invention is successful, CEC expects repayment of the funding plus interest, and the government retains the right to use the technology without paying a royalty or license fees.

Program Activities

CEC has focused on developing advanced energy technologies, including solar, geothermal, cogeneration, biomass, and wind resources; high-efficiency combustion power plants; and efficient end-use technologies that help keep energy costs competitive. Since 1974, California's investment in renewable energy sources and cogeneration has resulted in more than $30 billion in sales and more than 30,000 jobs (CEC 1994).

CEC conducts work that demonstrates and commercializes fuel-flexible natural gas and electric vehicles. Programs include demonstrating a technology that allows vehicles to operate on methanol, ethanol, gasoline, or any combination of these fuels; a public/private partnership program with several major oil companies to distribute methanol at retail outlets throughout the state; and the country's largest demonstration of fuel-efficient school buses, 35 percent of which

will be fueled with natural gas or methanol (CEC 1996a). CEC's California Building Code Project for Electric Vehicle Chargers developed, adopted, and is now training building officials on new codes necessary to ensure safe and effective installation of electric vehicle charging systems in commercial and residential buildings (see the case-study section of this report for details).

California Institute for Energy Efficiency

Mission: "To coordinate and implement a statewide program of research and technology development aimed at advancing end-use energy efficiency and productivity in California."

The California Institute for Energy Efficiency (CIEE) was conceived in 1988 and was operating at full scale by 1990. It was created as a result of regulatory proceedings conducted by the California Public Utilities Commission (CPUC) which requested California's largest electric and natural gas utilities to fund CIEE and collaborate with the CPUC, CEC and DOE. CIEE was created to leverage university and laboratory capabilities to research and develop the next generation of end-use technologies and applications. California utilities consider CIEE a complementary component of their end-use efficiency R&D programs (Cole 1997).

CIEE plans, coordinates, and implements applied research to advance productivity and competitiveness through energy efficiency. CIEE is a research unit of the University of California and is administered by Lawrence Berkeley National Laboratory (LBNL). Its goal is to translate successful energy efficiency R&D into practical products and processes that help secure sustainable, affordable energy for California while improving the state's economy and environment. CIEE's R&D activities involve developing science or technology that benefits California energy consumers (Cole 1997).

The Organization

CIEE's 1996 budget was around $2.6 million, down from the prior years' budgets of around $3.2 million. In 1995, utilities cut their R&D budgets, and thus their funding to CIEE, in anticipation of utility industry restructuring. The CPUC ordered restoration of CIEE funding for 1996 and 1997. CIEE is funded primarily by utility contributions, with co-funding on special projects from partners such as DOE, EPA, CEC, EPRI, and the South Coast Air Quality Management District. In addition, CIEE works collaboratively with a wide range of research partners, including other ASERTTI members, BPA, GRI, NRDC, the California Building Industry Association, the Union of Concerned Scientists, state advocacy groups, and others. A staff of three professionals and four administrative personnel manage R&D projects, which are performed by national laboratories, universities, and the private sector.

The Process

Each year, CIEE and its Planning Committee develop and update the Multiyear R&D Plan based on its Research Board's policy guidance. The plan identifies specific research objectives, outlines an implementation strategy, and recommends funding levels for specific projects. The Board of Directors makes the final decision on how funds are used. Most funding supports multiyear projects in targeted areas, but CIEE also supports exploratory research programs and scoping studies on new R&D areas.

CIEE is located at and administered by LBNL, but the CIEE director reports to the University of California. As a result, some confusion has existed about the decision-making process, who reports to whom, and who controls funds, and hiring and firing. In addition, DOE provides oversight to LBNL, which adds another layer of bureaucracy and slows down the process further. CIEE has a proposal before DOE to simplify the oversight process.

An important part of this process is to factor into each project plan a way to transfer new knowledge and technologies to its sponsors, the energy service industry, energy and environmental policymakers, and, ultimately, to California consumers.

Program Activities

CIEE's research is organized into three programs. The Building Energy Efficiency program develops energy-efficient end-use technologies that reduce buildings' energy costs and maintain safe, productive indoor environments. The Air Quality Impacts of Energy Efficiency program develops energy-efficient end-use technologies that reduce energy-related pollutants and improve air quality. The Exploratory Research program funds development of new end-use efficiency technologies and solutions to energy efficiency areas of special interest.

Through a Cooperative Research and Development Agreement (CRADA) with DOE, CIEE provides a link between DOE-sponsored research and the energy efficiency research and other programs of California utilities and other partners (CIEE 1996).

Highlights of CIEE's 1994-1995 program include:

- Research on improving thermal distribution efficiency in residential and commercial buildings is estimated to have the potential to save California consumers $300-600 million in annual energy costs while improving comfort (see profile in case-study section for details).

- LBNL is testing integrated envelope and lighting systems in commercial buildings in cooperation with Pacific Gas & Electric and Southern California Edison. CIEE and LBNL are also collaborating with these utilities to develop the Building Design Advisor, a software design tool to help building owners and architects incorporate integrated

envelope, lighting, and other advanced building systems and components in new construction and retrofits.

- CIEE completed two multiyear projects in 1994 and 1995 that quantified building-specific and community-scale benefits of using trees and reflective surfaces as energy efficiency measures. Savings in seasonal cooling loads of 30-40 percent have been measured (see profile in case-study section for details).

CIEE is collaborating with research partners on many additional projects, including (1) an automated system that will help on-site and remote building operators diagnose problems with building systems, (2) energy efficiency in laboratory facilities, (3) energy-efficient combustion in industrial burners, and (4) air jackets that reduce worker exposure to pollutants and improve the energy efficiency of industrial spray booths.

Connecticut Office of Policy and Mangement—New Energy Technology (NET) Program

Mission: "To save energy, to improve air quality, and to help invigorate Connecticut's economy by creating employment opportunities."

The New Energy Technology (NET) Program began in 1994 and is operated by the energy unit of the State Office of Policy and Management (OPM) of the State of Connecticut (State Energy Office). NET encourages R&D by offering competitive grants to individuals and small companies in Connecticut that are developing innovative energy-saving and renewable energy technologies. Technologies considered for funding must be in the pre-commercialization phase. As part of this program, OPM helps grant recipients find technical and additional financial assistance, including potential industry partners or other state and federally sponsored programs. NET fills gaps in businesses programs offered in the state by assisting start-up companies that may have no track record and that usually don't qualify for more traditional programs, such as those offered by the Department of Economic and Community Development.

The Organization

NET's annual grant budget is around $100,000 and is funded from the petroleum violation escrow account. No other program in Connecticut provides grant funding for start-up companies. In 1994 and 1995, NET awarded five grants each. In 1996, NET offered 10 grants of $10,000 each. Seven out of 14 applicants were awarded grants. NET has one staff person (Ruckes 1997).

