Creating Institutions for Energy Efficiency R&D: New Roles for States and Utilities

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There is a growing trend toward state-level sponsorship of energy efficiency R&D and technology-transfer programs. At least eight states have established such programs, with others in the planning stage. In contrast to energy R&D at the Federal level, most state programs emphasize applied research on end-use efficiency and renewable energy. A recurrent theme is the importance of linking research to technology-transfer; in some cases the division between research and implementation is deliberately blurred. The eight states discussed in this paper now spend about $39 million/year on energy R&D, or one-fifth as much as DOE's total budget for conservation and renewable energy. Moreover, when indexed to R&D spending per capita or to dollars spent on energy, the average rate of R&D spending in these states is about 65-75% that of DOE's level of effort devoted to conservation and renewables research.

This paper summarizes the existing state energy R&D programs, discusses some of the reasons for their creation, and raises several issues they face in common--including opportunities for collaboration among the state programs, with DOE, and with other existing research institutions such as EPRI and GRI. A final section presents the rationale for energy efficiency R&D at the state (or regional) level, including the potential for such programs to advance not only the science and technology of energy efficiency but also to contribute to educating the next generation of "energy literate" practitioners, teachers, and public leaders.

Introduction

States and local governments have often been the innovators in emerging areas of public policy. Perhaps this is because they are closer to the source of problems--and opportunities--and more accessible to the constituencies seeking action or offering solutions. This tendency for states and localities to innovate has occurred repeatedly in the field of energy efficiency and renewables. Examples include:

- state regulatory policies and collaborative planning processes to encourage a "level playing field" for utilities that invest in demand-side management (DSM) resources as well as conventional energy supplies
- added regulatory incentives in some states to reward utilities that can demonstrate specific savings from their DSM investments
- effective use of "off-budget" financing (such as revenue bonds) to finance energy-saving retrofits in public buildings
- early involvement in designing and sponsoring the "Golden Carrot" consortium to provide refrigerator manufacturers with a competitive financial incentive to introduce advanced, energy-saving technologies
- initial field-tests of home energy rating systems, designed to better inform both home buyers and sellers, and energy-efficient mortgages which can help translate energy performance into "financeable market value"

State energy initiatives have also been extended to energy R&D. In the past few years, a growing number of states have established energy research and technology-transfer programs--almost all of them focused on end-use efficiency and (in varying degrees) renewable energy resources and the related goals of environmental quality and sustainable economic development. Starting with the well-established energy R&D programs in New York, Florida, and North Carolina, five other states (Kansas, California, Minnesota, Wisconsin, and Iowa) have created their own energy research organizations during the past few years. Still other states are contemplating or actively planning such programs.

These state programs emphasize applied research on efficiency and (secondarily) on renewable energy sources. They have often forged close working relationships with electric and gas utilities (who provide most of the funding for several of the programs), and have explored promising new ways to tighten the links between technology research and implementation. The states' specific interest in energy R&D is in turn part of a broader trend toward investing in technology innovation to support the economic infrastructure, often as a three-way partnership among state government, industry, and universities. In 1988, 44 state-sponsored technology innovation programs represented a total annual investment estimated at $550 million (Strauss, 1989).

Recognizing their common interests, the state energy R&D programs have also formed an informal coalition, the Association of State Energy Research and Technology Transfer Institutions (ASERTTI, 1991 and Markle, 1991). The purpose of this organization is to facilitate the regular exchange of ideas and experience among the states, and to identify opportunities for jointly sponsored research and technology-transfer activities. To date, the Association has identified a common R&D interest in topics such as heating, cooling, and ventilation (HVAC) distribution system efficiency; improved methods for measuring and analyzing energy savings; quality control and commissioning of buildings and subsystems; and energy-efficient office technologies. The group meets twice a year, once in conjunction with the research subcommittee of the National Association of State Energy Officials (NASEO).

The following sections provide a brief summary of each state energy R&D program, discuss some issues they face in common, and examine their future prospects--including possible implications for Federal energy policy.

An Overview of State R&D Programs

State Program Descriptions

The existing state energy R&D programs differ in several respects but share other features in common. The organizational base varies: four of the states have set up nonprofit entities, three have established university-based centers, one is a state agency (CEC), and the remaining program (NYSERDA) is a semi-independent state corporation. Program scale varies by about an order of magnitude, from the smaller programs at $1-2 million/year to the largest (and oldest) program in New York, at over $15 million. Six of the programs are funded primarily from utility assessments or voluntary contributions; the other three rely mainly on state budget allocations or Oil Overcharge revenues.

