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Promoting Emerging Energy-Efficiency Technologies and Practices by Utilities in a Restructured Energy Industry: A Report from California

Edward Vine

Environmental Energy Technologies Division

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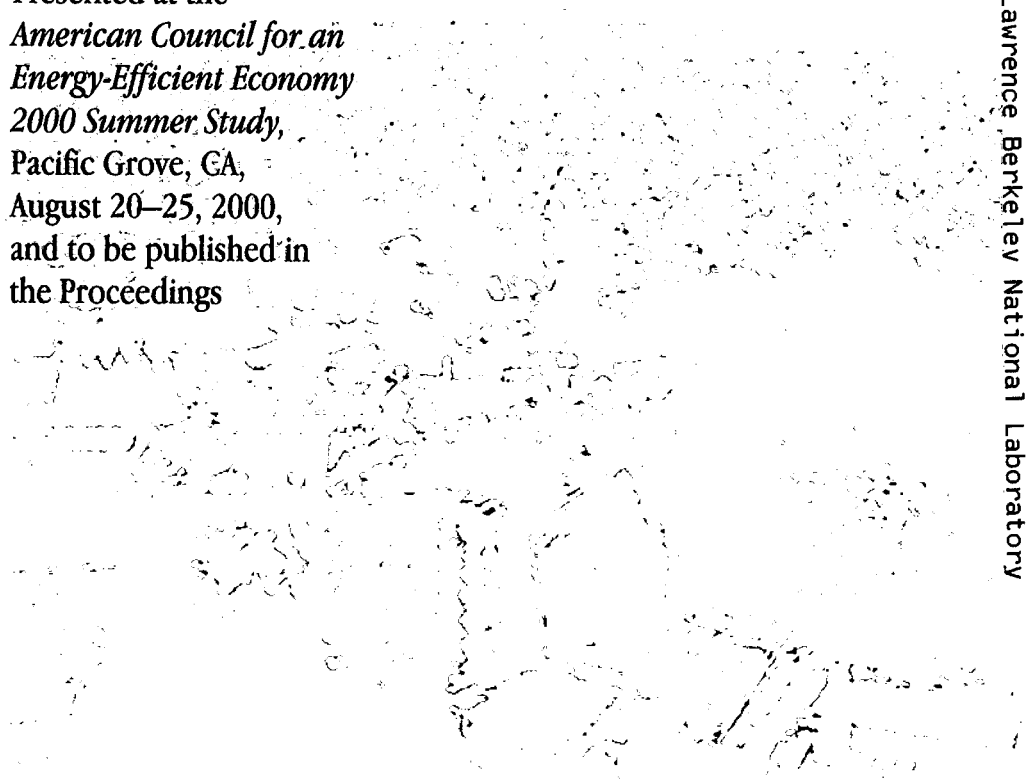

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Environmental Energy Technologies Division
Ernest Orlando Lawrence Berkeley National Laboratory
Berkeley, California 94720

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ABSTRACT

The potential energy savings from emerging technologies (i.e., those technologies emerging from research and development) represent a significant resource to California and the U.S. This paper describes how California's investor-owned utilities (IOUs) have been promoting emerging technologies over the last three years to increase energy efficiency in the buildings sector. During these years, the IOUs have experienced significant changes in their regulatory environment as part of the restructuring of the energy industry in California. These regulatory changes have impacted the way emerging technologies are treated by the regulatory community and the IOUs. After reviewing these changes, the paper concludes by discussing potential opportunities to improve the market penetration of emerging technologies.

Introduction

There is no standard definition of an emerging technology.[1] For example, one study defines emerging technologies as those that either "are not yet commercialized but are likely to be commercialized and cost effective to a significant proportion of end users by 2005" or "are commercialized, but have penetrated less than 2% of the market" (ACEEE et al. 1998). A second study considers an emerging technology as one that is commercially available but is not common, or one that could become commercially available within the next five years (Daniel et al. 1998). While these definitions imply that a product or service does not have to be "new" to be considered an emerging technology, "emerging" is often taken to mean emerging from research and development, and that a particular technology or practice has not reached a particular threshold of market penetration or development (e.g., aerosol-based duct sealing).