The Process

Grant applications are reviewed by a seven-member team, including two OPM staff knowledgeable in the areas of energy, the environment, and economic development. Proposals are evaluated and ranked based on the technology's potential to meet energy

conservation/production requirements, environmental benefits, and job creation opportunities; status of project and soundness of development plans; and qualifications of applicant(s) and ability to complete the project successfully.

Program Activities

Award recipients have used grant funds for product development, prototype testing, patent application, business plan development, payroll, and product marketing and promotion at trade shows. The technical and financial networking assistance provided by OPM has been particularly valuable to award recipients, heightening awareness of new technologies, tapping into additional funding, identifying potential demonstration sites, and generally catalyzing the commercialization process. New technologies helped by NET include super-efficient air-conditioning, batteries for electric vehicles, wind energy conversion systems, air-to-air heat-exchangers, light-emitting-diode lighting technology, software to adjust roadway lighting levels, and a boat propeller system twice as efficient as current propellers, among others.

One success story involves a manufacturer of polystyrene footing and wall blocks used as forms for pouring concrete and left in place as insulation. OPM helped the company develop contacts with trade groups and through conferences that have generated media coverage of and interest in the product, which have led to inquiries from distributors.

Energy Center of Wisconsin

Mission: "To sponsor and conduct research in efficient use and management of energy, and to develop, demonstrate, and transfer the results of that research to Wisconsin's energy service consumers and providers."

The Energy Center of Wisconsin (ECW) is a private non-profit RD&D and training organization. ECW evaluates new energy efficiency technologies and new applications of existing technologies, and encompasses all customer sectors (Hanson 1996a). ECW also develops and refines methods for assessing how well energy efficiency programs are working and how to make these programs more effective. ECW studies how to connect energy efficiency technologies and programs to their intended audiences, accomplishing this through workshops, energy efficiency programs, demonstrations, publications, and its library and World Wide Web site (ECW 1996c). In addition to its energy efficiency projects, ECW is now working on some renewables research (Hanson 1997).

ECW was formed in 1989 as the Wisconsin Center for Demand-Side Research (WCDSR) as the result of an agreement among the University of Wisconsin, the Public Utility Commission, and the state's investor-owned utilities (IOUs) in response to the need they identified for state-level collaboration. WCDSR concentrated on developing, applying, and evaluating new energy efficiency technologies, conducting market research, and acting as an information resource. As the organization evolved, the need for demonstration projects was identified, resulting in the

formation in 1991 of the Wisconsin Demand-Side Demonstration (WDSD), which tested new programs and marketing techniques. WDSD remained separate until 1994, when it merged with ECW to streamline operations and improve service to its members, business partners, and the public (ECW 1996a). Public-interest and trade-ally constituencies were added to the collaborative mix (ECW Board and committees) to broaden the scope of the organization. To reflect ECW's broader mission, its name was changed to the Energy Center of Wisconsin in October 1995.

The Organization

ECW's FY97 budget is approximately $4.2 million. This figure is down from the $5.8 million combined budget for ECW and WDSD during their two peak years, 1993-94. Member utilities provide 75 percent of the funding, with the balance from grants, workshops, and interest. Funding from outside sources has been rising recently. ECW has a staff of 29, including 14-15 project managers (with backgrounds in economics, engineering, finance, energy analysis, and policy), four publications staff, three in continuing education, and two library staff. R&D is performed in house if it is more cost-effective and a priority area; however, most R&D work (70 percent, down from 90 percent) is contracted out (Hanson 1997).

The Process

ECW works collaboratively with other ASERTTI members, government organizations (e.g., the Public Service Commission of Wisconsin, Wisconsin Energy Bureau, DOE, and EPA); businesses, R&D organizations (e.g., EPRI); public-interest groups; and Wisconsin's electric, gas, and municipal utilities. Its RD&D focus is on public-interest energy efficiency, and to a limited extent renewables. Most other RD&D activities in Wisconsin are for private interests. Some of the state's utilities' research activities are of public interests, but these activities are diminishing. Thus, ECW is becoming even more important to public-benefit R&D in energy efficiency, and to a smaller degree, renewables (Hanson 1996a).

A twelve-member Board of Directors includes representatives from utilities, a trade ally, public interest groups, the University of Wisconsin-Madison, and a public service commissioner. The board determines an annual program plan encompassing research, demonstrations, workshops, and other training. Several standing working committees (e.g., residential, industrial, continuing education, evaluation, market research, etc.,) and two main advisory committees (Research and Program Demonstration) work with staff to develop and oversee execution of the annual plan. Once a year ECW solicits ideas from all committees, members, and outside sources. After review by Standing Working Committees, priority proposals then go to ECW's Research and Program Advisory Committees, which make recommendations to the Board for approval of the annual budget, programs, and projects. Once approved, ECW's Executive Director oversees staff in carrying out the annual plan through contractors or in house, as warranted (Hanson 1996a).

Program Activities

Currently, ECW has about 60 RD&D projects under way and sponsors more than 30 workshops per year. Program activities encompass a wide range of areas, including industrial processes, motor systems, low-income energy services, residential efficiency, green buildings, heat pumps, HVAC, and restructuring issues. Three of ECW's programs—Biopulping, Responsible Power Management (RPM), and Performance Optimization Service (POS) were profiled earlier in this report. In addition to its numerous RD&D projects, ECW notes three areas of particular success:

- *Continuing education's* 30^{+} events per year. The education program has three main functions: training constituents on new technologies, reporting project results, and creating forums for industry professionals to exchange ideas (ECW 1996b).

- *Publications* has increased ncreased its timeliness and content, producing technical and research reports and summaries, educational and outreach materials, a quarterly newsletter, annual reports, videos, and other documents distributed to more than 5,000 people, mostly within Wisconsin.

- *Library services* have expanded significantly, including development of a web site.

These three areas are particularly important because they are the vehicles that carry the message of ECW's work to the public and professional communities, enhancing the effectiveness of the organization in getting its information to those who can use it.

Florida Solar Energy Center

Mission: "To research and apply energy technologies that enhance human and environmental systems."

The Florida Solar Energy Center (FSEC) is a statewide research institute administered by the University of Central Florida. FSEC focuses on programs in solar energy and energy efficiency, and is the largest state-supported renewable energy and buildings research institute in the country. FSEC has five divisions: Advanced Technologies and Photovoltaics, R&D, Testing and Operations, Institutional Affairs (education, information, and data research services), and Business Affairs (administrative services).

FSEC's objectives include conducting RD&D on and promoting, and educating the public about solar energy, energy efficiency, and alternative energy resources that will reduce per-capita conventional energy growth and attract clean-energy manufacturing and service industries to the state.

