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ENERGY EFFICIENCY RD&D: NEW ROLES FOR STATES

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Energy Efficiency RD&D: New Roles for States

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Abstract

At least eight states have established energy research, development, and demonstration (RD&D) programs. In contrast to Federal and utility energy RD&D, most states emphasize applied research on end-use efficiency and renewable energy. States are also trying to closely link research and technology deployment, in some cases deliberately blurring the line between the two. The eight states discussed in this paper now spend about $39 million/year for energy RD&D. This is one-fifth the US Department of Energy (DOE) budget for conservation and renewable energy RD&D, but when indexed per capita or per energy dollar, the average rate of RD&D spending on conservation and renewables by these states is about 65-75% that of the US DOE.

Keywords:Research, energy efficiency, state governments

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 in the field of energy efficiency and renewables has been often noted in the literature,[1,2] and recently surfaced in the form of legislation proposing that states lead the transition to a "sustainable energy path."[3]

Examples of specific energy initiatives by states include:

- o 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[4]

- o further regulatory incentives in some states to reward utilities that demonstrate specific savings from their DSM investments[5]

- o effective use of "off-budget" financing (such as revenue bonds) to finance energy-saving retrofits in public buildings[6,7,8]

- o first energy performance standards for residential appliances and equipment such as refrigerators and air conditioners[9,10]

- o 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"[11,12]

State energy initiatives have also been extended to energy research, development, and demonstration (RD&D). In the past few years, a number of states have established energy research and technology-transfer programs--almost all of them focused on end-use efficiency, renewable energy resources, and related goals of environmental quality and sustainable economic development. The earliest energy RD&D programs were established in New York, Florida, and North Carolina, followed by five other states: Kansas, California, Minnesota, Wisconsin, and Iowa. Still other states are now considering such programs.

Each of these state energy RD&D programs emphasizes applied research on efficiency and, to a lesser extent, on renewable energy. These programs often forge close working relationships with electric and gas utilities, who provide the majority of RD&D funding in several cases. The states are also exploring promising

new ways to tighten the links between technology research and implementation.

This specific interest in energy RD&D is in turn part of a broader trend in state government toward investing in technology innovation to support the economic infrastructure. This is often designed as a three-way partnership among state government, industry, and universities.[13] In 1988, 44 state-sponsored technology innovation programs represented a total annual investment estimated at $550 million.[14]

Recognizing their common interests, the state energy RD&D programs have recently formed an informal coalition, the Association of State Energy Research and Technology Transfer Institutions (ASERTTI).[15,16] The purpose of this organization is to promote 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 interest in RD&D topics that include distribution system efficiency for heating, cooling, and ventilation; improved methods for measuring and analyzing energy savings; quality control and commissioning of buildings and subsystems; and energy-efficient office technologies. The ASERTTI group schedules one of its semi-annual meetings as a joint session with the research subcommittee of the National Association of State Energy Officials (NASEO).

The following sections begin with a brief summary of each state's energy RD&D program, discuss some issues they face in common, and examine their future prospects, as well as some possible implications for Federal energy policy.

AN OVERVIEW OF STATE RD&D PROGRAMS

State Program Descriptions

The existing state energy RD&D programs differ in some respects but also share features in common (Table 1). Their organizational base varies. Four of the states have set up non-profit entities; three have university-based centers; one is a state agency (CEC); and the remaining program (NYSERDA) is a quasi-independent state corporation. Program scale varies by about an order of magnitude. The smaller programs have budgets of $1-2 million/year while the largest (and oldest) program, in New York State, has annual funding of more than $15 million. Six of the programs are supported primarily by utility assessments or voluntary contributions; the other three rely mainly on state budget allocations or Oil Overcharge revenues.