Examples of emerging technologies to promote energy efficiency in the buildings sector include daylighting tools and controls, indirect/direct evaporative coolers, and innovative duct sealing technologies (see Box 1 and Table 2). The energy savings from emerging technologies are significant (Nadel et al. 1998). Emerging technology projects provide targets for new market transformation projects, an important strategy in several regions of the U.S.: e.g., the Pacific Northwest, California, New England and New York (Nadel 1999).

The barriers confronting the penetration of emerging technologies are similar to those confronting conventional energy-efficiency technologies (e.g., consumer acceptance and awareness, performance/reliability uncertainties, and lack of information). In particular, because of their low penetration in the marketplace, reliable and/or trustworthy information

[1] In this paper, emerging technologies includes both equipment and services (practices); in addition, emerging technologies may not only be devices, but also tools or methods.

about the cost or performance of these technologies is usually not available to many of the key market players (e.g., consumers, retailers, distributors, manufacturers, builders, building owners, architects, engineers, contractors, utility companies, regulatory agencies, nonprofit organizations, and government agencies). Accordingly, special attention is needed for focusing on emerging technologies in market transformation programs. Furthermore, projects that aim to promote emerging technologies may benefit from the participation of the researchers who were involved in the development of the technology. As shown in this paper, utility companies and government agencies, in particular, have played, and can continue to play, a critical role in promoting emerging technologies.

The Restructuring of the Energy Industry in California

As a result of legislation in 1996 (1996 Statutes, Chapter 854, Assembly Bill 1890, hereinafter "AB 1890"), California's landmark electric industry restructuring bill dramatically changed the funding structure of publicly funded energy-efficiency, research and development, and low-income programs in the state. AB 1890 directed Pacific Gas & Electric (PG&E), Southern California Edison (SCE) and San Diego Gas & Electric (SDG&E) to collect, via a public goods (benefits) charge, a total of $872 million from the utilities' existing ratepayers over the 1998 to 2001 time period for "cost-effective energy efficiency and conservation activities." Additional funds were to be spent on research, development and demonstration (RD&D), renewables, energy efficiency and low-income programs. As they had been in the past (pre-AB 1890), energy efficiency and low-income programs were placed under the direction of the California Public Utilities Commission (CPUC). RD&D and renewables were placed under the direction of the California Energy Commission (CEC).

The CPUC and the CBEE

In February 1997, the CPUC issued Decision 97-02-014 to create a new structure to implement public purpose energy efficiency under a restructured utility industry. The CPUC changed its goal for energy-efficiency programs from resource acquisition to market transformation: energy-efficiency programs are now supposed to induce sustainable changes in the market that would be result in energy savings and practices that will last long after a program is terminated. The CPUC appointed an independent advisory board called the California Board for Energy Efficiency (CBEE) to provide guidance on a market transformation approach to program funding.[2] This effort focused on reducing and possibly eliminating a variety of market barriers to energy efficiency through a series of program interventions funded by the public goods charge.

Following guidance from the CBEE and the CPUC, the California IOUs reorganized their energy-efficiency programs into three program areas (residential, nonresidential, and new construction) and 14 programs.[3] Previous to this reorganization, utilities had separate

[2] The CBEE was disbanded by the CPUC on March 31, 2000.

[3] The programs were: (1) residential heating and cooling systems, (2) residential lighting, (3) residential appliances, (4) residential retrofit and renovation, (5) small nonresidential comprehensive retrofit, (6) large nonresidential comprehensive retrofit, (7) nonresidential HVAC equipment turnover, (8) nonresidential motor turnover, (9) nonresidential process, (10) nonresidential renovation and remodeling,

programs on emerging technologies; as shown above, emerging technologies were now expected to be integrated in one or more of the above programs.