The Organization

In 1995, FSEC had a budget of $11.5 million, $8.5 million of which was contracted R&D, with state support making up the $3 million balance. FSEC employs a staff of 150, half of whom have backgrounds in engineering, energy research and analysis, buildings science, policy analysis, and education and training. The other half of the staff provides technical and administrative support, including university student assistants. Unlike most ASERTTI members, FSEC performs all R&D in house.

The Process

Selected staff and the Executive Committee are involved in planning. Traditionally, planning has reflected the state's energy resources, demographics, and economy; however, with potentially diminishing government resources, FSEC planning must now take into account which program areas have the greatest promise for sustained support and funding and seek new program partners, particularly in the private sector.

Program Activities

RD&D at FSEC is based on experimental data from highly instrumented laboratories and field-test sites, and is complemented by systems and cost/benefit analyses, and technology transfer. Major FSEC activities include:

- A decade-long photovoltaics R&D program focused on developing and integrating solar electric systems into utility, residential, and stand-alone applications;
- Developing new thin-film photovoltaic technologies;
- R&D on advanced housing technologies to increase quality, efficiency, and affordability;
- Developing innovative cooling systems augmented by heat pipes and desiccants;
- R&D on indoor air quality and allergy-resistant construction processes;
- R&D on solar-hydrogen production, storage, and use;
- Research on alternative transportation fuels, including natural gas and hydrogen;
- Developing solar-related technologies for detoxifying hazardous wastes;
- Refining solar water-heating systems for institutional and residential applications;
- Developing computer software to aid energy research;
- R&D on electric vehicles and system; and
- Education and training for students and professionals.

FSEC also publishes and distributes a wide range of publications for energy consumers, as well as the academic, research, and governmental sectors. FSEC's library, which is open to the public, holds an extensive collection of alternative-energy-related documents.

In 1995, FSEC moved to new facilities at the University of Central Florida Brevard Area campus in Cocoa. The complex is a "living" example of the new energy concepts that are the subject of

FSEC research. The New Energy Center demonstrates the significant savings available from solar and energy efficiency technologies (FSEC 1996).

Hawaii's Department of Business, Economic Development, and Tourism—Energy, Resources, and Technology Division, Energy Branch

Mission: "To support statewide economic development and diversification by promoting, attracting and developing Hawaii-based industries which engage in high- and other technological enterprises for the sustainable development of Hawaii's technology, energy, environmental and ocean resources."

The Energy Branch of the Energy, Resources, and Technology (ERT) Division of the Department of Business, Economic Development, and Tourism (DBEDT) promotes commercialization of Hawaii's sustainable energy resources and technologies (biomass, geothermal, hydro, ocean thermal energy conversion, direct solar, and wind), and supports energy conservation and efficiency programs, including a Model Energy Code, integrated resource planning, demand-side management, education and information. Energy is of particular interest to Hawaii because the state has to import so much of its energy (DBEDT 1997).

In 1981, the Energy Division was established to carry out the Department's energy programs. In 1995, the Energy, Resources, and Technology (ERT) Division was created to combine the state's responsibilities in energy and ocean industry development and provide a focus for developing new strategic technologies for Hawaii. The ERT Division is composed of an Energy Branch, an Ocean Resources Branch, and a Strategic Technology and Market Development Branch.

The Organization

The state energy program is funded by federal oil overcharge funds ($3 million) and state appropriations ($1.2 million). Approximately $2.5 million is used to support research, demonstration, and commercialization activities. In addition, privately and federally appropriated funds add approximately $3 million in co-funding. Co-funding partners include DOE and the Hawaii Coalition (a consortium of government, utility, and private entities).

The Process

Program planning and project selection is a collaborative process that includes input from staff members. Efficiency and effectiveness are key points considered during the planning process to ensure various objectives and goals are met, and to eliminate any duplication of effort by staff. Project selection criteria include contribution to meeting DBEDT's policy mission, objectives, and goals; potential environmental, economic, and social benefits; technical feasibility, including application and technology transfer; and relationship to other state programs.

Program Activities

More than 30 energy-related publications available free of charge to the public discuss biomass, geothermal, hydropower, ocean thermal energy conversion, photovoltaics, solar thermal, alternative transportation fuels, wind power resources/technologies, demand-side management, integrated resource planning, and other energy conservation/efficiency practices.

DBEDT has several research areas that focus on energy issues:

- *Energy Planning* develops an integrated energy policy and plan to reduce dependence on imported fossil fuels, limit economic and societal costs of energy service, increase public awareness of energy issues, and provide energy security and emergency preparedness. The Model Energy Code created by DBEDT is the basis for new county building codes, which are expected to save four million barrels of oil and more than $200 million in utility costs and avoid the construction of a 50-MW power plant over the next 20 years.

- *Alternate Energy Development* provides information to potential developers on renewable energy resource availability and promising new technologies. A Biomass Gasification Facility project is currently under way.

- *Energy Conservation* focuses on integrated resource planning and demand-side management, building efficiency, and education and information. One of the largest projects involved installation of 47 heat pipes throughout a large medical center, which is expected to result in savings in excess of 3 GWh and $230,000 annually. A performance contract that will invest $4.5 million in private money in energy efficiency measures at a university campus is expected to save more than $500,000 annually. DBEDT has written a *Performance Contracting Guide* and provides technical assistance to interested facilities (DBEDT 1996).

- *Transportation* works to reduce transportation energy demand and develops alternative fuels to reduce petroleum usage. DBEDT is working with a variety of state, county, and private agencies to find and support ways of saving energy and reducing traffic congestion. The Hawaii Electric Vehicle Demonstration deployed 64 electric vehicles (buses, trolleys, sedans, vans, light trucks, and a shuttle boat) in 1995 (DBEDT 1996).

- *Communication and Education* is a community outreach/education program to increase public awareness of Hawaii's overdependence on imported fossil fuels, the need to conserve energy, and the importance of developing renewable/sustainable energy resources and technologies. The program actively involves communities, schools, businesses, and residents through exhibitions, contests, workshops, educational

programs, and publications. In 1995, DBEDT received the "State of the Year" award from the National Energy Education Department (DBEDT 1996).

- *Energy Emergency Preparedness (EEP)* is a critical part of DBEDT's contingency planning to deal quickly and effectively with supply disruptions, and involves coordinating, reviewing, and updating state and county plans in conjunction with State Civil Defense, the Federal Response Plan, the military, and private industry.

- *Strategic Technology and Market Development* involves assessing, defining, analyzing, developing, marketing, and servicing technology business opportunities in areas such as energy efficiency, renewable and conventional energy supply-side technologies, telecommunications, environmental control and management, and ocean technologies.

