New California PIER R&D Product Introduction Process

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ABSTRACT

The Public Interest Energy Research (PIER) program of the California Energy Commission (CEC)[1] has developed a new approach in moving research and development (R&D) products into commercial use, focusing on the state's many college campuses. PIER had previously developed a variety of new lighting and space conditioning technologies in collaboration with manufacturers. The new PIER strategy for moving these innovations to market focuses on retrofit demonstrations for the state's universities, which offer a wide variety of applications, many available sites, and active energy efficiency retrofit and new construction programs. These qualities enabled PIER to find economies in siting, negotiating, and managing each project. The approach has recently been expanded to more markets including new campus construction, the community colleges, other state facilities, and commercial building operators. The program has also been expanded to include industrial technologies.

This paper presents some early results. Some 15 new products have been demonstrated at over 40 sites, and several of those products have been adopted for broader installation. The process has also given the manufacturers useful product refinement ideas as well as large-volume orders. The PIER program is now using those proofs of success to inform energy services companies and commercial building operators about these new products. Examples of the products include a variety of new LED light fixture applications, dimming and occupancy sensing, energy saving controls for space conditioning systems, and compact fluorescent downlights for retrofit uses. All have attractive paybacks and energy savings.

Introduction and Overview

This paper is a status report on an innovative PIER effort, the Campus Energy Efficiency Program, in moving new energy efficiency technologies toward market acceptance. The program has produced a variety of both technical and administrative results leading to conclusions that could benefit other R&D organizations as well as PIER.

The R&D problem addressed in this program is 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 practicality and user acceptance, licensing and warranty

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[1] The California Energy Commission's buildings R&D is done within its PIER program. PIER is funded from the state's Public Goods Charges on all electricity and natural gas users. The major investor-owned utilities that collect those funds provided some $80 million in RD&D funding to PIER in 2007. The PIER Buildings program is one of several topical components, committing some $12-15 million to projects each year. PIER Buildings contracted with the California Institute for Energy Efficiency (a unit of the Office of the President, University of California) to manage this campus-focused program, and CIEE in turn commissioned a variety of subcontractors and consultants to assist with implementation.

concerns, difficult production investment decisions, marketing and product support complexities, and resistance to change among the commercialization participants from producer to wholesaler, regulator to advocate, retailer to consumer. This PIER campus demonstration program is seeking to provide a new and easier path through those obstacles.

The program has demonstrated that the PIER innovations tested provide substantial energy savings and are market ready. Nearly 30 separate demonstration projects have been completed, involving 14 of the 33 locations of the University of California (UC) and California State University (CSU) systems.[2] The results of those relatively small scale projects are summarized in Table 1, along with a projection of the savings possible with more extensive systemwide implementation. That projection includes only the university campuses; broader commercial market adoption of the technologies would yield far greater savings.

Table 1. Summary of Program Results and Projections

	Demand Savings (kW)	Energy Saved (kWh)	CO2 (tons)	Total Energy Cost Savings
Demonstration Projects to date: Annual Savings	74	1,240,000	500	$ 133,000
Lifecycle		18,600,000	7,180	$2,000,000
Projected Systemwide Potential: Annual Svgs	2,440	26,200,000	10,534	$ 2,821,217
Lifecycle		393,000,000	158,000	$42,300,000

Source: California Institute for Energy and the Environment, March 2008

The program also showed that siting more than one technology demonstration on a campus built productive relationships with campus energy managers and resulted in reduced project administration effort and cost for PIER as well as the campuses. Campus-type facilities appear to be advantageous sites for economical R&D product demonstrations and early market adoptions, helping to encourage manufacturers to invest in bringing those technologies to broader commercial and institutional markets.

The California Energy Commission's buildings R&D is done within its Public Interest Energy Research (PIER) program. PIER is funded from the state's Public Goods Charges levied on all electricity and natural gas users. The major investor-owned utilities that collect those funds provided some $80 million in RD&D funding to PIER in 2007, with gradual programmed increases in future years. The PIER Buildings program is one of several topical components of the PIER organization at CEC, committing some $12-15 million to projects each year. PIER Buildings contracted with the California Institute for Energy Efficiency (a unit of the Office of the President, University of California) to manage this campus-focused program, and CIEE in turn commissioned a variety of subcontractors and consultants to assist with implementation.

Program Description and Rationale

At the beginning of the Program, members of the PIER Program and CIEE developed a list of available new energy efficient technologies that are relevant to campus needs. Those

[2] California's two university systems may be confusing to the reader. The UC system has ten campuses and a strong emphasis on academic research, while the separate CSU system's 23 additional campuses comprise the original "state college" system that focused on undergraduate education with more open admission policies. The CSU system is now larger than the UC system and offers advanced degrees and a substantial research component.

recent technology developments are focused on lighting as well as heating, ventilating and air-conditioning (HVAC) applications. The campus facilities and energy managers were involved in selecting the technologies as well as the campuses and sites that were most appropriate for specific demonstrations.

The technology innovations selected for initial consideration as demonstration project candidates had been developed primarily in PIER-funded projects. Each of the technologies was screened for its commercial readiness and applicability to college campuses. The technologies included some that were considered market-ready and others nearing commercial readiness but still involved in beta testing. Table 2 lists both groups.