The promotion of promising emerging technologies was considered a priority for both the CBEE and the CPUC, and these technologies were expected to be integrated into one of the 14 programs mentioned above (CBEE 1999). On April 1, 1999, the CPUC issued Resolution E-3592. Among other things, E-3592 approved CBEE's recommendations regarding its 1999 energy efficiency policy rules, performance incentives, market assessment and evaluation plans, budgets and program area descriptions, with certain modifications. The CPUC directed the IOUs to incorporate eight program design and implementation principles into their programs; one of which was to "support the commercialization of emerging technologies." Emerging technologies were eligible for inclusion in all programs and program elements, and the IOUs included them in their 1999 programs. Through Decision 99-08-021, the CPUC decided not to reserve funding specifically for emerging technologies until more was known about the role and opportunities for emerging technologies in the utilities' programs (CPUC 1999). The CBEE maintained that there was already sufficient fund-shifting flexibility to promote emerging technologies within the 14 existing programs as new program elements or intervention strategies. However, the CPUC directed the IOUs to address explicitly, in their compliance applications, the role of emerging technologies in their 2000 program plans, including the coordination of these activities with other utilities and the CEC. Among other things, the IOUs proposed the formation of the Emerging Technologies Coordinating Council (see below).

The CBEE also approved funding for a scoping study on emerging technologies to develop and recommend strategies for tracking the market shares of "near-term" emerging energy-efficiency products and services in California (Regional Economic Research 1999). First, a needs assessment was conducted to identify priority emerging technologies and services for tracking in the California market. Second, a market assessment described the markets of priority measures to determine points in the distribution channel at which data for market share tracking could be obtained. Finally, recommendations for market share tracking of emerging technologies were developed according to whether any given measure could be incorporated into an existing or recommended market share tracking effort. These recommendations are still being discussed.

The CEC and PIER

Previous to AB 1890, IOUs were receiving funds and administering RD&D programs under the direction and guidance of the CPUC. The IOUs had RD&D programs and projects on emerging technologies, which fed into the energy-efficiency programs that they were also developing and administering. The integration of RD&D and energy-efficiency programs changed with restructuring. As a result of AB 1890 and CPUC Decision 97-02-014, the CEC was authorized to receive and administer at least $61.8 million annually for specified public interest energy research. The CEC is now administering a Public Interest Energy Research (PIER) Program to conduct this research. The PIER Program is comprised of six program areas: (1) buildings end-use energy

(11) residential new construction, (12) commercial new construction, (13) industrial/agricultural new construction, and (14) codes and standards support and local government initiatives.

efficiency, (2) industrial/agricultural/water end-use energy efficiency, (3) renewable energy, (4) environmentally-preferred advanced generation, (5) energy-related environmental research, and (6) strategic energy research. Projects that have been funded, or are in the process of being funded, in the buildings end-use energy efficiency area (one of the more developed program areas) are listed in Table 1.

Unfortunately, the CEC has been given limited opportunities for supporting the commercialization of emerging technologies. In particular, the PIER program is restricted to support for RD&D, rather than for commercialization (CEC 1997).[4] Other CEC programs, that could or already support commercialization, are not large enough to provide a comprehensive platform for taking most PIER projects from RD&D through commercialization.

The Utility Role in Promoting Emerging Technologies

To date, IOU efforts in promoting emerging technologies have been planned and implemented primarily by individual utilities. The objectives of these programs are to (1) demonstrate and validate the performance of innovative emerging technologies, (2) assure customers that selected new technologies work and are consistent with vendor claims, (3) broaden the awareness and distribution of new technologies and methods, (4) examine emerging technologies to determine if they will be viable for a market transformation program, (5) determine the level of market transformation assistance needed to make emerging technologies sustainable, and (6) achieve a sustainable market for sales of these emerging technologies. Prior to AB 1890, some IOUs had spent significant amounts of funding on specific emerging technology programs. And prior to restructuring, utilities' emerging technology programs were conducted out of the IOUs' research and development departments (all of which have been eliminated as part of restructuring and utility reorganization).

Since 1999, the IOUs have been ordered to adopt programs that reflect the structure set up by the CBEE (see above). As a result, the utility program applications for 1999 and 2000 filed with the CPUC do not allow for ready identification of emerging technology activities. Consequently, it is difficult for one to quickly assess which specific technologies have been (or will be) targeted and how such efforts are (or are not) being coordinated with other RD&D programs, such as the CEC's PIER program, or with the programs of other utilities in California or elsewhere. As indicated in Table 2, IOUs are promoting emerging technologies, but the depth and intensity of these efforts are unclear.