DBEDT also provides funding and technical assistance to retrofit facilities of private, non-profit, care-providing organizations; develops and promotes energy education and awareness through the schools and public awareness programs; funds applied research and small-scale demonstration projects; sponsors workshops; assists private energy developers seeking permits; assesses environmental, social, cultural, economic, legal, institutional, and financial aspects of a proposed energy project; provides the public with current energy information on Hawaii's sustainable energy and energy conservation programs; and develops, implements, and maintains a comprehensive energy data modeling and forecasting system.

Iowa Energy Center

Mission: "To be a model for state efforts to reduce reliance on imported fuels and on energy produced from nonrenewable sources."

Iowa created the Iowa Energy Center (IEC) in its 1990 Energy Efficiency Act to support efforts to increase energy efficiency in all areas of state energy use. IEC is administered by Iowa State University (ISU). IEC's goal is to minimize the impact of energy production and consumption and reduce reliance on nonrenewable energy sources by conducting and sponsoring energy efficiency research, assisting Iowans with developing and assessing relevant technologies, and supporting educational and demonstration programs.

The Organization

IEC's estimated budget for the fiscal year ending June 30, 1997, is $2.8 million, funded primarily by an annual assessment of 0.85 percent of the total gross operating revenues of all Iowa gas and electric utilities. This budget is down about 18 percent from the previous year, in part due to several IEC grants ending in 1996 and being replaced by smaller grants (IEC 1996). A professional staff of five reports to the IEC director; the project manager and industrial program manager oversee the technical research program, the administrative specialist handles the business side of the grants program, the communications specialist heads public relations and

publications efforts, and an engineer manages the Energy Resource Station (ERS) Building System Research Facility.

Most of IEC's technical program activities have been supported by the competitive grants program. The 1990 legislation mandated that IEC award grants to nonprofit organizations in the state. IEC initiated its competitive grants program in the fall of 1991 and has awarded more than $8 million in support of more than 70 research, demonstration, and conference projects.

The Process

IEC receives input from an advisory council of 13 members representing universities, colleges, the Department of Natural Resources, the Iowa Utility Board, utilities, and consumers. The advisory council gives guidance on research and funding decisions and major activities, but is not involved in day-to-day activities (Barwig 1997).

IEC collaborates with a variety of partners, including funding and serving on the board of the National Lighting Product Information Program (NLPIP). IEC also works with the National Renewable Energy Laboratory (NREL) on collecting wind data, and collaborates with a variety of other partners, including the Department of Natural Resources, ISU, and other ASERTTI members (Barwig 1997).

Program Activities

The IEC's technical research and demonstration program focuses on three areas: alternative and renewable energy, energy efficiency, and energy information transfer. The flagship of IEC's technical program is the Energy Resource Station (ERS), which opened in the fall of 1995 to test and demonstrate commercial heating, air-conditioning, and ventilation (HVAC) systems. The ERS is housed in an 8,700-square foot building on the Des Moines Area Community College (DMACC) campus. ERS has four pairs of test rooms as well as a resource library and computer lab through which clients can access multimedia and on-line sources of information on energy-efficient building design, construction, retrofitting, and maintenance. Classroom/training space allows DMACC to expand its residential HVAC technician program to the commercial sector. ERS activities span all three areas of the IEC's technical program, helping Iowans and others make informed, practical decisions about energy sources and systems.

The technical program also targets research and demonstrations in biomass-to-energy systems. IEC is supporting a comprehensive study of the state's biomass-to-energy potential, which, along with additional research supported by the IEC, has created the opportunity to collaborate with the private sector in research and demonstration focused on the use of municipal and industrial wastes as feedstock. IEC is actively pursuing the development of a biomass demonstration facility to highlight work in anaerobic digestion, thermal gasification, and cellulose-derived ethanol production. IEC is gathering long-term Iowa wind regime data at 16 meteorological sites

(Barwig 1997). An IEC grantee is testing an interactive computer program to assist in wind-turbine siting in Iowa (IEC 1997).

Kansas Electric Utilities Research Program

Mission: "A cooperative venture performing applied research to proactively seek and deliver technologies enhancing the value of electric services to its members, utility customers, and the state of Kansas."

The Kansas Electric Utilities Research Program (KEURP) was formed in 1981 as a joint research venture among seven electric utilities in Kansas. KEURP provides a mechanism for the state's utilities to pool funds and collaborate with partners on larger, non-duplicative applied research projects that provide public benefits statewide, and position the state's utilities and universities in regional and national leadership roles. KEURP identifies and addresses utility customer needs, such as increased reliability, decreased environmental impacts, greater reliance on renewable resources, and cost-minimization. The organization also develops a planning process that has a substantial implementation component and a methodology for measuring the adoption of technologies. KEURP also has a communication process to disseminate research results.

The Organization

KEURP's 1995 budget was $1.4 million, up from about $950,000 in the previous year. In 1995, KEURP leveraged its utility members' voluntary funding (around $900,000) by almost 8:1, resulting in more than $8 million of research supported by partners such as EPRI, DOE, NREL, and the Kansas Regents Institutions. A staff of three full-time professionals manages the projects. The majority of the research is conducted by the state's universities, participating in 29 out of 47 projects in 1995.

The Process

KEURP collaborates with a variety of local and national partners, including EPRI, DOE, NREL, the National Science Foundation, utilities, universities, regulatory representatives, private companies, and others. These partnerships allow expanded project scopes by leveraging KEURP's investment and drawing on a broad range of expertise.

KEURP relies heavily on the technical and operational knowledge of professionals at each member utility. Kansas universities also participate on a voluntary basis. Oversight and direction are provided by the Technical Committee, which is made up of one representative from each member utility and participating university. In addition, the Kansas Corporation Commission (utility commission) provides a liaison to KEURP. Quarterly, the Technical Committee reviews and votes on proposals, monitors research projects in progress, identifies potential research projects, develops an annual research agenda, and assists with transfer of project results to the

utilities. The Executive Committee, comprising each utility's President/CEO or designee and the Executive Director of the Kansas Board of Regents, meets to review and vote on actions taken at the Technical Committee's meeting. The Executive Committee has final voting authority on all proposals and monitors KEURP's progress.

Program Activities

KEURP activities include (1) assessing the potential and economic viability of renewable energy in the state, (2) demonstrating and conducting training seminars on emerging off-road and on-road electric transportation projects, (3) researching electric and magnetic field issues, (4) collecting and analyzing power quality data, (5) developing a ground-source heat pump manual, and (6) providing industry troubleshooting assistance.

In 1994, KEURP developed a renewable energy R&D plan for the state that identifies steps required to assess the potential for wind, solar, and biomass. So far, through DOE funding from the Utility Wind Resource Assessment Program, KEURP is collecting data from six of the most promising sites for wind farms, and KEURP has received $160,000 to review the feasibility of generating electricity from farm crops in the state.