All but one of the nine states (Kansas) target all or most of their RD&D efforts to end-use efficiency and renewable energy. In

contrast to basic energy research--which until recently was the nearly exclusive focus of DOE research at the Federal level--the state programs lean decidedly toward applied R&D, demonstrations, and some pre-commercial product development that is jointly funded with private industry (e.g., in California's Energy Technology Advancement Program, ETAP). Most of these programs rely on a formal advisory committee structure to help plan the program and to review research 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 seek an explicit link between their energy efficiency and renewables programs and other state policy goals involving environmental quality and economic development. Another common goal, either explicit or implicit, is to strengthen institutional capabilities within the state. Finally, each of the states has made technology-transfer a high priority, both in research design and in allocating funds.

The remainder of this section briefly summarizes the nine[17] existing state RD&D programs, drawing upon an earlier compilation.[18] There is more detail on the California Institute of Energy Efficiency (CIEE), since it illustrates many of the general issues and because three of the authors were directly involved in CIEE's creation.

Excluded from the summaries are states: where energy RD&D programs are in the planning stage (e.g., Colorado), where RD&D is only one of several functions of the state's energy office (Hawaii), or where informal RD&D coordination is taking place without a 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 RD&D (Ohio Coal Development Office) is not discussed here. Nor have we included several state energy offices that have allocated Oil Overcharge revenues or other funds to individual RD&D projects but have not created a new program or organization charged with RD&D.

New York State Energy Research and Development Authority (NYSERDA)

By far the largest and (along with Florida's) one of the two oldest state energy RD&D agencies, NYSERDA manages a $15.5 million/year program aimed at improving energy efficiency within the state, adopting innovative technologies, protecting the environment, and promoting economic growth. The 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 RD&D funding.[19] There is a strong emphasis on matching funds and on multi-party collaboration in planning and managing research.

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]
Calif. CIEE	1988	Univ.	4,500	Utility contrib.	Elec./gas end-use effic. R&D [contract]
Calif. 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]
Minn. 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]

Notes to Table 1:

[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.

NYSERDA programs address all forms of energy and all end-use sectors. 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 royalties and other intellectual-property agreements for some of its research products; these currently produce more than $1 million/year in revenues to the program. NYSERDA operates under a 13-member Board of Directors, appointed by the Governor. With a staff of over 80, it is significantly larger than that of most other state RD&D organizations (except for 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.[20] 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 funding comes 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 account. All major projects are approved by the CIEE Research Board, whose 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), the Gas Research Institute (GRI), and the US DOE. These same organizations also provide technical staff for a Research Planning Committee.

Research funding is divided into four categories: (1) large ($300-500K/year) multi-year projects which involve more than one participating institution; (2) smaller ($60K), one-year exploratory grants; (3) a small discretionary fund for the Director's use in responding to new opportunities; and (4) Supplemental Projects which allow 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.[21]

The multi-year projects account for about two-thirds of CIEE's annual budget. These address three program themes: energy efficiency in buildings, improving urban air quality through end-use energy efficiency, and utility "demand-side" resource planning (including energy demand modeling and measurement of savings). Typically funding for each project involves roughly $1 million over a period of three to five years. One of the participating

researchers assumes lead responsibility for coordination and reporting. CIEE explicitly encourages several institutions to participate in a project, in order to draw on diverse disciplines and to use the research process itself to create or strengthen institutional capabilities 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 heating and cooling ducts has developed better measurement methods, improved techniques for quantifying system energy performance, and new approaches to improved the thermal integrity of ducts in new construction and retrofits. The topic has captured the interest of DOE and other ASERTTI members; a national workshop was held in Spring 1992 and plans are being drawn for an expanded program, cosponsored by states, utilities, homebuilders, and the Federal government.

CIEE also funds about ten smaller, one-year "exploratory" projects. These projects typically involve a single investigator and a graduate student, and together account for about one-sixth of CIEE's core funding. The intent is that at least some of these projects will evolve into new, multi-year research efforts.