[4] The PIER projects have a component for disseminating results, but this is just one step in a multi-step process in the commercialization of emerging technologies.

Table 1. PIER Projects in Buildings Area

Transition Projects (Funded)	Funding ($000)
Residential thermal distribution systems	400
Commercial thermal distribution systems	400
Alternatives to compressor cooling	350
Diagnostics for building commissioning and operations	350
Development and demonstration of high-efficiency lighting torchieres	90
Building design advisor	350
Evaluate small air conditioner units for Northern/Central California climates	500
Improve the cost-effectiveness of building commissioning using new techniques for measurement, verification and analysis	300
Improve the cost-effectiveness of building control systems sensing and data collection	250
Food service technology center	350
PIER2 Contracts	
Energy efficient downlights for California kitchens	649
HVAC distribution systems in commercial buildings	537
Next generation power management user interface for office equipment	450
Instrumented home energy rating and commissioning	710
Increased energy efficiency of refrigerators and air conditioners through use of advanced power electronics	412
Removing the key technical barriers to the widespread use of advanced absorption cooling	690
Development of an advanced indirect evaporative heat exchanger module	249
Alternative to compressor cooling - Phase V	868
Conceptual design energy analysis tool	453
A tool for comprehensive analysis of low-rise residential buildings	216
Building specification guidelines for energy efficiency	233
Design refinement and demonstration of market-optimized residential heat pump water heater	756
Improve energy efficiency of commercial kitchen exhaust systems	276
Investigation of secondary loop supermarket refrigeration systems	300
Programmatic Contracts (Pending)	
Energy efficiency and affordable small commercial and residential buildings program	5,422 [3 years]
High performance commercial building systems program	5,995 [3 years]
Integrated energy systems productivity and building science program	5,883 [3 years]
Memberships	
Electric Power Research Institute	Several projects
Gas Research Institute	Several projects
Center for Built Environment	60

Sources: California Energy Commission (2000); Jenkins (2000); CEC PIER Web site: http://www.energy.ca.gov/research/PIER/index.html

IOUs are promoting emerging technologies in the buildings area in California (examples are listed in Table 2). In addition to these projects, three approaches of addressing emerging technologies are noteworthy: (1) SCE's program demonstrating emerging technologies at customer sites, (2) PG&E's strategic planning process for identifying key emerging technologies, and (3) SDG&E's technology assessment process for identifying, screening and classifying appropriate emerging technologies.

In 1999, SCE established an "Emerging Technologies Showcase" to promote emerging technologies by providing end use information and assistance. Demonstration projects are located at customer sites and are selected based on an assessment that there is significant unexploited market potential for a new technology, design, or procedure (Ander 1999). The project may be initiated by a customer interested in the new solution or by the utility's program planners, who are aware of solutions that need customer demonstration efforts. In limited situations where the costs of actual installations are high, the showcase may entail a feasibility study to determine if equipment installation is warranted. Most showcases have the following characteristics: (1) demonstration of state-of-the-shelf technologies[5] or new and innovative design techniques, (2) documentation of energy and demand impacts through engineering analysis, (3) documentation of performance and maintenance requirements, (4) customer visits to showcase sites to increase knowledge and comfort level, and (5) transfer of project results through fact sheets, a Web site, and presentations at trade associations.

The primary targets of these projects are commercial and industrial customers, small business/residential customers, builders and building owners, design professionals, and building operators. To develop showcase sites, trade alliances are formed with customers in key market segments. The showcases are carefully structured projects that are well documented, generate actual data on energy-efficient technologies, and are widely publicized through the business media. Customers are sought for showcase sites who are willing to allow other customers to visit the installations. Where possible, customers who have already installed the promising technology are sought out, and agreements to allow visitors to inspect the site and relevant data are solicited.

SCE program staff conduct feasibility studies at showcase sites to identify and quantify energy-savings results and performance impacts of the emerging technologies including the interactive effects among systems. Funding from SCE supports the technology/site selection process, financial assistance to the customer installing the innovative measures, installation of measurement equipment, and expert engineering analysis of the performance of the measures. The showcasing activities could require up to a two-year commitment for installation, measurement and analysis, and customer visits. There are currently about 60 Showcase projects: e.g., card key control of air conditioning and lights in motel rooms, integrated design of relocatable classrooms, supermarket refrigeration cases, integrated design of affordable housing, and electrochromic glazing. The program has not been evaluated for its effectiveness in distributing the results of these projects to other customers.