KEURP developed an information and education seminar that alerts utilities on off-road electric vehicle issues and strategies for bringing these emerging technologies to manufacturers. This project resulted in EPRI funding the national technology transfer of that information. KEURP also supports Kansas State University's on-road electric transportation research, which has led to the development of an alternative-fuel research and evaluation center (KEURP 1995; 1996).

Massachusetts Division of Energy Resources

Mission: "Implement energy policies that ensure an adequate supply of reliable, affordable and clean energy for business and residents of Massachusetts [and to] improve and streamline energy regulation, promote greater efficiency in all energy uses, reduce energy costs and mobilize energy education."

The Executive Office of Energy Resources was formed in 1975 and converted to the Division of Energy Resources (DOER) in 1993 as part of the state's Division of Economic Development. DOER works with energy suppliers and interest groups through negotiations and partnerships to create a competitive energy industry, and encourage energy suppliers to pursue environmentally sound methods of energy production and transportation. DOER also intervenes in proceedings at the state, regional and federal levels to advocate for the administration's policies on deregulation, enhanced utility performance, and increased value for businesses and residential customers.

Program Activities

DOER provides a variety of services for Massachusetts residents and businesses:

- The Energy Conservation Service, available to ratepayers through their gas or electric utility, helps residents lower their energy bills through comprehensive, all-fuels home energy audits and follow-up technical assistance;

- Through public/private partnerships, DOER promotes the development and use of vehicles fueled by compressed natural gas, electricity, propane, and other alternative fuels;

- DOER supports the development of fuel cell, wind, photovoltaic, and other environmentally sound energy production technologies through demonstration and testing in partnership with the private sector and cities and towns;

- In partnership with the Department of Environmental Protection, DOER promotes the recovery of landfill gas for energy production and long-term emissions reduction;

- DOER administers federal Institutional Conservation Program matching grants for schools and hospitals that fund the identification and installation of energy conservation measures. Public schools and school administration buildings are also eligible for DOER grants for energy conservation projects under the state bond-funded Energy Conservation Improvement Program (ECIP). One million dollars of grant funding was available through June 1997;

- The Energy Efficiency Program helps cities, towns, and other public entities work with energy service companies to reduce energy use with little or no initial capital expenditure;

- The Energy Advisor Service offers technical assistance to manufacturers to help them identify and act on energy efficiency opportunities, using private-sector engineers to develop flexible, comprehensive energy efficiency analyses of manufacturing processes and facilities. Investments made in measures identified by EAS typically are paid back through energy savings in less than three years; and

- STEP (Strategic Envirotechnology Partnership) provides technical assistance to help commercialize emerging energy and environmental technologies. Services include technology assessment, business planning, technology demonstration and purchasing, expedited permitting and guidance, and technology transfer.

Minnesota Building Research Center

Mission: "To work with the design professionals and the building industry to identify and address critical research problems; to contribute to building research related to critical societal needs such as designing sustainable and healthy buildings; to provide missing feedback to the design professions on building performance, operation, and user satisfaction; to create opportunities for graduate research in the area of building science and technology, thus providing training to future professionals; to transfer information to the design and building community through publications and outreach activities."

The Minnesota Building Research Center (MnBRC) was formed in 1987. It coordinates and conducts basic and applied building research at the University of Minnesota, as well as outreach activities with the potential to affect the state's and country's resource use and economic competitiveness.

MnBRC is motivated by the building industry's estimated use of 17-50 percent of the world's wood, minerals, water, and energy. In addition, building design affects indoor air quality, physical environments, health, and productivity. Besides technical and environmental concerns, the building industry suffers from ineffective communication. MnBRC attempts to give designers the technical and scientific information they need to make informed judgments.

The Organization

During the past eight years, MnBRC has administered research grants and projects totaling $21 million. The MnBRC staff of seven includes physicists, engineers, and architects, who perform R&D in collaboration with a variety of partners both within and outside the University.

The Process

MnBRC collaborates with the University of Minnesota's College of Architecture, as well as other University departments, and other colleges, involving specialists in environmental health, human factors engineering, and housing. It also collaborates with private corporations, DOE, and other energy efficiency organizations (e.g., the Center for Energy and the Environment).

Program Activities

Highlighted MnBRC projects include:

- The multiyear University Building Energy Efficiency Project, designed to improve the energy efficiency of University buildings by auditing and retrofitting existing buildings and assisting in new building design;
- Sponsored by Certainteed Corporation, MnBRC is building a Research House to study a variety of building systems and materials;

- MnBRC is monitoring and evaluating indoor air quality in gas-heated homes;
- Funded by DOE, MnBRC is developing design information and computer tools to guide selection of high-performance windows.
- MnBRC assisted the University in developing a procedure to assist designers and owners of new commercial buildings with reducing operating costs. The program is now used by Northern States Power to assist customers in reducing peak electrical demand;
- MnBRC operates a University facility that tests foundation construction and insulation materials for energy and moisture performance; and
- MnBRC is collaborating with the Center for Energy and the Environment, with support from DOE, on the Competitive Building Initiative, which improves energy performance and occupant comfort in commercial and multifamily buildings in the Twin Cities.

MnBRC staff are also involved in teaching and developing curriculum for the Building Science Minor in the College of Architecture and Landscape Architecture, as well as directing the new Bachelor of Construction Management program at the University. Staff are also involved in planning and participating in conferences and workshops, and are noted for their publications (MnBRC 1997).

Missouri's Environmental Improvement and Energy Resources Authority

Mission: "To protect the state's environment, develop energy alternatives, and promote economic development."

Missouri's Environmental Improvement Authority was established by the Missouri General Assembly in 1972 as a quasi-governmental agency to finance pollution control projects. In 1982, legislation transferred the agency to the Department of Natural Resources (DNR), and it became the Environmental Improvement and Energy Resources Authority (EIERA). Projects focus on recycling, market development, solid waste management and energy, and range from pollution control/prevention activities to financing energy efficiency measures in state facilities. EIERA accomplishes its goals by issuing low- and no-cost tax-exempt financing to businesses and local governments for environmental projects, providing technical assistance, and conducting studies and research. It works with citizens and the business community to show them that caring for the environment does not cost jobs or significant tax dollars.

The Organization

In 1972, EIERA received a one-time $225,000 appropriation that it has leveraged into more than $3.4 billion for environmental financing and more than $5 million in grants to support research, educational projects, and technical assistance programs. EIERA operates on the fees it receives

for its financings, grant income, and interest income on EIERA funds. The structure of EIERA financings varies greatly and depends on the uses and repayment sources of the projects. Some projects involve matching funds from, for example, federal sources. Overall, EIERA projects have a 2:1 co-funding ratio. A director and a staff of eight conduct day-to-day activities and oversee projects (EIERA 1997; EIERA 1994; Mahfood 1997).

