State Partnership for Energy Efficient Demonstrations: Market Transformation Partnerships for Crossing the "Valley of Death"

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ABSTRACT

Between the lab and the marketplace, new energy-efficient technologies often succumb to the "valley of death," a set of perilous barriers to market introduction that can prevent best practice technologies (with typical energy savings of 50% to 80%) from entering and transforming the market. The California Energy Commission created the State Partnership for Energy Efficient Demonstrations (SPEED) Program in 2004 to transform the market for deep energy-efficient products developed or enhanced with Public Interest Energy Research (PIER) Program funding.

The program strategy has successfully bridged the divide for new energy-efficient technologies, completing over 130 partnership demonstrations and utilizing over 35 lighting and HVAC technologies for campuses, public facilities, military bases, and other end-users. These demonstrations optimize the coordination among: technical R&D, manufacturers, designers, distributors, installers, utilities, energy codes, policy-makers and programs. Furthermore, the SPEED program can serve as a model for local, state, and federal public goods organizations.

This paper illustrates the successes and documented savings since the SPEED program began in 2004, as well as how the partnership pipelines it created can lead to successful market transformation. Pipelines lead to more effective market penetration through improved RD&D; campus adoption of PIER technologies and specifications; use of best-practices guidelines, case studies and market outreach; utilities adoption of emerging technologies and incentive programs; group purchasing programs; state and national code changes; effective education and market communications. In all these ways SPEED is helping meet state and national energy and carbon savings goals while paving the way for future innovations with even greater potential.

Introduction and Overview

The California Energy Commission created the State Partnership for Energy Efficient Demonstrations (SPEED) Program (The "Program") in 2004 to transform the market for best practice technologies developed or enhanced with Public Interest Energy Research (PIER) Program funding. The Program partnered with industry, public entities, and utilities to overcome the market barriers facing these innovative energy-efficient technologies, so they could succeed in the marketplace and help California achieve significant energy, peak-demand, and carbon dioxide (CO_2) savings.

One of the key aspects of the PIER and SPEED technologies are that they are deep energy saving solutions or best practice solutions that typically save 50% to 80% verses standard technologies that save 20% to 35%. One of the key market barriers to adapting the best practice solutions is the higher first costs and longer payback periods. But these best practice solutions are essential for meeting the goals of the California Public Utilities Commission’s 2010 Long-Term California Strategic Energy Efficiency Plan. The plan’s lighting goals are to:

“By 2020, advanced products and best practices will transform the California lighting market to deliver improved quality, zero net energy (ZNE) buildings, and a 60 – 80% reduction in statewide electrical lighting energy consumption”.

Using standard lighting practices would require several separate retrofits of the same facility over the next 8 years while best practices would only take one retrofit. The total technical potential for using best practices is to save twice as much energy, peak demand and carbon as standard retrofits as shown in the CPUC 2010 Lighting Technologies Overviews and Best Practice Solutions.

The Energy Commission’s PIER Buildings Efficiency and Industrial Agriculture and Water (IAW) End-Use Energy Efficiency Areas provided $6.75 million from mid 2004 through mid 2010 to demonstrate and field-test promising PIER technologies, conduct technology transfer activities, and otherwise support and encourage their success. The Program was extended from July 2010 through February 2012 with an additional $1.8 million of Buildings Efficiency funding.

As performing institution for the program, the California Institute for Energy and Environment of the University of California (UC) led the planning, implementation, and documentation of the demonstration projects and other activities, with the assistance of primary team members: the California Lighting Technology Center and the Western Cooling Efficiency Center at UC Davis. Other team members included the Pacific Gas and Electric Company’s Food Service Technology Center, the Center for the Built Environment at UC Berkeley and California State University Sacramento.