In 1996, PG&E initiated a strategic approach to identify and support emerging technologies. First, an assessment was conducted to identify, screen and rank all known gas and electric emerging technologies that were not already covered by current PG&E

[5] Technologies that are commercially available but have a very low penetration rate in the market.

programs. This assessment identified 64 residential and commercial emerging technologies that were then ranked according to their cost-effectiveness, potential savings, likelihood of success of intervention, and other factors. Second, the top 20 emerging technologies were recommended for further assessment. Six of the top 20 were further evaluated for their potential for PG&E intervention.

In 1998, PG&E commissioned a much more detailed technical assessment of 15 residential and small commercial emerging technologies. This assessment included a more rigorous assessment of market status, energy savings and costs, benefit/costs, and market barriers as well as recommendations for intervention strategies for each measure. These recommended strategies are still being discussed at PG&E.

In 1999, SDG&E developed a screening process for identifying, screening and classifying appropriate emerging technologies for their fourteen programs (San Diego Regional Energy Office 1999). For each technology, market barriers were identified, and the following criteria were used for screening candidate technologies: (1) technology maturity; (2) technology risk; (3) market benefits; and (4) support from utility market transformation programs. In addition to the screening criteria, additional criteria were applied to determine appropriate utility program integration of the emerging technology: (1) appropriate program actions; (2) appropriate program elements; and (3) program implementation costs. Based on the assessment and screening methods, five technologies were recommended for consideration as demonstration projects.

Verified Duct Sealing

Duct leakage accounts for much of the inefficiency of residential forced air heating and cooling systems—the leakage of hot or cold air through ducts that means a waste of energy dollars. Most duct leakage could be prevented with proper duct sealing. But field examinations of ducts often find their seals failing over time. To provide data about which sealants and tapes last, and which are likely to fail, PG&E is funding the accelerated testing of duct sealants at Lawrence Berkeley National Laboratory (LBNL). The test procedures include different combinations of heating and cooling together with pressurization of the sample. The procedures are used to stress standard duct joints and their sealants in different environmental conditions. In testing rigs, duct leakage is periodically measured; a sealant has failed when it leaks more than 10% of the air that the joint leaked before being sealed.

The major conclusion drawn so far is that one can use anything but duct tape--when duct tape is defined as fabric-backed tape with rubber adhesive--to seal ducts. Under challenging (but realistic) conditions, duct tapes fail. Other kinds of tape and other sealant methods have good longevity when installed properly. The tests have also shown that tapes do not have to be strong to have good longevity, and that none of the various ratings, including those from Underwriters' Laboratories, addresses sealant longevity in realistic conditions.

Sources: Sherman and Walker (1998) and the following Web sites: http://ducts.lbl.gov/ and http://www.homeenergy.org/898ductape.title.html

Table 2. Examples of Emerging Technologies and Practices Promoted by California Utilities in the Buildings Sector*

Emerging Technologies and Practices	PG&E	SCE	SDG&E	SCG
Verified duct sealing	√	√	√	
Advanced high-efficiency supermarket refrigeration	√	√		
Energy-efficient windows	√	√	√	
Geothermal heat pumps	√	√		
Cool roof rating methodologies	√			
Lower illuminance LEDs	√		√	
Efficient coin-op clothes washers	√		√	
High efficiency air compressors	√	√		
Efficient dishwashers	√		√	
High efficiency (gas) storage water heaters	√		√	
High efficiency furnaces	√		√	
Roof top air conditioner performance analysis tool	√	√		
Evaporative condenser cooling	√	√		
Optimized air conditioners	√		√	
Indirect/direct evaporative coolers	√	√		
Daylighting tools and controls	√	√	√	
Commercial building controls and commissioning	√	√	√	
Residential pool pumps		√		
High-efficiency commercial packaged HVAC units	√	√	√	
Combined space/water heat (hydronic)	√			
Combined space/water heat (forced air)	√			
Food processing plant process and waste-water treatment	√	√	√	
Efficient furnace blowers	√		√	
Optimized chilled water system	√	√		
Integrated building design	√	√		
High efficiency inject mold		√		
Variable speed drives (HVAC, dairy, etc.)		√		
Portable classroom	√	√		

*This table contains examples of emerging technologies in the buildings sector. Utilities are also promoting emerging technologies in other areas. For example, SCG is conducting research on small fuel cells, microturbines, and distributed generation.