The Process

Major policy decision-making is the responsibility of a five-member Board of Directors, which meets monthly. The Board is appointed by the governor for three-year terms, and members have backgrounds in business, law, finance, and environmental affairs. The EIERA works in cooperation with a variety of partners, including the Missouri Clean Water Commission, EPA, the Missouri Public Service Commission, and other state agencies. EIERA also develops incentives and negotiates with private financial institutions to give special consideration to public entities for financial assistance for pollution-control equipment, facilities, and projects (Mahfood 1997).

EIERA does not solicit project proposals, but operates on a request-only basis. If bonds and notes are issued, they are repayable by the project partners only—the state of Missouri does not guarantee repayment. There have never been any defaults on EIERA financings. EIERA staff work with prospective applicants to determine their eligibility and then structure the most economically attractive transaction (EIERA 1994).

Program Activities

EIERA produced an analysis of solid waste issues in Missouri; published an extensive study examining many opportunities and recommendations for the state's energy usage in the *Missouri Statewide Energy Study*, and released a comprehensive report entitled *Economic Opportunities through Energy Efficiency*. The EIERA is involved in numerous educational activities across the state in the energy and environmental fields. These include the nationally recognized Household Hazardous Waste Program, which educates citizens about the safe management and disposal of household products; the Kansas City Energyworks Project, which manages a DOE-funded Rebuild America Project; and the Missouri Energy Resources Project, which interactively teaches schoolchildren about energy efficiency and solid waste issues in their schools. EIERA is also involved in many other projects, such as helping to develop a solar-powered car at Crowder College.

EIERA also manages the Missouri Market Development Program (MMDP), in coordination with DNR and the Department of Economic Development. The Market Development Program offers financial and technical assistance to businesses that develop marketable products from recovered solid waste, and provides for the purchase of equipment to enhance product development. The Market Development Program coordinates the Missouri Buy Recycled Initiative, which

encourages businesses and government to purchase products with recycled content. The program also administers the Missouri Recycling Information System (MORIS), which is a statewide computer bulletin board for information exchange on recycled products, end-use markets, processors, and timely news and issues in this field (EIERA 1997).

EIERA is also developing partnerships and consensus building in the energy community through programs to promote a Home Energy Rating System (HERS), Energy-Efficient Mortgages (EEMs), and the Green Builders Program. HERS evaluates the relative energy efficiency of homes for home buyers. HERS programs can also be combined with other programs that reach out to home builders and the low-income weatherization community. EEMs can help home buyers by either qualifying them for a larger mortgage, allowing them to purchase more energy-efficient homes, or allowing them to mortgage cost-effective energy improvements. The Green Builders Program is an educational program established by an environmental education agency to provide information to architects, developers, and manufacturers about the availability of energy-efficient products (EIERA 1994).

EIERA is also promoting energy efficiency education through its grant to the Missouri Energy Resources Project (MERP). MERP is using the grant to develop two programs:

- School Energy Efficiency Development (SEED) programs teach students about environmental and economic impacts of energy use by helping them conduct school energy audits and create energy-reduction plans. SEED programs can save Missouri schools 15-25 percent of their energy costs in the first year and up to 45 percent in future years; and

- Leadership in Environmental Action Projects (LEAP), which has provided teacher and student training in the implementation of solid waste reduction projects in 22 district schools.

MERP plans to expand these two programs to bring self-sustaining, educational programs to teachers and students across the state (EIERA 1995).

Nebraska Energy Office

Mission: "To promote the efficient, economic and environmentally responsible use of energy."

The Nebraska Energy Office was created in November 1973 as the Fuel Allocations Office, a division of the Nebraska Department of Revenue. In 1987, it became a division of the Governor's Policy Research Office by executive order of the Governor. The Energy Office has divisions responsible for Energy Projects, Weatherization, Energy Financing, Natural Gas Technical Assistance, Grants and Legislation, and Ethanol and Other Alternative Fuels. The Energy Office's goals are to:

- Advance energy conservation;
- Encourage development of alternative and renewable energy sources;
- Further energy-related economic development;
- Advise state government in the development of energy policy;
- Implement state energy policy; and
- Administer statewide energy conservation programs.

The Organization

In FY 1995, the Nebraska Energy Office had a budget of approximately $12.8 million, of which an estimated 10 percent went toward RD&D. Its budget has ranged from $8.6 million to $21.4 million over the past five years. A little more than half the budget was funded from oil overcharge funds, with the balance from federal funds and state severance tax funds.

The Process

The Nebraska Energy Office's direction and decision-making process are guided by the agency's mission and Nebraska's 1992 Energy Action Plan. At least once a year, the Energy Office is required to "identify emerging trends related to energy supply, demand, and conservation and to specify the level of statewide energy need within the following sectors: agriculture, commercial, residential, industrial, transportation, utilities, [and] government...." The Nebraska Energy Office collaborates with others such as DOE Climate Wise and Rebuild America.

Program Activities

The Nebraska Energy Office has three programmatic divisions: Energy Financing, Energy Projects, and Weatherization, which implement a variety of programs providing low-interest loans and mortgages and grants to promote energy efficiency in many areas, including lighting, public transportation, and the residential, commercial, and public sectors, as well as informational and educational programs. The Energy Office also administers the Low-Income Weatherization Assistance Program (WAP)—a federally funded program for weatherizing low-income households to save money and energy. Some specific successes include:

- The Dollar and Energy Saving Loan Program, which began more than six years ago, has provided about 12,000 low-interest loans totaling $72.3 million to finance home, building, transportation, and system improvements (e.g., replacing furnaces, air conditioners, and windows). Resulting energy savings are estimated at more than $3.6 million per year. The program has also spurred economic activity by creating more than 1,200 jobs in communities across the state.

- The Electrical Load Management Resource Fund offers interest-free financing to utilities to help purchase, install, or upgrade load-management systems that allow utilities to

monitor and reduce peak demand, save energy, and avoid being charged for expensive peak energy (Nebraska uses 100 percent public power). This program has saved ratepayers more than $6 million over its 14-year life.

In addition, in late 1996, the Energy Office began offering Energy Efficient Mortgages that reduce interest rates by 1/4 to one percent for homes that meet or exceed the 1993 Model Energy Code. In conjunction with DOE's Climate Wise and Rebuild America, the Energy Office also offers free or low-cost energy assessments of buildings and operations and low-interest financing of up to $150,000 for energy efficiency improvements.

The Energy Office has also recently taken a more active role in developing alternative transportation fuels. In addition to advocacy and demonstration projects, the Energy Office has become involved in coordinating the development and use of ethanol-based fuels, not only in the state, but also around the country. The Energy Office has been successful in securing favorable policy treatment for ethanol and in locating funding for state, municipal, and county transportation systems using alternative fuels. The state's seven plants employ 735 Nebraskans directly and an estimated 3,600 indirectly in this new growth industry (NEO 1996).