The first three years of the program (2004–2007) focused on developing partnerships with UC California State University (CSU) campuses offering to demonstrate over a dozen new PIER technologies. A second focus was to build the capabilities of the California Lighting Technology Center and partner with the UC/CSU/Investor-Owned Utility (IOU) Energy Efficiency Partnership to help campuses meet their energy efficiency goals. In its second three years (2007–2010), the program expanded its scope to encompass California community college campuses, state agencies, Silicon Valley Leadership Group organizations, energy service companies, and others—as well as adding many new technologies to the demonstration portfolio. In 2007-2010 the Program shifted to a variable cost-share demonstration model—to leverage PIER funding more effectively and enable substantially more demonstrations. In 2010-2012 the Program expanded again to include military bases in California, while focusing more effort on fostering pilot scaled deployments of demonstrated technology, as well as documenting the energy use reduction resulting from already-achieved deployments of the technologies through major subsidy programs.

Figure 1 illustrates the market transformation process. PIER works with manufacturers in the RD&D phase to evaluate and develop products that meet identified energy and market needs. The program[1] then partners with public and private stakeholders to conduct prototype demonstrations in public facilities to validate the field performance of each commercial PIER technology. Partnerships among these varied stakeholders greatly increase the efficiency of the demonstration program and provide expert feedback for product improvements. This collaboration leads to adoption by energy efficiency implementation programs and purchases of the technologies, which supports state energy and sustainability goals. The program also links to electric utility programs and incentives, informs code changes in Title 20 and Title 24, stimulates market demand and supplier interest, and identifies customer needs for derivative products. As a whole, this market transformation pipeline leads to faster and more widespread market adoption.

Figure 1. The Innovative State Partnership for Energy Efficient Demonstrations (SPEED) Market Transformation Process

Program Results and Market Transformation Accomplishments to Date

This paper is a status report on an innovative PIER SPEED program in moving new deep energy efficiency technologies and best-practice solutions "over the valley of death" and into market acceptance. The program has produced a variety of technical, policy, organizational and administrative results providing examples that could benefit other public and private R&D organizations; government energy and sustainability policy and programs; university and non-profit energy and sustainability organizations. The R&D challenges addressed in this program constitute the classic conundrum of how to overcome the barriers faced by innovative technology developers in moving innovations into commercial production and market acceptance. Many innovations have promise, but relatively few are produced and even fewer become commercially successful. The barriers are well known: high initial cost, unclear value, unknown field performance, user acceptance, licensing and warranty concerns, designer and contractor unfamiliarity, marketing and product support complexities. Also key is the resistance to change among the commercialization participants from producer to wholesaler, regulator to advocate, retailer to consumer. This PIER demonstration and market transformation program is seeking to provide a new and easier path through those obstacles.

The program has field-tested the PIER innovations to document the deep energy savings, customer value and market readiness. Nearly 130 separate demonstration projects have been completed, involving over 35 lighting and HVAC technologies on campuses, public facilities, military bases and other end-users. The high and low California market potential for a partial list of the technologies is summarized in Table 1. Table 2 shows the documented savings already achieved and targeted as well as the estimated market penetration savings in CA for the SPEED technologies.

Potential Program Impact

One measure of potential Program impact is the California statewide energy savings resulting from the market potential of the demonstrated technologies in retrofit applications. Table 1 provides high and low estimates for energy savings from a partial set of Program technologies.

Table 1. Market Potential of SPEED Program Technologies (Partial)

	Annual Electricity Savings (kilowatt-hours, kWh)	Annual Natural Gas Savings (therms)	Reduction in Annual Carbon Emissions (Tons of carbon dioxide equivalent, CO_2e)	Annual Monetary Savings
Low Retrofit Market Penetration	2,507,000,000	17,142,000	965,000	$343,015,000
High Retrofit Market Penetration	6,268,000,000	42,855,000	2,412,000	$867,602,000

Notes: Assumed Low Retrofit Market Penetration is 10% of all commercial and institutional floor space Assumed High Retrofit Market Penetration is 25% of all commercial and institutional floor space 0.6 pounds of CO_2e per kWh, 11.65pounds of CO_2e per therm, $0.13 per kWh, $1.00 per therm

Progress has been documented toward achieving this market potential in a partial accounting of the actual achieved and projected targeted savings of deployment programs resulting from Program technology transfer:

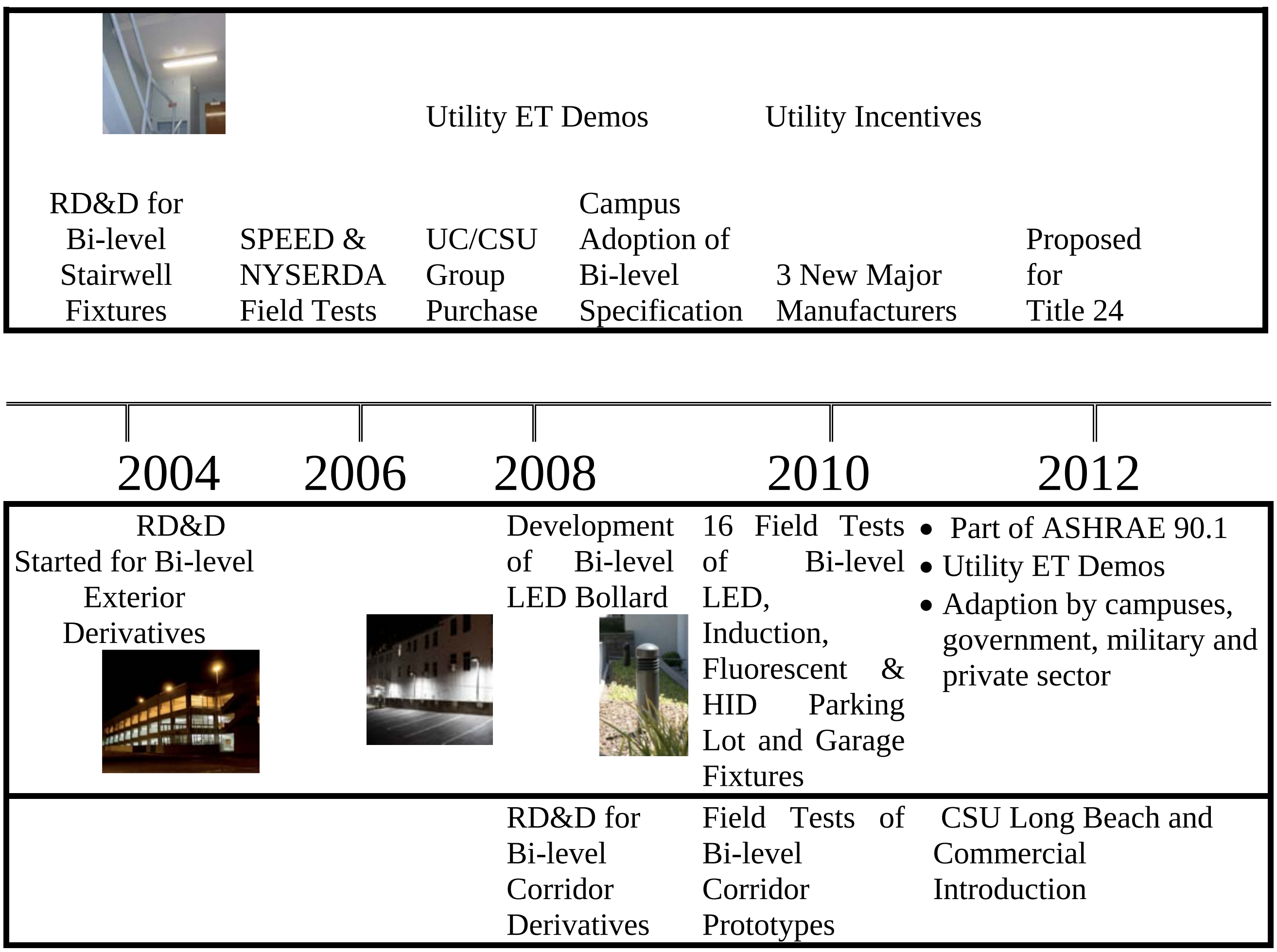
Table 2. Achieved or Targeted Savings of Deployment Programs