All but one of the nine programs (Kansas) focus all or most of their R&D on end-use efficiency and renewable energy sources. In contrast to the basic energy research emphasized until recently at the Federal level, the state programs lean decidedly toward applied R&D, demonstrations, and (in the case of California's ETAP program) some pre-commercial product development jointly funded with private industry. Most of the programs rely on a formal advisory committee structure to help plan the research and review proposals. In about half the cases, a Board of Directors (or the equivalent) is responsible for final decisions on research funding.

Several of the programs also make an explicit link between environmental quality and statewide economic development objectives, on the one hand, and energy efficiency and increased reliance on renewables. Each of the states has made technology-transfer a high priority in designing their research and allocating budgets. Another common goal, either explicit or implicit, is to strengthen institutional capabilities within the state.

The remainder of this section briefly summarizes the nine existing state R&D programs (two of them are in California). Table 1 summarizes key characteristics; this is followed by brief narratives, which draw upon an earlier compilation (ASERTTI, 1991). We provide somewhat more detail on the California Institute of Energy Efficiency (CIEE), since it illustrates many of the general issues, and since three of the authors were directly involved in CIEE's creation.

Excluded from the summaries are states: where energy R&D programs are in the planning stage (Colorado), where R&D is only one of several functions of the State Energy Office (Hawaii), or where informal R&D coordination occurs with no specific organization or budget (the Pacific Northwest region). Since our focus is on efficiency and renewables research, the one state program devoted almost entirely to supply-side R&D (Ohio Coal Development Office) is not discussed here. Finally, we have not included several state energy offices that allocate Oil Overcharge revenues or other funds to individual R&D projects, without creating a specific new program or organization charged with R&D.

Table 1. Characteristics of State Energy R&D Programs

State/Agency	Year Est.	Type	Funding Level[a] ($M/year)	Primary Source of Funds	Program Focus; Use of Funds[b]
New York NYSERDA	1975	State Corp.	$15,500	Utility surcharge	Energy supply + end-use waste mgmt. R&D [contract]
California CIEE	1988	Univ.	4,500	Utility contrib.	Elec./gas end-use effic. R&D [contract]
California CEC/ETAP	1985	State	2,900	Utility surcharge	Renewable + cons. tech. commercial'n matching grants + loans [contract]
Florida FSEC	1974	Univ.	5,800	State $; contracts	Solar, renewable, end-use effic. [in-house + contract]
Iowa IEC	1991	Univ.	2,200[c]	Utility surcharge	Effic. + renewable R&D [contract]
Kansas KEURP	1981	Non-Profit	600[d]	Utility contrib.	Elec. supply and end-use R&D [contract]
Minnesota BRC	1987	Univ.	1,900	State PVEA $	Building energy use effic. and indoor AQ [in-house/ faculty]
N.Carolina AEC	1980	Non-Profit	3,100	Utility contrib.	Effic. + renewable R&D and outreach [contract]
Wisconsin WCDSR	1990	Non-Profit	2,200[c]	Utility contrib.	R&D on DSM tech. + program savings; market + consumer decisions [contract]

(a) Average annual expenditures, 1987-1991, including research planning and management but excluding project-level matching funds (excluded due to varying accounting practices and treatment of in-kind matches, etc.).
(b) Except for FSEC and Minn. BRC, with substantial in-house R&D activities, these organizations mainly sponsor research contracts with other entities.
(c) Projected for 1992, first full year of operation.
(d) Total annual expenditures, including about 35% for end-use projects in FY 90 and FY 91.

New York State Energy Research and Development Authority (NYSERDA). By far the largest and (along with Florida) one of the two oldest state energy research programs, NYSERDA manages a $15.5 million/year RD&D program aimed at improving energy efficiency within the state, adopting innovative technologies, protecting the environment, and promoting economic growth. The Energy Authority was established by the state legislature as a Public Benefit Corporation. Assessments on electric and gas sales by investor-owned utilities and a proportional (voluntary) contribution from the New York Power Authority are its main sources of R&D funding

(NYSERDA, 1990 and 1991). There is a strong emphasis on matching funds, and on multi-party collaboration in planning and managing research.

NYSERDA programs address all forms of energy and each end-use sector. Research funds are allocated among four roughly equal programs: industrial efficiency, building systems, energy resources (mainly renewables and alternative vehicle fuels), and municipal wastes. The Authority also manages disposal sites for low-level radioactive waste and issues revenue bonds to help utilities finance pollution-control and other energy projects. The Authority has negotiated royalty and other payback agreements on some of its R&D projects; currently these return more than $1 million/year in revenues. NYSERDA operates under a 13-member Board of Directors, appointed by the Governor. Its staff of 80+ is significantly larger than that of most other state R&D organizations (excluding the Florida Solar Energy Center).