Sources: PG&E: Brohard 1999 and 2000; Daniel 1998; Elberling 2000; SCE: Ander 2000; Lau 2000; SCG: Becker 2000; and SDG&E: Rubin 2000.

Emerging Technologies Coordinating Council

In response to the concerns expressed in 1999 by the CBEE and CPUC, the IOUs proposed the formation of an Emerging Technologies Coordinating Council (ETCC). The ETCC is comprised of program representatives from the IOUs and the CEC. The objective of the ETCC is to seek opportunities to coordinate efforts among utilities' emerging technologies program offerings and with the CEC's PIER program. The CPUC is still reviewing the IOUs' applications containing the ETCC. The details of this coordination effort are being explored, and the role and objectives of the ETCC are still being defined.

Recommendations for Promoting Emerging Technologies in California[6]

The experience of restructuring of the energy industry in California has led to an incredible amount of change and uncertainty. New roles and responsibilities are being defined and redefined as new institutions emerge and disappear. IOUs are promoting emerging technologies, but it appears that there is room for improvement in developing and commercializing these technologies.

1. **Identify the emerging technologies promoted by California's IOUs.** Because of the new programmatic structure and CPUC decisions, the utilities no longer have specific programs on emerging technologies. Emerging technologies are scattered throughout utility programs in the residential, non-residential, and new construction areas, and it is difficult to determine which emerging technologies are being promoted in market transformation programs.

2. **Establish a forum for coordinating the promotion of emerging technologies among California's IOUs and other organizations.** Utility projects on emerging technologies are not fully coordinated with emerging technologies projects funded by other organizations: e.g., the U.S. Department of Energy, the Gas Research Institute, the Electric Power Research Institute, the California Institute for Energy Efficiency, and CEC's PIER Program (and vice versa). While several IOUs have worked with these organizations on several projects, the opportunities for collaboration among utilities and other stakeholders, in California as well as outside California, should be exploited to their full potential.

3. **Develop a succinct statewide strategic vision and plan for the selection and deployment of emerging technologies in publicly**

[6] The views that follow reflect the opinions of this author and do not represent the consensus views of the ETCC, California IOUs, the CPUC, or the CEC.

funded market transformation programs. Presently, each IOU is responsible for selecting and promoting emerging technologies. It is impossible to know at this time whether the best opportunities for emerging technologies are being targeted or whether their efforts are well coordinated with each other, or with the CEC. A strategic vision and plan needs to be developed that clearly identifies policy-level goals and related guidance concerning program implementation. As part of this plan, other activities would also be addressed, for example: decision making regarding major funding allocations among emerging technologies; obtaining feedback and evaluation on program performance; and determining future emerging technology program directions and duration. The plan will need to be developed by many stakeholders to ensure the plan is in the "public interest."

4. **Assess the ratepayer funds that are currently devoted to promoting emerging technologies and assess how these objectives are being met with current program offerings.** As noted above, emerging technologies are scattered throughout utility programs in the residential, non-residential, and new construction areas, and it is difficult to determine how much money is being spent on the promotion of emerging technologies versus other technologies. Tracking expenditures on emerging technologies over time would provide one measure of the amount of attention being paid to these technologies.

5. **Develop criteria and indicators for assessing the progress and performance of emerging technology-specific programs.** The methods for assessing the progress of emerging technology-specific programs will undoubtedly be based on the methods being used to evaluate California's market transformation programs. However, additional criteria and indicators may be needed for evaluating the performance and success of emerging technology-specific programs: e.g., assessment of perceived risk of a technology over time.