	Annual Electricity Savings (kWh)	**Annual Natural Gas Savings (therms)**	**Annual Energy Cost Savings (US Dollars)**
Deployment Program (Achieved Savings)			
UC/CSU/IOU Partnership **Monitoring-Based Commissioning (MBCx)** 2004–2011	47,700,000	4,200,000	$10,370,000
Lighting projects documented by December 2011 Survey, plus UC Davis Smart Parking Lighting	13,500,000	0	$1,760,000
Total Savings Achieved by Deployments To-Date	**61,000,000**	**4,200,000**	**$12,000,000**
Deployment Program (Targeted Savings)			
State Energy Program (SEP) / American Recovery and Reinvestment Act: (ARRA) Active Management of Cooling Systems to Reduce Energy Consumption for the Data Center Market (**Datacenter Automation Software and Hardware**)	4,700,000	0	$611,000
SEP/ARRA—Municipal & Commercial Building Targeted Measure Retrofit Program—**Energy Technology Assistance Program** (n/I achieved savings above)	11,400,000	243,200	$1,700,000
MBCx: Additional potential in UC Strategic Energy Plan portfolios, plus.3rd-Party by EnerNoc with SCE and PG&E	61,500,000	1,830,000	$9,825,000
Kitchen Demand Controlled Ventilation (3rd-Party)	28,600,000	1,700,000	$5,418,000
Total Additional Targeted Savings (In-Progress)	**106,000,000**	**3,800,000**	**$18,000,000**

Overall SPEED Program Market Transformation Process Example

Figure 2 below shows one example of the effectiveness of the SPEED program's market transformation pipeline for the evolution of the bi-level (adaptive) interior and exterior lighting starting in 2004 with the bi-level stairwell fixture. The bi-level stairwell fixture project lead to a variety of new derivative products of interior and exterior bi-level and adaptive lighting systems. This also illustrates the effectiveness of the SPEED market transformation process with the university campus utilities use of the products and having the cost effective field data to have these deep energy savings solutions adapted into codes and standards

Figure 2. Bi-level (Adaptive) Lighting Technology Timeline: From Stairwell Fixtures to Corridor and Exterior Derivatives



SPEED Process Example for Adaptive Corridors: Success Story from Demonstration to Deployment to New Standards

To continue to illustrate the Program's effectiveness in market transformation for bi-level and adaptive lighting, a more detailed example for adaptive corridor lighting is given below. Lighting accounts for about 35 percent of energy use in California's commercial buildings. But what exactly is being lit, day in and day out, and at what cost, in both wasted dollars and wasted energy? In buildings of every type, corridors, stairwells, lobbies, and service rooms are brightly lit 24/7, even though people occupy these "secondary spaces" infrequently or intermittently. Installing adaptive, bi-level lighting — systems that detect the presence of people and dim or raise the lights accordingly — is an effective way to save energy, shed load during peak demand, and realize a satisfying return on a manageable investment in energy efficiency.

Progress in implementing adaptive corridor lighting is an excellent example of how PIER-funded research, development, and demonstration lead effectively to pilot-scale deployment, widening use, and new standards and policies to benefit California — precisely the continuum of progress and market transformation that the SPEED program is designed to foster. Adaptive corridors are a "derivative product" of a cascade of successful PIER-sponsored activities, launched in 2004 with initial work on bi-level stairwell fixtures, and on the bi-level exterior pathway and parking-garage fixtures that followed soon after. The stairwell fixtures were demonstrated on ten California campuses in 2005-2006 and subsequently purchased for the entire University of California and California State University systems. A portfolio of exterior parking and pathway lighting fixtures was demonstrated in 16 field tests in 2010, leading to an initiative to retrofit all such lighting on all ten UC campuses, plus other state facilities.

In step with the forward motion on these projects, work began in 2008 on adaptive bi-level lighting for corridors and other secondary spaces. The California Lighting Technology Center (CLTC) at UC Davis led this effort, working with manufacturing partners to develop and field-test prototype systems. The SPEED demonstration process — designed to prove the efficacy and value of PIER R&D — put these new technologies into practical use, showed how they yield direct energy and cost savings, deployed them on a pilot scale in an award-winning initiative, and ultimately are generating new statewide standards for corridor lighting. See Figure 2 Bi-level (Adaptive) Lighting Technology timeline.