California Institute for Energy Efficiency (CIEE). The California Institute for Energy Efficiency was created in 1988 as a statewide research unit of the University of California (CIEE, 1991a). The Institute funds medium- to long-term research projects at California-based universities and non-profit research centers, including the DOE National Laboratories in the state.

CIEE's revenues come mainly from electric and gas utility contributions based on a percentage of utility revenues. Additional funds were provided in 1990 by the California Energy Commission from the state's Oil Overcharge revenues. All major projects are approved by the CIEE Research Board, whose voting members include a senior management representative from each participating utility, the University, the California PUC, and the California Energy Commission. Non-voting Board members represent the Electric Power Research Institute (EPRI) and the Gas Research Institute (GRI). These same organizations provide technical representatives for a research planning committee.

Research funding is divided into four categories: larger, multi-year projects which involve more than one participating institution; smaller, one-year exploratory grants; a small Discretionary Fund for the Director's use in responding to new opportunities; and Supplemental Projects which allow either CIEE's participating utilities or outside sponsors to focus additional resources on a topic of special interest. Since an explicit aim of the program is to strengthen the technical capabilities of research institutions within the state, technology transfer is a required element for each funded project. In addition, CIEE sponsors an annual conference to present results and status reports on all of its projects (CIEE, 1991b).

The multi-year projects, accounting for about two-thirds of CIEE's annual budget, focus on three program themes: building energy efficiency, the potential for end-use efficiency to improve air quality in urban areas, and end-use resource planning (including performance measurement and analysis). These projects typically involve total funding of roughly $1 million over a period of about three years. One of the participating institutions assumes lead responsibility for coordination and reporting. Encouraging several institutions to participate in a project is part of an explicit strategy to draw on diverse disciplines, and to use the research itself as a means of creating or strengthening institutional capabilities and networks within the state.

None of these CIEE multi-year projects is yet complete but several have made notable progress. For example, a multi-year project on thermal performance and air leakage in residential ducts has already developed new measurement methods, better techniques for quantifying overall energy performance, and new approaches to improved duct integrity in new construction and retrofits. The topic has captured the interest of DOE and other ASERTTI members, with a national workshop held in the spring of this year and plans for an expanded program with cosponsors from other states.

CIEE also funds about ten smaller ($60 K) "exploratory" projects, for one year at a time. These projects, typically involving a single investigator and a graduate student, account for about one-sixth of CIEE's core funding. The hope is that at least some of these projects will lay the groundwork for new, multi-year research efforts.

Director's Discretionary Funds for R&D and technology transfer account for CIEE's remaining core funding. These quick-response grants have demonstrated their value; one project on gas-filled, CFC-free insulating panels has already generated patents and "graduated" to an exploratory grant, which is, in turn, evolving into a larger effort with DOE co-funding.

Supplemental projects provide a mechanism for CIEE to attract and manage additional resources, beyond its annual core funding. This approach has been used to let one or more sponsors initiate a project in which they have a special interest, but which do not yet fit into the research priorities and core funding level arrived at by consensus of the entire CIEE Board. For example, two CIEE sponsors, the Los Angeles Department of Water and Power (LADWP) and the Sacramento Municipal Utility District

(SMUD) have sponsored projects to measure the cooling effect on summer "heat islands" from light roofs and roads, and from strategically planted trees and other vegetation. Success in these experiments could well lead to state and Federal co-funding.

California Energy Commission - Energy Technology Advancement Program (CEC-ETAP). The California Energy Commission, created in 1975 as the state's energy office, also plays a significant role in funding pre-commercial energy research, development, and demonstration projects. A special program was initiated in 1986 to provide matching grants and loans for energy technology development projects. Both private firms and consortia and public agencies (including utilities) are eligible for funding; repayment is required where projects are judged likely to produce significant commercial revenues. Most projects require a match of 50% or more; in some cases the matching funds have been significantly greater. Projects are peer-reviewed and recommended for approval by a majority vote of the five CEC Commissioners. A total of $17.5 million in ETAP awards were made from 1986 through 1991 (Rashkin, 1992). Of these, about 60% were for power generation from alternative energy sources and another 30% for end-use efficiency projects. In addition to the ETAP program, the Energy Commission supports a variety of research and analysis activities on alternative-fuel vehicles, efficient buildings and appliances, and renewable resource development. These are not shown in Table 1, however, since there is no cumulative list of such projects or funding amounts.