Director's Discretionary Funds for RD&D and technology transfer account for the rest of CIEE's budget. The Director's ability to provide small grants with quick turnaround has demonstrated its value; one project on gas-filled, CFC-free insulating panels has already generated patents, recognition in the form of an industry innovation award, and a successful exploratory grant project which, in turn, has stimulated DOE co-funding.

Supplemental projects provide a mechanism for CIEE to attract and manage additional resources, beyond its annual "core" budget. This approach allows one or more sponsors to initiate a project in which they have special interests, but which does not yet fit within the research priorities established by consensus of the entire CIEE Board. For example, two CIEE sponsors have supported field research projects to measure the cooling effect on summertime "urban heat islands" from light-colored resurfacing of roofs and pavement and from strategic planting of trees and other vegetation. Success in these experiments could lead to further state and Federal co-funding.

California Energy Commission - Energy Technology Advancement Program (ETAP)

The California Energy Commission (CEC) was created in 1975 as the state's Energy Office. It 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 (or consortia) and public agencies, including utilities, are eligible for funding. Projects are first peer-reviewed and then recommended for approval by a majority vote of the five CEC Commissioners. Repayment is required where a project is expected to produce significant commercial revenues. Most projects require a match of 50% or more; in some cases the actual funding match has been significantly greater. A total of $17.5 million in ETAP awards were made from 1986 through 1991.[22] 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 their funding.

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. The Center's mission is to conduct research and education in support of solar energy, renewable energy sources, and energy efficiency. It also tests and certifies the performance of solar products. 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.[23]

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. FSEC differs from most of the other state energy RD&D programs in that a large fraction of its work is done by in-house staff rather than contracted out to other research organizations or consultants.

Iowa Energy Center (IEC)

The Iowa Energy Center was created by the State Legislature in 1990. Its budget 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 energy use from fossil fuels 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 IEC's 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.[24] About two-thirds of its annual RD&D expenditures of $0.6 million are directed to utility operations, with the remaining third aimed at end-use efficiency. Most research projects are carried out by university faculty within the state and funded on a multi-year basis; several projects are cofunded by EPRI. A Technical Committee advises the Director on research proposals. Each funded project must be approved by an Executive Committee consisting of utility sponsors.

Minnesota Building Research Center (MnBRC)

The Minnesota Building Research Center was created 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. 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. To date, most of the Center's $1.9 million/year research budget has come from the state's Oil Overcharge allocations; some project-specific funding has recently been added. The University has also agreed to share part of the savings generated by a campus-wide energy management program for which the Center provides technical support.[25]

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, with the aim of promoting energy efficiency and the use of renewable energy resources. Its $3.1 million/year budget comes from voluntary utility contributions.[26,27] The North Carolina 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 topics such as compressed-air storage, photovoltaics, and electric vehicles. The Corporation's 12-member Board of Directors is appointed by the Governor and the sponsoring utilities; an extensive advisory committee structure participates in research program planning. A major new program is being organized around the recently completed Electrotechnology Laboratory, which provides production-scale industrial demonstration, training, and testing facilities. The Laboratory is a cooperative venture between the NCAEC, 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 involving the state Public Service Commission, the University of Wisconsin, and the state's electric and gas utilities.[28,29] The Center is an independent, non-profit organization supported by electric utility contributions and some project-level contracts. It has a three-part mission: (1) to sponsor and coordinate applied research on demand-side technologies, markets, and utility program effectiveness; (2) to improve the quality of information available for demand-side resource planning; and (3) to support university faculty and student research and education. As of 1992, the Center's annual budget of about $2.2 million was organized into five major programs: research, data bases, academic support, professional education and development, and communications and publication.[30] An 11-person Board of Directors includes members from the sponsoring utilities, the Wisconsin PSC, the University of Wisconsin, and a public member. As in California, each Board member also designates a technical representative to a Research Advisory Council.