The *SPEED Demonstration Process for Adaptive Corridors*

At UC Davis, CLTC's home campus, keeping corridors lit accounts for 25% of lighting energy use — surprisingly, more than expenditures for lighting offices, laboratories, or exterior spaces. By monitoring occupancy in corridors (and stairwells), CLTC learned that these areas are vacant from 64% to 94% of the time. Existing lighting in these spaces was provided through non-dimmable ballasts, operated by wall switches or from panel boxes — standard for campus buildings yet incapable of adapting to changes in occupancy and lighting need. The situation was ripe for improvement, an ideal testing ground to demonstrate new technologies and products for lighting efficiencies.

The SPEED demonstration was carried out in UC Davis's Bainer Hall, an engineering building constructed in 1966. Three different adaptive, bi-level lighting systems were installed for demonstration, assembled from components currently marketed by several manufacturers. These systems each deliver bi-level lighting by pairing occupancy sensors with dimmable light sources in corridors. The evaluations conducted through the demonstration gauge energy savings, demand-response effectiveness, and occupant response.

There are several ways to implement the adaptive, bi-level lighting systems now on the market. The simplest methods use existing ballasts coupled with occupancy sensors and a wireless communications system or replace the each ballast and add an occupancy sensor to each fixture. More advanced systems using dimming ballasts offer additional control capabilities, such as daylighting, scheduling and tuning, with components linked either wired or wirelessly.

Each of the more advanced systems can be incorporated into the building management system, allowing easy control of lighting loads and participation in automatic demand-response programs offered by utilities, leading to lower energy bills and incentive payments from utilities. In addition, maximum and minimum light levels for the corridors can be set according to occupant preferences, providing improved visual comfort as well as energy savings.

The three Program corridor-lighting installations at Bainer Hall generated an average energy-cost savings of 73%, with payback on the investment in the retrofits ranging from four-and-a-half to eight years simple payback. Incentives offered by local utilities greatly accelerate that return time; additionally, the larger and more comprehensive the installation throughout a building, the greater the energy savings and the more attractive the investment.

Pilot-Scaled Deployment

The SPEED demonstrations at UC Davis have led quickly to a "pilot-scaled deployment" in 11 buildings at California State University at Long Beach — with award-winning results. The campus retrofitted the buildings with Adura bi-level, wireless corridor lighting controls, one of the three solutions successfully demonstrated by CLTC at UC Davis.

In all, CSU Long Beach installed combinations of bi-level and other energy-efficient lighting in corridors, stairways, parking garages, and other areas of 24 campus buildings over two years — 11 as part of PIER's SPEED program and the others funded through the Energy Technology Assistance Program (ETAP). The changes resulted in an estimated savings of 600,000 kilowatt-hours of electricity and $72,000 per year, in addition to cutting the campus's greenhouse gas emissions. The effort earned the campus the Best Practice Award for Lighting Design and Retrofit, presented at the California Higher Education Sustainability Conference in July 2011.

A second scaled-up deployment of adaptive corridors is in the works at the UCSF, where a comprehensive lighting initiative aims to transform approximately 5 million square feet of corridors throughout the campus (excluding Medical Center facilities). The project is planned in two phases: about half will be completed in 2013 and the remainder in 2014. The project targets some 2.3 million kilowatt hours in energy savings, with a net payback on the retrofit investment (after utility incentives) over approximately eight years.

New Standards and Other Derived Benefits

These new corridor-lighting technologies, now successfully demonstrated and deployed, have great potential to penetrate and alter the lighting market for commercial buildings. Because corridors make up a significant percentage of the square footage in these buildings and bi-level lighting retrofits are available and affordable, the incentive is strong to implement them — and save significant energy and money.

Title 24, California's Energy Efficiency Standards for Residential and Nonresidential Buildings, is a key driver in accelerating market penetration of new energy-efficiency technologies and market transformation. Following quickly on its successful demonstration and deployment, the use of bi-level lighting with occupancy-based controls for corridors has been incorporated into the ASHRAE 90.1 standards and proposed as a standard in the 2013 update of Title 24, now being prepared. Adoption is expected in April 2012, with the revised standards taking effect in January 2014.