Florida Solar Energy Center (FSEC). The Florida Solar Energy Center was established in 1974 as a non-profit research institute within the State University system to conduct research, education, and performance certification of solar products. Since then, the Center has broadened its program to include all forms of renewable energy and end-use efficiency. The Center's staff of 137 includes about 50 professionals, as well as technicians, support personnel, and graduate students. About half of its $5.8 million/year budget comes from state appropriations; the rest is project funding awarded by Federal and state agencies, utilities, and other sponsors (Huggins, 1992). FSEC is distinguished from most of the other state energy R&D programs because a large fraction of its work is done by in-house staff, rather than contracted out to other research organizations. Major program areas include energy-efficient buildings (envelopes, cooling, and air-distribution systems), photovoltaics, solar thermal systems (including product testing and design review for solar hot water systems in schools), other advanced systems for renewable energy and end-use efficiency, field monitoring techniques, and energy education and training (FSEC, 1991a and 1991b). These research programs share an emphasis on experimental field research and innovative instrumentation methods.

Iowa Energy Center (IEC). The Iowa Energy Center was authorized by the State Legislature in 1990. Its state funding of about $2.2 million/year is based on an assessment on electric and gas utility bills (IEC, 1992). The mission of the Center is to sponsor research, demonstration, and education and technology-transfer programs that can improve energy efficiency in all sectors and help shift usage from fossil to renewable energy sources. A 13-member Advisory Council helps guide the research program; members represent electric and gas utilities in Iowa, state agencies, and public and private universities in the state. The first competitive research solicitation was held in 1991, with eligibility open to colleges, universities, and non-profit organizations in the state. Initial project awards were made in early 1992.

Kansas Electric Utilities Research Program (KEURP). The Kansas program is a joint venture among six electric utilities in the state. It was established in 1981 to cosponsor applied research that can improve the reliability and reduce the costs of electric service in the state (Loux, 1992 and Markle, 1991). About one-third of the annual R&D expenditures of $0.6 million is devoted to end-use efficiency, with the rest focused on utility operations. Most research projects are funded on a multi-year basis and carried out by university faculty within the state; several projects are cofunded by EPRI. A Technical Committee advises the Director on proposed research; each funded project is approved by an Executive Committee consisting of utility sponsors.

Minnesota Building Research Center (MnBRC). The Minnesota Building Research Center was established in 1987 as a research unit of the University of Minnesota. The Center funds and coordinates interdisciplinary faculty research that can improve the energy efficiency and indoor environmental quality of new and existing buildings in cold climates. To date, most of the Center's $1.9 million/year research budget has come from the state's Oil Overcharge allocations, with the recent addition of some project-based funding (Grimsrud, 1992). Also, the University has agreed to share part of the savings generated by a campus-wide energy management program for which the Center provides technical support. Major program areas include construction technologies and building systems (envelopes, foundations, lighting), building environment and occupant response, existing buildings, and information and technology-transfer. Most projects are funded for 3-5 years.

North Carolina Alternative Energy Corporation (NCAEC). The NCAEC, an independent, non-profit organization, was created in 1980 by the Utilities Commission and the state's regulated electric utilities in order to promote energy efficiency and the use of renewable energy resources. Its $3.1 million/year budget comes from voluntary utility contributions (NCAEC, 1990, 1991a and 1991b). The Corporation's program--even more than those in other states--emphasizes community outreach, education, training, and demonstrations, as well as applied R&D. Program areas include commercial and residential buildings, agriculture, industry, and other utility-related interests such as compressed-air storage, photovoltaics, and electric vehicles. An extensive advisory committee structure helps in program planning; the Corporation's 12-member Board of Directors is appointed by the Governor and the sponsoring utilities. A major new program is being organized around the Electrotechnology Laboratory, which provides production-scale industrial demonstration, training, and testing facilities as a cooperative venture between the NCEAC, the College of Textiles at N. Carolina State University, and several corporate and utility cosponsors.

Wisconsin Center for Demand-Side Research (WCDSR). The Wisconsin Center for Demand-Side Research was established in 1990 as a result of an extensive, two-year planning and consultation process among the state Public Service Commission, the University of Wisconsin, and the electric and gas utilities (Prahl, 1990, and Wisconsin EURWG, ND). The Center is an independent, non-profit organization supported by electric utility contributions and some project-level contracts. Its mission is to sponsor and coordinate applied research on demand-side technologies, markets, and utility program effectiveness; to improve the quality of information available for demand-side resource planning; and to support university faculty and student research and education. The Center's annual budget of about $2.2 million (as of 1992) is organized into five major programs: research, data bases, academic support, professional education and development, and communications and publication (Feldman, 1992). An 11-person Board of Directors consists of members from the sponsoring utilities, the Wisconsin PSC, the University of Wisconsin, and a public member. Each Board member also designates a technical representative to a Research Advisory Council.