New York State Energy Research and Development Authority

Mission: "To foster and conduct R&D in new energy technologies that assist the state's businesses, municipalities, and residents in solving energy and environmental problems while developing innovative products and services that can be manufactured or commercialized by NYS businesses, thus promoting economic growth."

The New York State Energy Research and Development Authority (NYSERDA) is a public-benefit corporation created in 1975 by the New York State Legislature. NYSERDA's R&D program is designed to fill public needs that are not met by the private sector. The goals of NYSERDA's R&D program are to:

- Promote energy efficiency and the development of energy and environmental technologies to encourage economic growth in New York;
- Expand the use of New York's indigenous and renewable energy resources; and
- Reduce or mitigate adverse environmental effects associated with energy production and use (NYSERDA 1996b).

Much of NYSERDA's R&D deals with end-use technologies, but NYSERDA also works on renewables, environmental research, and transportation. In addition to managing an R&D program, NYSERDA is responsible for providing energy efficiency services and energy analysis, issuing tax-exempt bonds for utilities and special energy projects, managing the Western New York Nuclear Service Center in West Valley, and addressing radioactive waste issues and coordinating the state's nuclear programs (NYSERDA 1996b; 1996c). The NYS Energy Office (NYSEO) was abolished in 1995 and NYSERDA absorbed responsibilities

ranging from administering federal energy efficiency grant programs to energy planning, with an addition of about 20 staff.

The Organization

NYSERDA's R&D is funded by an assessment on the intrastate gas and electric sales of the state's investor-owned utilities (IOUs). The New York Power Authority (NYPA) and royalties from successful projects provide additional funding. Ninety-five percent of NYSERDA's R&D projects are cost-shared by research partners, with co-funding accounting for about 75 percent of total R&D funding. In the 1996/97 fiscal year, NYSERDA's R&D funding of $15.9 million was matched with $64 million of co-funding, for a total program of $80 million (Joseph 1997). This budget supports a 40-person staff, the majority of whom have backgrounds in engineering, chemistry, math, and other sciences. Staff do not generally do the hands-on research itself but develop and manage the projects that are contracted out to businesses, individuals, institutions, and other organizations.

The Process

To ensure its program meets evolving needs, NYSERDA uses stakeholder-based planning, competitive selection of projects and programs, efficient delivery of program services, and program review and evaluation. In its R&D program, NYSERDA collaborates with other organizations, including private companies; utilities; universities; and local, state and federal agencies. This collaborative approach allows NYSERDA to leverage its research funds and involve those who can benefit from the research results, especially small businesses, municipalities, and institutions, which do not have the resources or expertise to research their energy problems (NYSERDA 1996a).

NYSERDA is governed by a Board of Directors that is appointed by the governor. The Board approves the budget and research plan, which are first reviewed and approved by Board subcommittees. *Ad hoc* committees review programs periodically and serve as technical and business advisors. NYSERDA uses scoping sessions to bring together stakeholders and plan programs in new or changing research areas. NYSERDA primarily uses competitive solicitations to select research teams and projects. Research area identification is a multiyear planning process. Project proposals are evaluated by a technical review panel of internal and external experts. Approximately 85 percent of NYSERDA's R&D projects are selected through competitive solicitations.

Program Activities

NYSERDA's R&D program is divided into five areas that reflect New York's energy use sectors and needs: Industry, Buildings, Energy Resources, Transportation, and Environment. NYSERDA's R&D program reduces the cost of energy for businesses, municipalities, and

residents, as well as minimizing environmental impacts and helping create and retain jobs in the state. Since 1990, NYSERDA has developed and brought into commercial use more than 60 innovative energy-efficient and environmentally acceptable products and services. As a direct result of NYSERDA R&D assistance, New York businesses sold more than $20 million worth of new energy and environmental products in 1996. In addition, these projects saved New Yorkers approximately $30 million in 1996 in reduced energy costs. Many of these products are sold nationally and internationally, reducing energy costs and environmental pollution throughout the world (NYSERDA 1997).

Several of NYSERDA's R&D programs are detailed in the case study section of this report, including: Residential and Commercial Heating, Low-Income Housing and Weatherization, Hybrid-Electric Vehicles, and Energy-Efficient Wastewater Treatment and Sludge Management. In addition, NYSERDA created the Lighting Research Center at Rensselaer Polytechnic Institute, which operates the National Lighting Product Information Program, a collaborative ASERTTI project profiled in the case study section.

Other highlights of NYSERDA's R&D achievements include:

- An advanced, high-efficiency commercial air-conditioning system that uses up to 25 percent less energy than comparable conventional systems has allowed one of NYSERDA's NYS business partners to avoid bankruptcy, triple its workforce, retool its factory, and become the third largest manufacturer in a field dominated by Japanese companies.

- The nation's first non-ozone-depleting supermarket refrigeration and air-conditioning system, with a global warming factor approximately 90 percent less than conventional units, was demonstrated in a supermarket in New York. The protocol developed for converting to non-ozone depleting systems saved supermarkets in New York millions of dollars in reduced conversion costs.

- A New York company developed a non-intrusive load monitor, with support from NYSERDA and the utility industry. This technology will enable utilities and customers to economically obtain better data on energy use and electric loads, on a disaggregated basis, by interpreting the load signatures at the meter. The product was selected by more than 1,500 DSM professionals as the most valuable DSM product in 1996.

North Carolina's Advanced Energy Corporation

Mission: " To help residential, commercial, and industrial customers transform energy into productivity by increasing the return on their energy investment."

North Carolina's Advanced Energy Corp. (formerly Alternative Energy Corp.) is a nonprofit organization established in 1980

by the North Carolina Utilities Commission in cooperation with the state's major electric utilities. Advanced Energy, located on the North Carolina State University Centennial Campus in Raleigh, provides services to all sectors of the economy through its Industrial Energy Laboratory (IEL) and Applied Building Science Center (ABSC). IEL offers consulting, testing, and educational services in technologies such as infrared, radio frequency, microwave, and powder coating, as well as motors and drives. ABSC offers services related to residential and commercial buildings, including performance testing; field assessment; monitoring; analysis; applied research; quality assurance; program design and delivery; and training for builders, designers, HVAC contractors, utility personnel, and others.

The Organization

Advanced Energy had a budget of $4.4 million in 1996, up $0.2 million from 1995. Its 35-member staff has a broad range of expertise in education, planning, marketing, communications, administration, manufacturing process technologies, and applied building science. Advanced Energy collaborates with other organizations and experts, including staff from electric utilities, universities and community colleges, other nonprofit organizations, equipment manufacturers, and industry trade associations.