Program Market Transformation Accomplishments

The interactive SPEED market transformation process developed by this Program (see Figures 1 and 2) has strongly supported the PIER program efficiency areas and the California energy efficiency goals.. Beyond the documented energy, peak demand, gas and CO2 savings, the Program created a variety of tangible benefits to California. Some of the major accomplishments are as follows:

1. ***The technologies developed with PIER funding have gone out to the market***. By getting technologies into the University of California and California State University campuses, the Program created a market pull, so that they are available for other sectors of the commercial buildings market. These and other organizations are specifying PIER technologies in their retrofit and new construction projects.
2. ***Results of the performance evaluations have gone back to the PIER RD&D Program***. Those results suggest further productive RD&D, such as derivative products and product improvements. Not all of the technologies were ready for wide commercialization, but ideas for derivatives of products were developed during the testing and analysis and reported back to the PIER Program. Examples include the bi-level exterior lighting systems, Adaptive Corridor Lighting, the Integrated Office Lighting System, and the Discharge Air Regulation Technique (DART) and Data Center Automation Software and Hardware (DASH) systems.
3. ***Results have gone to utilities so they can be included in Emerging Technology Programs and incentive programs.*** Program demonstrations have developed performance data for utilities to use as they develop their incentive programs. Emerging Technology program managers have visited the California Lighting Technology Center to see what technologies are ready for the Emerging Technology pipeline. Emerging Technology programs have also partnered with the program in demonstrations and conducted additional field-testing of almost all of the PIER technologies in the Program portfolio. This collaborative relationship leverages the market adoption of PIER technologies and helps the Emerging Technology groups serve the special needs of the utility deployment and incentive programs.
4. ***Results have influenced California Energy Commission-developed codes and standards.*** Program demonstrations have shown that codes can have more aggressive energy efficiency goals because products are available to meet them. Results of the demonstrations have been communicated to the Codes and Standards group at the Energy Commission for use in developing the next versions of Title 24. Examples include occupancy-based bi-level switching in many interior and exterior scenarios and lower power densities for classrooms and offices.

5. ***Program results have prompted manufacturers to enter the market.*** Products that are similar to, or even better than, the PIER technologies have been developed and introduced to the market. When this happens, the influence of the PIER Program is leveraged or magnified, and the benefits are more available to state organizations and to the public. For example, about 20 different manufactures are now making products similar to the Integrated Classroom Lighting System, the bi-level stairwell fixtures, smart exterior lighting fixtures, and demand-controlled kitchen ventilation systems. One key example of the market influence of the program has been the development of the "smart" occupancy-based control of parking and exterior fixtures and the introduction of light-emitting diode and induction technologies. Over a dozen manufacturing partners now produce a large array of "smart" exterior fixtures and are shifting the market to these new technologies.
6. ***Success stories have been created.*** Over fifty case studies or fact sheets were developed to showcase the successful products, much earlier than for a typical commercialization process. These have contributed to faster technology adoption by California university campuses, as well as exposure of the broader commercial building market to the verified performance of PIER innovations.
7. ***The broader market is now aware of options that were previously not available.*** Raising market awareness is another step in promoting the PIER technologies. Documented demonstration results and case studies on a significant number of buildings help to build confidence in the new technologies and reduce early adopter risks. The program has produced a large and varied number of technology transfer and market communication materials and activities including: case studies, technical briefs, several design guidebooks, new construction specifications, dozens of major presentations per year, websites, training and education, and published papers.
8. ***Successful new companies creating jobs and investment opportunities.*** Several new companies have evolved out of PIER RD&D and many more have added products and jobs. In addition, several new companies, such as Adura Technologies and Vigilent (formerly Federspiel Controls), have won awards in the California Clean Technology Open. Adura is growing fast with venture capital.