Research Funding

The nine state energy research organizations described above are, collectively, a significant but little-recognized presence in U.S. energy efficiency and renewables R&D. Table 1 shows the average spending by each of the state R&D organizations from 1987-1991, including funds spent internally for research planning, management, and other administrative activities. Not included in these totals is the amount of cost-shared or matching funds. Even though these are substantial in some cases, it is difficult to compile the numbers for a consistent comparison, due to differing accounting methods, definitions of "hard" vs. "soft" matches, etc. For the organizations that are relatively new, like those in Wisconsin and Iowa, only the most recent year(s) of funding are included, to represent their expected level of funding after start-up.

Collectively, these eight states represent about 33% of the U.S. population and 28% of total energy expenditures; they now spend about $39 million/year on end-use efficiency and renewables R&D. This is equal to about 20% of the total U.S. DOE budget for conservation and renewables research, excluding state grant programs (Sissine, 1991). It is also roughly equal to EPRI's Customer Systems budget (not including renewable power production), and about half of the annual GRI budget for end-use research, excluding GRI R&D for gas-fired power generation and cogeneration (EPRI, 1991; GRI, 1991).

Figure 1 illustrates two different methods of comparing the level of R&D "effort" among the eight states and three national programs (budgets for the two California programs are combined here). Each state's R&D spending is first scaled by population and then by annual energy expenditures. Using these two indices, the average combined "R&D effort" for the eight states is about 65-75% that of the corresponding values for DOE conservation/renewables research, and significantly greater than that of EPRI. The Figure shows an even higher spending index for GRI's end-use R&D program. This is due, in part, to the fact that (compared with electric utility systems) there seem to be fewer research issues for natural gas production and distribution than for end-use applications.

Note that both the EPRI indices in Figure 1 would be significantly higher if they included research on power production or fuels from renewable energy sources. However, comparison with state programs might then be misleading, since the state programs emphasize end-use efficiency more than renewables. (Unlike the state and DOE indices, the per capita index for GRI is based on gas customers only.) The energy-spending scales for both EPRI and GRI are based on fuel-specific expenditures. However, for a better comparison with the other indices, the last bar in the Figure shows combined EPRI and GRI spending on end-use R&D as a fraction of total dollar sales of electricity plus natural gas.