Research Funding

These nine state energy research organizations represent, collectively, a significant but little-known presence in U.S. research on energy efficiency and renewables. Collectively, these eight states (representing about 33% of the U.S. population and 28% of total energy expenditures) now spend about $39 million/year on end-use efficiency and renewables RD&D. This equals about 20% of the total U.S. DOE budget for conservation and renewables research (excluding state grant programs).[31] It is also roughly equal to EPRI's Customer Systems budget (not including renewable power production), and is about half of the annual GRI budget for end-use research (excluding GRI's research on gas-fired power generation and cogeneration).[32,33]

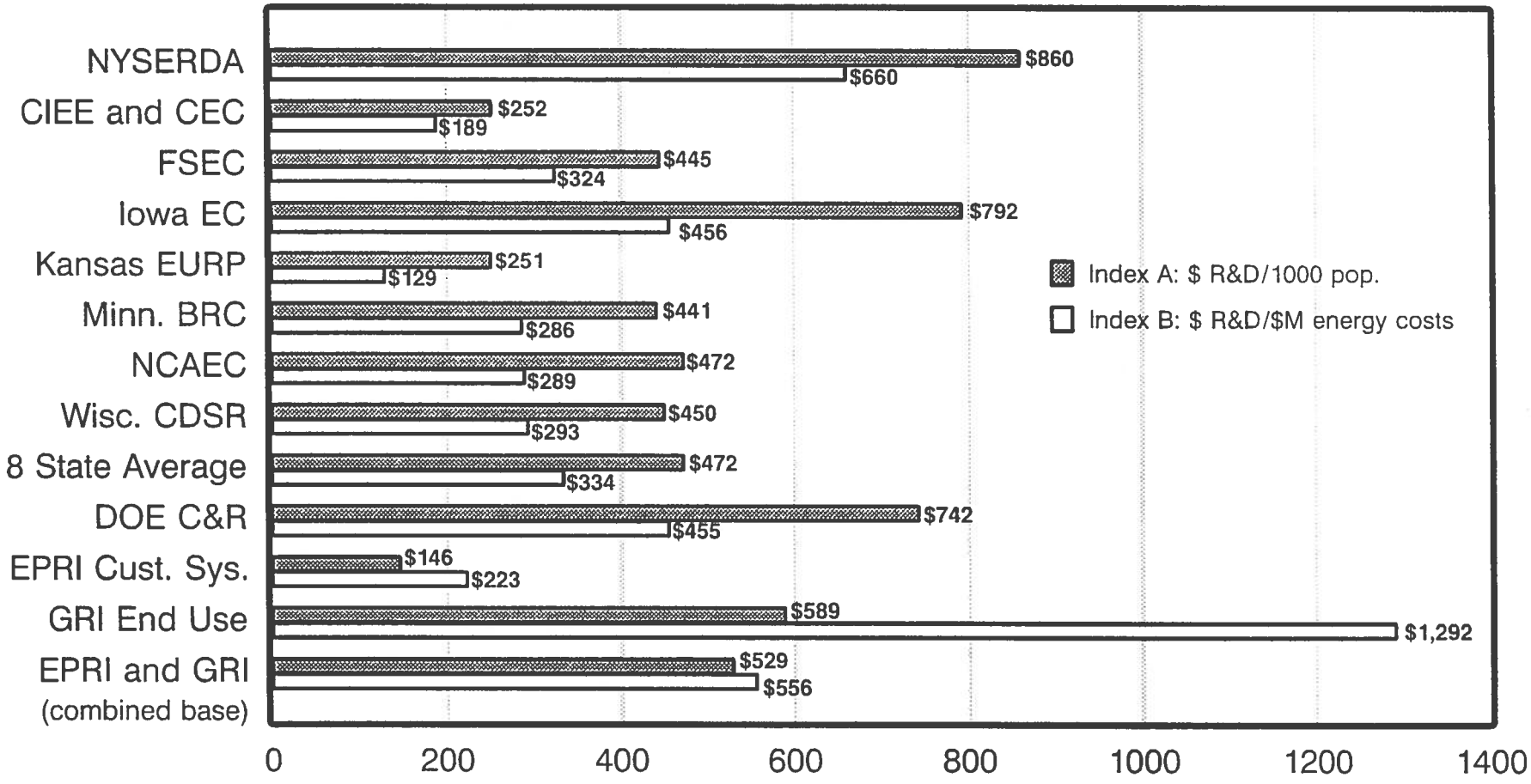
Table 1 shows the average spending by each state RD&D organization from 1987-1991, including funds spent internally for research planning, management, and administration. Not included in these totals is the amount of cost-shared or matching funds--even though these are substantial in some cases. It is difficult to compile consistent data on RD&D matching funds, due to differing accounting methods, definitions of "hard" *vs* "soft" matches, etc. For the relatively new organizations, like those in Wisconsin and Iowa, only the most recent year(s) of funding are shown in the Table. This represent a more realistic estimate of the expected program scale after a start-up period.