Conclusions and Lessons Learned

Developing an integrated market transformation process from RD&D all the way over the "valley of death" is a very successful model to accelerate the market adoption of the deep energy efficient products of public and private R&D programs. The SPEED Program effectively meets this market transformation need by maintaining a consistent long-term effort of building strategic partnerships and relationships supporting the market transformation efforts for the last 8 years. The Program employs demonstrations, field performance data, case studies, guide specifications, technology catalogs, presentations, and a variety of other technology transfer tools to cross the "valley of death" that often stalls new technology. The nimble partnership approach taken by the Program is necessary to maximize the dispersion of technology and applications knowledge by customizing the information to each diverse market segment. The Program has been very effective in facilitating partnerships and integration of new technology into university campuses, public sector, utility energy efficiency programs, economic stimulus programs and codes and standards.

There has now been enough market penetration to validate the investment and effectiveness of a consistent Program. The energy savings accruing each year from deployment of the demonstrated technology is now multiple times the cost of the program, making a dent in the market potential, and growing steadily. Multiple technologies and new start-up companies are now benefitting California energy consumers earlier than they would have without the Program. Using the SPEED Program integrated and sustained market transformation approach establishes the partnerships and collaboration to accelerate the adoption of best practice technologies.

Most scaled deployment of best practice technologies is so far associated with pier-to-pier collaboration and a robust financing structure including subsidies. The most scaled deployment has been and will likely continue to be by the UC system, a very large market sector with substantial incentives offered by the UC/CSU/IOU Energy Efficiency Partnership, along with a low rate loan program fully integrated into system and campus debt management. The CSU system and local governments have also achieved substantial scaled deployment of PIER technologies and may be good venues for Program activity, but this progress has been more dependent on economic stimulus funding which will likely be ending soon.

An effective demonstration and information dissemination program can not only provide case study information to enable accelerated technology adoption, but can also provide the feedback crucial to the creation of new "derivative" products, including new classes of products with expanded applications. The Program has been highly successful in stimulating manufacturers to offer more new technology in their product lines. The Program has enabled the development of products for an expanding set of end-use applications with more market potential.

The university RD&D centers such as the SPEED program partners, the California Lighting Technology Center and the Western Cooling Efficiency Center at UC Davis are an effective model for public and private R&D partnerships and for demonstration activities. These centers have the right mix of faculty, student, and staff personnel to conduct and document demonstration projects and can work with both university and private technology providers in developing, demonstrating and evaluating technology.

Higher education campuses can provide a good setting and partnerships for technology demonstration. The culture of learning and professional accomplishment often found among facility personnel leads to a desire to try new things and the opportunity to demonstrate newer technologies. Students and faculty add to the rich innovation environment, along with leadership present in system wide management that minimizes the effort needed to organize demonstration activities. And when the technologies are proven, the campuses will implement them on the campuses.

The Program has been highly successful in fostering new manufacturers to offer products and for other manufacturers to develop new product lines based on demonstrated technologies. The Program has also strongly supported the evolution of codes and standards tracking new technology, as well as compelling institutional organizations to adopt demonstrated technologies as internal standards. When these technologies are incorporated into the codes and standards they have successfully crossed the "valley of death". The Program has enabled integration of demonstrated technologies into utility energy efficiency and economic stimulus programs, as well as addressing the goals of California Long Term Energy Efficiency Strategic Plan. Program activities have been recognized with multiple awards. The result has been accelerated market adoption of new energy efficiency technology.

The Program continues to facilitate market adoption of new technology through ongoing demonstrations, special technology transfer projects, and market transformation activities in follow-on phases. Acceleration of technology adoption can continue for more PIER products with continued demonstration program efforts. Demonstration activities will more likely lead to scaled deployment when implemented with host sites that have the strongest financing structure (e.g., UC). Additional resources would allow exploration of financing models in other sectors such as local government or the private sector.

The historic level of funding for the Program and for accompanying R&D programs will need to be maintained to sustain momentum toward the expansive and comprehensive California goals. The integrated partnership approach of the SPEED program market transformation process has effectively accelerated the adoption of best practice PIER solutions. Increased funding can be effectively used by the Program to achieve even more rapid and widespread adoption of PIER technology and progress toward program goals. Leveraging of program funding with resources from deployment programs and demonstration host sites will maximize program effectiveness. The program market transformation process might be replicated for other California Energy Commission programs, or in other state, national or international programs.

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