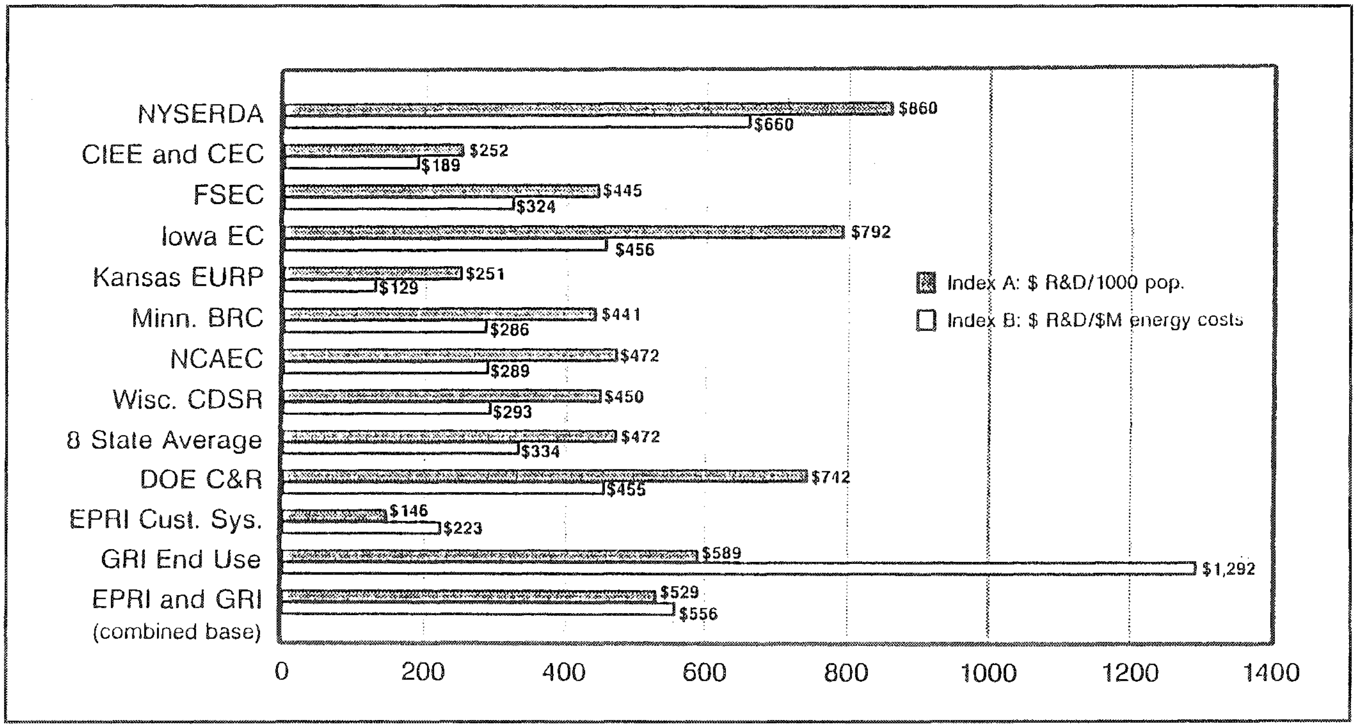

Figure 1. Indices of Relative Spending on Energy Efficiency and Renewables R&D, 1987-1991

Notes to Figure 1: Energy R&D expenditures for selected states are from Table 1. The population index for 1990 is from (Commerce, 1991); the energy expenditures index is estimated for each state as of 1988 (EIA, 1990). For GRI, the index of R&D spending per capita is based on natural gas customers only (about 65% of U.S. households and commercial space). For both GRI and EPRI, the index of R&D per $ spent on energy is based on fuel-specific expenditures (EIA, 1992b). For a more realistic comparison with the R&D indices for states and DOE--which are multi-fuel--the EPRI and GRI indices are also shown together in the final pair of bars, using a combined base of total U.S. population (index A) and total (electricity + gas) expenditures, but excluding spending on oil or miscellaneous fuels.

In interpreting Figure 1, several additional factors should be considered: (1) None of the spending values include matching funds, which are substantial in cases such as EPRI and NYSERDA. (2) Much of the end-use research by both EPRI and GRI focuses on market and interfuel competitiveness rather than energy efficiency per se. (3) EPRI's budget for the Customer Systems program has increased steadily over the past five years; the 1991 budget is about 20% higher than the 5-year average shown in Table 1 and Figure 1. (4) Finally, the EPRI budget amount for Customer Systems does not include fuels and power generation from renewable energy sources, which are part of the research efforts of some of the state programs, and are included in DOE's budget totals for conservation and renewables.

In addition to their EPRI contributions, some electric utilities conduct their own in-house R&D--but this is not aimed primarily at energy efficiency. Both in-house and EPRI funding are reported as a combined total in the Federal Energy Regulatory Commission. FERC's Form 1 shows total 1990 R&D spending by electric utilities of about $600 million (EIA, 1992a). Electric utility research spending grew more slowly than the rate of inflation from 1986 to 1990, shrinking from 0.43% to 0.39% of utility net revenues. No separate numbers are reported for energy-efficiency R&D, but if the experience of California's large electric utilities is a guide, the national figure would show perhaps 5-10% of total electric utility spending on R&D (excluding the EPRI program) devoted to energy efficiency.

The Case for State-Level Energy R&D

States have a vital interest in how energy is used within their borders and how they might influence this use--even if these interests are sometimes recognized only partially or, in a few cases, not at all. Consider private and public expenditures as just one measure of relative importance: energy, at over $450 billion/year, should rank among the top concerns of both state government and its citizens, along with education ($243 billion), passenger transportation ($595 billion), and health services ($604 billion; EIA, 1992b; Commerce, 1991). Yet we must keep in mind that energy, as a public policy issue, has only recently appeared on the scene. While energy use is ubiquitous, its influence on any single arena of public policy or private decisions may be so subtle that it receives little attention.

The emergence of nine state-level research organizations causes us to ask: what is the common the thread? It is not easily found in the geography or political traditions of the states involved. Far more than climate and 2000 miles separate California from North Carolina; there is also the matter of divergent politics, economic foundations, and utility regulatory practices. In part, this very diversity among states has helped stimulate the creation of energy research institutions to fill unmet needs. As one observer has noted, many research questions are either too regionally specific, too applied, or too much of a departure from the national research agenda to be addressed at a national level (Prahl, 1990). Does this suggest that some research activities, by their very nature, must be done at the state level, or that those on the national scene haven't been doing the full job? The answer, we think, is some of each.

At one level, states offer an appropriate scale of effort for energy efficiency R&D. By providing a means for cost-sharing among utilities (and other sponsors), state R&D programs can undertake some projects that would be considered too risky, or simply take too much of each year's budget, for a single utility to sponsor--even a very large utility such as those in California or New York. Improved communication and coordination among researchers, even where state funding is modest or absent, can help avoid duplicative research.