Figure 1 illustrates two different methods of comparing the RD&D "effort" among the eight states[34] and three national programs. Each state's RD&D spending is scaled both by population and by annual energy expenditures. Using these two indices, the combined "RD&D effort" for these eight states is, on average, about 65-75% that of the corresponding (indexed) value for DOE end-use energy efficiency research, and is significantly greater than EPRI's indexed budget for end-use efficiency RD&D (excluding power production from renewable sources). While the Figure shows an even higher spending index for GRI's end-use RD&D program this is due, in part, to the relatively limited opportunities for RD&D on natural gas production and distribution (compared with the issues facing electric utility systems).[35]

In interpreting Figure 1, several additional factors should be considered: (1) None of the spending indices include RD&D matching funds, which are substantial for organizations 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) Similarly, DOE's budget for efficiency and renewables RD&D has increased significantly since 1991, with continued growth proposed for future years. (5) 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 in-house RD&D, but most utility-sponsored research focuses on power generation, transmission, and distribution rather than end-use efficiency. Both in-house and EPRI funding are reported as a combined total to the Federal Energy Regulatory Commission (FERC). Data from FERC's Form 1 show total 1990 RD&D spending by electric utilities of about $600 million.[36] Research spending by electric utilities grew more slowly than the rate of inflation from 1986 to 1990, declining from 0.43% to 0.39% of utility net revenues.

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



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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.

Utilities do not report separately on their energy-efficiency RD&D, but based on the experience of California's large electric utilities, we expect that national averages would show that, at most, 5-10% of total electric utility RD&D spending (excluding EPRI) is devoted to energy efficiency.

THE CASE FOR STATE-LEVEL ENERGY RD&D

States have a vital interest in how energy is used within their borders and how they might influence patterns of energy use in order to mitigate the environmental and economic costs. Considering total expenditures, private and public, as just one measure of relative importance, energy (over $450 billion/year) should rank among the top priorities of state government and its citizens, along with education ($243 billion), passenger transportation ($595 billion), and health services ($604 billion).[37,38] Yet, as a public policy issue, energy has appeared only recently on the scene. And although energy use is ubiquitous, its influence on any single arena of public policy or private decisions is often drowned out by other, more direct concerns.

The emergence of nine state-level research organizations causes us to ask: what is the common thread? It is not evident from the geography or political traditions of these particular states. Far more than their climates and 2000 miles separate California from North Carolina; there is also a strong divergence of politics, economic base, utility regulatory practices, etc. In part, this very diversity has encouraged the creation of new institutions to help fill unmet research and technology-transfer needs. Over the past few years, many energy research issues that mattered to states have been either too regionally specific, too applied, or too much of a departure from the national research agenda to be addressed at that level.[39] Does this suggest that some RD&D activities, by their very nature, are best performed at the state level, or that our national institutions haven't been doing the full job? The answer, we think, is some of each.