6. **Ensure strong ties between the RD&D activities funded by the PIER program and the market transformation programs being funded by the public goods charge.** Commercialization of the energy-efficiency products and services produced by the research community should be placed into the marketplace (via market transformation programs) as soon as possible to maximize public benefits. Moreover, the research needs encountered in the implementation of market transformation programs should be addressed by the research community in a timely fashion. A more integrated, systematic, and strategic approach to promoting emerging technologies would help address this problem.

The ETCC offers an opportunity for addressing some of these concerns, however, other organizations (e.g., the CPUC, CEC, or the creation of a nonprofit corporation) could be responsible for one or more of these activities. For example, the ETCC could be responsible for #1 and 2, the CPUC could be responsible for #4 and 5, and the CEC could be responsible for #3 and 6. Alternatively, a nonprofit corporation could be responsible for all of these activities. The formation of the ETCC represents a first step in enhancing the communication among utilities and the CEC, to ensure effective coordination of efforts to support the commercialization of emerging technologies. But this is really just the first step in a long process that will demonstrate to other states undergoing restructuring a strategic framework for promoting emerging technologies.

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References

American Council for an Energy-Efficiency Economy (ACEEE), Davis Energy Group, and E-Source. 1998. *Emerging Energy-Saving Technologies and Practices for the Buildings Sector*. Berkeley, CA: California Institute for Energy Efficiency.

Ander, G. 1999. "Southern California Edison: Emerging Technologies," presentation to the California Board for Energy Efficiency, July 13, 1999.

Ander, G. 2000. Personal communication. Southern California Edison Company, March 8, 2000.

Becker, E. 2000. Personal communication. Southern California Gas Company, March 27, 2000.

Brohard, G. 1999. "PG&E Emerging Technologies: A Summary of Recent Activities and Future Plans," presentation to the California Board for Energy Efficiency, June 30, 1999.

California Board for Energy Efficiency (CBEE). 1999. Memo from CBEE to Utility Program Administrators, Aug. 25, 1999.

California Energy Commission (CEC). 1997. *Strategic Plan for Implementing the RD&D Provisions of AB 1890*. Sacramento, CA: California Energy Commission.

California Energy Commission (CEC). 2000. *1999 Annual PIER Report*. Sacramento, CA: California Energy Commission.

California Public Utilities Commission (CPUC). 1999. *Interim Opinion: Program Year 2000 Selected Policy, Program and Funding Modifications*, Decision 99-08-21. San Francisco, CA: California Public Utilities Commission.

Daniel, Mann, Johns and Mendenhall. 1998. *Technical Assessment of Residential and Small Commercial Emerging Technologies.* San Francisco, CA: Pacific Gas & Electric Company.

Elberling, L. 2000. Personal communication. Pacific Gas & Electric Company, March 7, 2000.

Jenkins, N. 2000. Personal communication. California Energy Commission, April 5, 2000.

Lau, H. 2000. Personal communication. Southern California Edison Company, March 8, 2000.

Nadel, S. 1999. "Market Transformation Evaluation: A Tale of Four Regions," *Proceedings of the 1999 International Energy Program Evaluation Conference*, pp. 101-113. Denver, CO: International Energy Program Evaluation Conference.

Nadel, S., L. Rainer, M. Shepard, M. Suozzo, and J. Thorne. 1998. *Emerging Energy-Saving Technologies and Practices for the Buildings Sector.* Washington, D.C.: American Council for an Energy-Efficient Economy.

Regional Economic Research, Inc. 1999. *Emerging Technology Efficiency Market Share Needs Assessment, Feasibility, and Market Penetration Study.* San Diego, CA: Regional Economic Research, Inc.

Rubin, R. 2000. Personal communication. San Diego Gas & Electric Company, March 7, 2000.

San Diego Regional Energy Office. 1999. *Emerging Technologies for the Residential Program Area and Other Public Purpose Energy Efficiency Programs.* San Diego, CA: San Diego Regional Energy Office.

Sherman, M. and I. Walker. 1998. "Can Duct Tape Take the Heat?" *Home Energy* 15(4): 14-19.

Ernest Orlando Lawrence Berkeley National Laboratory
One Cyclotron Road | Berkeley, California 94720

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