Yet another perspective on the surge of state support for energy R&D comes from the tradition of federalism, with the Federal government having specific, delegated powers and all other governmental responsibilities reserved to the states. While some constitutional provisions such as the interstate commerce clause have been interpreted broadly, much of the governmental authority in areas critical to energy efficiency and renewables still rests with the states and, through the states, with local governments. This includes the regulation of utilities; land-use planning and zoning; the enactment and enforcement of building codes; primary responsibility for education and transportation; and the authority to impose sales, property, and user taxes. These traditional governmental functions give states powerful levers to shape state energy policies--levers that are only starting to be recognized in some states. Within our Federal system, if there are to be coherent and cohesive U.S. energy programs and policies, then Federal and state governments must recognize their separate, yet complementary roles.

Research programs at the state level can also establish more intimate ties with many of the intended users of R&D results. Success in technology-transfer depends in large part on the familiarity and perceived legitimacy of the source. In other words, it helps when the research findings are "invented here"--or at least nearby. An example is the role that some state R&D programs (Wisconsin, New York, California) are beginning to play in providing technical support to the utility/public sector "collaboratives" to establish DSM goals, design utility regulatory incentives, and monitor program and policy results. Similarly, initial findings from CIEE's duct efficiency research in California may soon find their way into updates of the state's Title 24 residential energy building standards.

A number of important technical issues in energy efficiency are clearly region-specific. The most obvious examples relate to climate differences. Regions with extremely cold winters face different building design constraints than regions with mild winters, humid and dry regions must each address quite different strategies for improving air conditioning performance, and so on. These variations are reflected in the distinct building technology programs in Minnesota vs those in Florida.

Other differences--in regional economies, construction practices, fuel supplies, energy prices, utility industry organization, transportation networks, and environmental quality--also tend to support regional defined priorities for energy efficiency research. For example, improved productivity in the textile industry is an important concern for North Carolina, while New York and California are both more interested in efficient computers and office technology. A special interest in California is the role that end-use efficiency and solar energy can play in mitigating urban smog, by reducing the "upstream" need for power generation and thermal loads that use fuel directly--and perhaps modifying the urban form to affect the location of emissions and their mixing in the atmosphere.

However, the work being conducted by these state institutions shows a focus that is not entirely regional. Indeed, some of the most innovative work has broad national application, such as the leading efforts by California and Florida to improve duct system efficiency, reduce infiltration, and thus affect both cooling and space heat loads.

The Wisconsin program has taken a lead in exploring new ways to assess consumer decision-making and to track the impacts of DSM programs. And several state organizations, including Florida and (more recently) New York, California, and Minnesota are exploring better methods for monitoring the field performance of buildings, equipment, and systems.

We thus conclude that concerns other than region-specific research seems to play a role in the perceived need for new energy R&D institutions at the state level. At least three other issues appear to matter: the quantity of energy efficiency research conducted by national organizations, the objectives and focus of that research, and the types of organizations being supported.

At the national policy level, the 1980s were a period of malign neglect for energy efficiency. Administration budgets routinely proposed massive cuts in both DOE's research and grant programs for energy efficiency. While Congress rejected many of the proposed cuts, the available resources were steadily eroded, dropping two-thirds in constant dollars from 1979 to 1989 and--despite gradual increases since 1989, were still only at two-thirds of their 1979 level (inflation-adjusted) as of 1992 (Sissine, 1991). The creation of new R&D programs in several states--with their dominant focus on efficiency and renewables--was in part a response by those in government, utilities, and the research community who saw a continued commitment to improved energy efficiency as a critical need (Regens, 1985; NRC, 1990).

The Federal program also shifted its emphasis sharply away from applications and technology transfer, toward "long-term, high-risk" technologies (GAO, 1990). The utility-sector national research organizations, GRI and EPRI, did not face the same erosion of resources, and their work has remained more applied. However, neither organization has focused primarily on energy efficiency. Rather, due to the competition between electricity and gas for many end-uses, much of their research has centered on creating new markets and improving the competitive position of the sponsoring industry (EPRI, 1991; GRI, 1991). For EPRI, a second important concern has been load management--interpreted as not only decreases in on-peak sales but also new technologies and energy uses to increase off-peak sales. Despite a dramatic rate of growth in its Customer Systems program (over 50% from 1987 to 1991), EPRI's current budget for end-use R&D still totals only about one-fifth of its funding for supply-side (including environmental) research (EPRI, 1991).

Once again, some of the states seem to have been quicker to recognize the emerging realities of the electric utility business. The traditional focus on central power generation and rate-of-return regulation are giving way to a new set of utility roles emphasizing competitive procurement of power, efficiency in distribution, and customer services to enhance energy productivity. It is not surprising that energy efficiency has become a prime focus for R&D in many of the same states (California, New York, Florida) where regulatory policies now highlight demand-side technologies as a principal means of meeting energy service needs--and as a source of future revenue growth and profit for utilities.