For one thing, states offer an appropriate scale of effort for energy efficiency RD&D. By providing a mechanism for cost-sharing among utilities and other sponsors, state-level RD&D programs can undertake larger projects that might be considered too risky for a single utility (even a large utility such as those in New York or California), or require too great a share of each year's budget. Second, organizing energy RD&D at the scale of a state can improve communication among researchers and help avoid duplication, even where state funding is modest (or absent).

Yet another perspective on state support for energy RD&D comes from our tradition of federalism, which delegates specific powers to the Federal government while reserving to the states all other governmental responsibilities. Broad interpretation of some

constitutional provisions such as the interstate commerce clause has given Federal agencies wide latitude in regulating energy-related activities and supporting basic R&D on new energy technologies. However, much of the governmental authority in other 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 their energy futures--levers that in some states are only starting to be recognized and used. Within our Federal system, if there are to be coherent and effective national energy policies, both Federal and state governments must recognize their complementary roles.

Another strength of research programs managed at the state level is that they can establish more intimate ties with many of the intended RD&D users. Successful technology-transfer depends in large part on the perceived legitimacy and familiarity of the source. In other words, it helps when the research findings have been "invented here"--or at least nearby. An example is the role that RD&D programs in some states (Wisconsin, New York, California) have begun to play in providing technical support to utility/public sector "collaboratives," in establishing DSM goals, designing utility regulatory incentives, and evaluating technology performance and program results. As another example of prompt use of research results, initial recommendations from CIEE's duct efficiency research may soon find their way into an update of California's Title 24 residential building energy standards.

Some important technical dimensions of energy efficiency are highly region-specific; climate is one obvious example. Regions with extremely cold winters develop different building design traditions and construction practices than those with mild winters; humid and dry regions each require quite different strategies for saving air conditioning energy; and so on. These variations are reflected in the distinct building technology RD&D agendas of Minnesota, for example, *vs* Florida.

Other differences--in regional economies, locally available construction materials, fuel supplies, energy prices, utility industry structure, transportation networks, and environmental quality concerns-- can also lead to specific, regionally-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 more interested in efficient computers and office technology. A special priority in California is the potential benefits from end-use efficiency and solar energy in mitigating urban smog, by reducing the "upstream" need for power generation and thermal loads that burn fuel directly. Other energy end-use measures may offer the promise of

modifying the urban form or otherwise controlling the location and timing of pollutant emissions, and hence their ability to mix in the atmosphere to form smog.

In other cases, however, the RD&D being sponsored by states is not necessarily regional in character. Indeed, some of the most innovative work may have broad national application. In addition to the residential duct research already mentioned, Wisconsin has taken the lead in exploring new ways to assess consumer decision-making and track the impacts of DSM programs. And, several states, including Florida and (more recently) New York, California, and Minnesota, are exploring better methods of monitoring the field performance of buildings, equipment, and systems.

We thus conclude that factors other than region-specific needs and opportunities may play a role in the support for energy RD&D institutions at the state level. At least three other considerations have had an impact: the limited attention paid to energy efficiency research at the national level, 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.[40] 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. Despite a gradual increase since 1989, conservation funding was still at only two-thirds of its 1979 level (inflation-adjusted) as of 1992.[41] The creation of new RD&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.[42,43]

The Federal program also shifted its emphasis sharply away from technology application and technology transfer toward "long-term, high-risk" research.[44] The utility-sector national research organizations, GRI and EPRI, did not face the same erosion of resources, and their programs have continued to emphasize applied research. However, neither organization has focused primarily on energy efficiency. Rather, the competition between electricity and gas for many end-uses has led much of their research to concentrate on creating new end-use markets and trying to improve each industry's competitive position. For EPRI, a second important concern has been load management--aimed at not only decreasing on-peak sales but also increasing off-peak electricity use. Despite a dramatic rate of growth in its Customer Systems program (over 50% from 1987 to 1991), EPRI's current budget for end-use RD&D is still only about one-fifth as large as its supply-side (including environmental) research budget.[45]

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

The state RD&D programs have also brought about a partial shift in the mix of research participants. Traditionally, the major recipients of research support from national energy RD&D programs have been the National Laboratories, large industrial firms, and specialized consultants. These institutions tend to be remote from local concerns; their management and staff are often not readily accessible to state and local officials. Research institutions such as colleges and universities, with closer ties to the local scene, have played a much less significant role in the national energy research programs. By contrast, four of the nine state RD&D programs are based in universities; the others are closely tied to universities in their states through sponsored research, faculty membership on advisory committees, student internships, and the like.