The majority of Advanced Energy's research activities are conducted by its own staff, in cooperation with customers and utility partners, either at IEL and ABSC laboratories or at customer sites. Recently, the focus of some activities has shifted to on-site work in industrial facilities, and electrotechnology equipment has been reconfigured for portability since the early days. Since the early days, ABSC research and consulting have emphasized field work.

The Process

A President and Executive Director leads Advanced Energy, with activities overseen by a Board of Directors comprising representatives of investor-owned utilities and electric membership cooperatives, and public members appointed by the Governor. Program activities are driven by member utilities and customer demand. Each member utility's contributions are placed into an account that the utility can draw upon as it requests Advanced Energy support for its regulated customer service activities. Member utilities can contract with Advanced Energy if they want services above and beyond those covered by basic member fees; other parties can also contract for Advanced Energy's services.

Most activities are undertaken with an individual customer. Projects involving multiple sponsoring utilities have diminished in recent years as a result of the shift in project organization. Advanced Energy undertakes collaborative work with organizations and experts engaged in complementary activities. In particular, IEL's production electrotechnology capabilities are maintained as state of the art by working with equipment manufacturers to insure the most recent equipment is available for demonstrations and testing.

Program Activities

The research and deployment activities of Advanced Energy have shifted in recent years to meeting specific customer needs, by providing unique services available from no other source. As a result, public outreach activities have diminished.

Advanced Energy has developed unique expertise and extensive proprietary data sets over the past 15 years that staff can draw upon for technical and market analyses. These data can be supplemented, as needed for specific projects, by both field survey and long-term monitoring, and laboratory testing. Laboratory test capability and training facilities are developed as project demand warrants. These facilities may contain purchased, loaned, or donated equipment.

Advanced Energy's IEL focuses on manufacturing process technologies that are energy-efficient and environmentally responsible. Through testing, demonstration, education, and research, these technologies are used to improve industrial productivity and competitiveness. In addition, IEL has the only independent, accredited motors and drive-test facility in the country, with capabilities to test equipment from 1-250HP under a wide range of standard and non-standard electrical operating conditions. Test results data help support end-users' motor repair and replacement policies, evaluate substitution of standard motors for metric motors, and evaluate motor drives. Recently, IEL has begun supporting motor manufacturers seeking accreditation of their own test facilities to comply with the Energy Policy Act motor efficiency standards. IEL also prepares publications and presents workshops that address issues of motor management and policy.

Advanced Energy's Applied Building Science Center helps builders, contractors, and others apply sound principles of building science to houses and small commercial buildings. Because buildings are systems of interrelated components—the building shell; heating, ventilation, and cooling systems (HVAC); the site and surrounding environment; and the occupants—it is essential to understand these relationships and their impacts when buildings are constructed or remodeled. Advanced Energy is active at two building-science training sites:

- The Heat Pump Skills Center includes classrooms and a laboratory with 16 heat pumps and such specialized equipment as a ductwork air-flow trainer and a refrigeration cycle training board. Studies indicate that most heat pumps and central air conditioners operate at only 60-70 percent of rated efficiency. Advanced Energy teaches HVAC technicians to increase the efficiency of the 600 or more units each technician services annually. Advanced Energy calculates that each trained technician can save consumers about $12,000 annually in energy and equipment costs.

- The Duct Diagnostics and Repair Training Lab features a "living lab" with simulated repair sites incorporating typical duct sections and model test houses. Advanced Energy's field experience indicates that 80 percent of homes have leaky ducts that typically

deliver only 60 percent of the heating and cooling produced by the equipment. A two-week program in duct diagnostics and repair teaches HVAC contractors how to use diagnostic equipment to check for health, safety, and energy problems in a home and how to correct the problems by sealing duct leaks. Reducing duct leakage in manufactured homes (38 percent of North Carolina's new single-family homes) can reduce heating and cooling requirements by an estimated 20-30 percent.

Advanced Energy also sponsors workshops on Ground-Source Heat Pump Certification for HVAC contractors, excavation contractors, well drillers, and utility personnel; and has developed guidelines, training, and consulting services for building "exemplary homes" that are safe, healthy, durable, affordable, and environmentally responsible. Local Habitat for Humanity affiliates have used these services to demonstrate that "exemplary" also means "affordable."

Virgin Islands Energy Office

Mission: "To administer programs that will: (a) reduce vulnerability to oil supply disruptions and economic leakage related to expenditures for imported petroleum; (b) reduce percentage of Gross Territorial Product spent on energy by the public and private sectors, i.e., electricity and water, ground and inter-island air transportation; and (c) reduce the demand on the public power utility."

The Virgin Islands Energy Office (VIEO) is a government agency that was created in 1974 by executive order. VIEO is a division of the Department of Planning and Natural Resources. It is responsible for monitoring the integration of policies relating to conservation, use control, distribution, and allocation of energy, as well as planning and overseeing coordination of the State Energy Program (SEP), the Institutional Conservation Program (ICP), and other applicable DOE Grant Programs, with the exception of the Low-Income Heating and Energy Assistance Program (LIHEAP).

The Organization

Funding for VIEO's current budget of $4.8 million comes primarily from an Exxon Petroleum Violation Escrow account. VIEO has two facilities, the main office on St. Croix and a satellite office on St. Thomas. Staff include nine program staff, three administrators, two support staff, and seven vacant positions.

The Process

VIEO prepares and submits a Territorial State Plan to DOE's Atlanta Regional Support Office for review and approval. The plan lays out the administrative and programmatic areas VIEO will undertake for implementing and executing energy efficiency, conservation, and renewable energy resource programs. To accomplish its objectives, VIEO empowers its employees via training and decentralized management.

Program Activities

Approximately 20 percent of VIEO's budget goes towards renewables projects, and another 20 percent goes toward residential programs. VIEO is involved in such programs as:

- Implementing an alterative-fuel vehicles project that acquired a propane-powered bookmobile;
- Conducting student competitions to design, build, and race solar-powered cars;
- Upgrading a photovoltaic reverse-osmosis water treatment plant;
- Installing and collecting data from a system that assesses the potential of renewable energy;
- Providing rebates to consumers for energy-efficient appliances and products;
- Drafting building code standards that include energy conservation measures;
- Contracting out for services to implement government-wide energy audits and promote comprehensive energy management projects;
- Implementing a recreational facilities lighting project;
- Proposing comprehensive energy conservation legislation;
- Conducting car care clinics that analyze vehicles to maximize fuel efficiency; and
- Providing funding to LIHEAP.

VIEO also publishes a quarterly newsletter and promotes energy education at schools, community organizations, and summer camps. By using demonstration projects and energy savings data to facilitate the development, adoption, implementation, and endorsement of local energy policies (i.e., energy building code, and comprehensive DSM), VIEO is hoping to achieve a broader impact for its energy conservation programs (Barnes 1997).

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