The major recipients of research support from national energy R&D programs have been the National Laboratories, large industrial firms, and specialized consultants. These institutions have tended to be remote from local concerns; their management and staff are not always accessible to state and local officials. Conversely, research institutions such as colleges and universities, with closer ties to the local scene, have played a much less significant role in national energy research programs. By contrast, four of the nine state R&D programs are based in universities; the others have relatively close ties to universities in their states through sponsored research, faculty membership on advisory committees, student internships, and the like.

Thus, we might view the state R&D programs as decentralized, "little science" alternatives to the centralized "big science" model of research funding by national organizations. We don't wish to downplay the importance of the national programs; all of us have been closely involved with these programs during our careers. But, the problems of energy efficiency may well require more emphasis on decentralized approaches. This is because continued progress in energy efficiency requires not just a few points of intervention, as on the supply side, but a large number of behavioral and perceptual changes dispersed throughout the fabric of society, affecting how all individuals and institutions conduct their affairs. In the U.S., the job of encouraging and sustaining the changes needed for energy efficiency has been assigned mainly to decentralized institutions. Energy efficiency research is likely to be most effective when its own structure approaches that of technology-deployment process it is trying to support.

The state energy R&D programs described in this paper have shown they can identify technical challenges and opportunities that are significant both regionally and, in cases such as lighting, ducts, and office equipment, on a national level. They have brought together multiple sponsors within their states to successfully translate new ideas into well-managed research projects, ranging from single-faculty summer projects to multi-year, multi-dimensioned research programs involving several institutional participants and sponsors. We might even say that, in some ways, these states are already reshaping the boundaries of energy R&D:

- by clearly placing their research emphasis on efficiency and renewable resources rather than conventional energy supplies
- by moving beyond "hardware" research to also include systematic work on technology deployment, quality-control in real installations, consumer behavior and decision-making
- by seeking the direct involvement of universities and, in particular, emphasizing the role of multidisciplinary research as a training-ground for new entrants to the field, both as practitioners and as researchers
- by seeking to directly link energy efficiency to non-energy issues such as indoor and outdoor air quality, water savings, industry and job growth (retention), etc.
- by incorporating technology-transfer as a primary concern of each R&D project right from the start--and in some cases, deliberately blurring the traditional boundary between "research" and "implementation"

Implications for State and Federal Policy

While it is difficult to predict the future course of state-sponsored energy R&D, we expect that this movement will continue to grow. New institutions are most likely to be established in those states that are just now starting to redirect their utilities toward "integrated resource planning," with energy efficiency and renewable resources seen as the most credible resource options for both the near-term and longer-term. We expect that states will continue to move toward more active information-sharing and coordinated research planning, through informal networks such as ASERTTI and perhaps other mechanisms. In at least two areas, the upper Midwest and the Pacific Northwest, state organizations and utilities have begun to explore the possibilities of closer regional affiliation on energy efficiency R&D and related matters.

These new areas of emphasis, and the state R&D organizations that embody them, could in turn represent a new set of opportunities for the national energy R&D institutions such as EPRI, GRI, and DOE itself. Recent legislative proposals envision a stronger role for DOE in providing more flexible funding and technical assistance to states for conservation program implementation. But relatively little attention has been paid, thus far, to potential state roles in strengthening the technical foundations for energy conservation, through R&D. The Federal government could provide financial help and technical advice for new start-ups of state (or regional) energy R&D programs, assist the linking institutions (such as ASERTTI and NASEO) in similar efforts, and help improve coordination between research planning at the national and state levels.

Indeed, the growth of state-level energy R&D raises the possibility of increased "balkanization" and duplicative efforts--absent a renewed effort by the national organizations to provide constructive leadership and effective coordination. DOE itself could take the lead by involving states in joint R&D planning, cofunded research, and participation by state R&D Directors and staff on DOE program advisory groups. A similar array of opportunities are open to GRI and EPRI, to build bridges to this emerging group of prospective partners across the country.

We fully expect to see, throughout this country, a growing recognition of the importance of sustainable, affordable, and environmentally acceptable energy systems--for economic growth, job security, and a high quality of life. This process will generate new constituencies for energy efficiency and renewables within our states and communities, and help unleash their ideas and initiative. Energy efficiency research, properly conceived and effectively managed, has an essential role in supporting state energy policies. The research process and research institutions, if thoughtfully designed and adequately nurtured, can help us keep a perspective on the future, offer an independent source of criticism to guide current programs and practices, open up new possibilities, and--in the best of cases--provide a solid educational foundation for the next generation of technical and managerial leaders.

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