Thus, we might view the state RD&D programs as offering a more decentralized, "little science" alternative to the centralized "big science" model of national research funding. This is not to downplay the importance of the national programs or the value of large research multi-purpose laboratories; all of us have been closely involved with these programs during our careers. But, the challenges of energy efficiency may well benefit from more emphasis on decentralized approaches. This is because continued progress in energy efficiency--unlike energy supply--requires not just a few points of intervention but a large number of perceptual and behavioral changes dispersed throughout the fabric of society. In the U.S., the task of encouraging and sustaining the changes needed for energy efficiency has fallen mainly to decentralized institutions. Energy efficiency research is likely to be most effective when its own structure approaches that of the technology-deployment process it must support.

IMPLICATIONS FOR STATE AND FEDERAL POLICY

The state energy RD&D programs described in this paper have shown that they can identify technical challenges and opportunities that are significant both regionally and, in some cases, nationally. By bringing together multiple sponsors within their states, they have successfully translated new ideas into promising research projects,

ranging from single-faculty summer projects to multi-year, interdisciplinary research programs involving several institutional participants and co-sponsors.

In a number of ways, these states have begun to reshape the boundaries of energy RD&D:

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

While it is difficult to predict the future course of state-sponsored energy RD&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 as the most credible resource options for both the near-term and longer-term. We expect that states will continue to experiment with 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 organizing at a regional scale, for energy efficiency RD&D and related matters.

These new areas of emphasis, and the state RD&D organizations that embody them, could in turn represent a new set of opportunities for the national energy RD&D institutions such as EPRI, GRI, and DOE itself. Federal-state cooperation on energy conservation has been a prominent feature of US energy policy since the mid-1970s.[46] Recently enacted and proposed legislation would allow DOE to take a stronger role in providing flexible funding and technical assistance to states for implementation of these programs.[47,48]

While this may speak to the role of states as program providers, there has been virtually no attention paid at the Federal level, thus far, to the potential for states to help strengthen the technical foundations for energy conservation, through RD&D. The Federal government could provide financial help and technical advice for new start-ups of state (or regional) energy RD&D programs, support other efforts by non-Federal institutions such as ASERTTI and NASEO, and greatly strengthen the coordination of research planning between the national and state levels.

Indeed, the growing number of state-level energy RD&D programs could raise the possibility of increased "balkanization" and duplication--absent a renewed effort by DOE and other national organizations to provide constructive leadership and effective coordination. DOE could take the lead by inviting states to participate in joint RD&D planning, offering to cofund research, and assuring representation by state RD&D agencies on DOE program advisory groups. GRI and EPRI have a similar array of opportunities to build bridges to this expanding group of research partners across the country.

In the wake of the 1992 Earth Summit at Rio and a pro-environmental shift in electoral preferences at both the national and state levels, we fully expect to see a growing recognition across the U.S. of the value of energy systems that are sustainable, affordable, and environmentally acceptable. Part of this process will be the emergence of new constituencies for energy efficiency and renewables within our states and communities.

Energy efficiency research, properly conceived and effectively managed, can play an essential role in supporting state energy policies. Both the research process and research institutions themselves, if thoughtfully designed and adequately nurtured, can help open new perspectives on the future, offer an independent source of guidance for current policies, and--through the links with university research and education--help provide a solid intellectual foundation for the next generation of technical, business, and public leaders.

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