Table 2. Technologies for PIER Demonstration Program

Bi-Level Stairwell Lighting	Occu-smart® – Stairwell lighting with two brightness levels: bright when people are present and dim when stairwell is unoccupied; both code compliant
Bathroom Smart Fixture and Switch	Bathroom light fixture with light emitting diodes (LEDs) for night lighting and an occupancy sensor to control fluorescent lighting (wall switch also available)
Integrated Classroom Lighting System	High-performance direct-indirect lighting system, occupancy and daylight sensors, and modes of operation specifically designed for classrooms
Compact Fluorescent Downlight System	A recessed CFL downlighting system with a high-quality ballast serving multiple fixtures and high performance optics
Hybrid Entry/Path Light Fixture	Exterior light fixture for mounting on a wall or bollard, combining an LED, incandescent lamp, pedestrian sensor, and controls into one unit
Load Shed Ballast	Fluorescent lighting ballast and powerline carrier-based control components used to reduce lighting demand during peak periods
Low Glare Outdoor Luminaire	Outdoor luminaire for wall or pole mount providing better illumination with metal halide lamps, using less energy than conventional models
Kitchen Demand Ventilation Control	Reduces energy use and cost by controlling the speed of commercial kitchen ventilation fans based on the actual demand for ventilation created by cooking
Static Pressure Adjustment	(SAV with InCITe™)– A static pressure reset strategy for commercial building HVAC systems
Air Flow Measure-ment and Control	(SpeciFlow™ **)** – Air flow measuring and control damper for HVAC systems
Large System Duct Sealing	(Aeroseal) – An adhesive aerosol sealant system for patching holes and cracks in large commercial building ducts from the inside
Packaged Rooftop Unit Diagnostics	A permanently installed system to identify faulty performance of packaged rooftop units and display results via the Internet
Individually Addressable Ballasts*	Digital Addressable Lighting Interface (DALI) protocol allowing lighting control networks using components from various manufacturers
Cool Roof Coating*	(Cooltile IR Coating™) – Coating for concrete, clay, and fiber cement roof tiles; restores color and rejects solar heat
AHU/VAV Box Diagnostics*	Automated fault detection and diagnostic (FDD) software for air handling units and variable air volume boxes

*Not included in first round of demonstration projects

Campus Efficiency Innovations Program Goals and Strategy

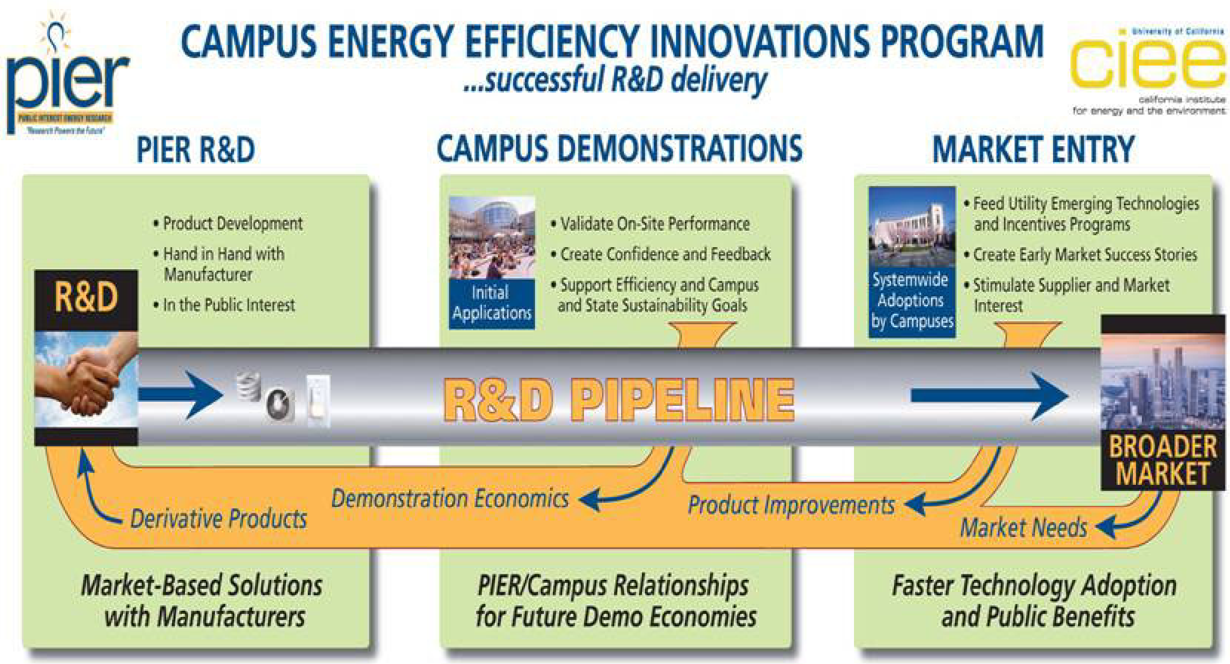
The program's goals include the following:

- Implement, refine, and confirm or reject a multi-technology/multi-site campus demonstration program

- Conduct field demonstrations to verify the performance and savings of a variety of PIER RD&D products
- Use publications and presentations of the demonstration project results to encourage commercial production and broader market adoption on California campuses and on other commercial buildings

The program strategy for achieving these goals was based on conducting field demonstrations on college campuses to create a pathway or "pipeline" from PIER product creation through demonstration and entry into the California utilities' internal new-technology validation and incentive programs to encourage production and broader market adoption. The strategy also included feedback loops—from the demonstrations and market entry activities back to R&D to refine products as needed and also to identify more specific market needs and develop additional products derived from the initial innovations. This approach is shown in Figure 1 below.

Figure 1. PIER Program Process Model



Program Development History and Milestones

The campus demonstration program began in 2006 with selection of technologies and creation of partnership agreements with the California university systems. In 2006-2007 the initial set of demonstration projects was begun, completed, and documented, and further projects were identified and planned or begun. As projects were completed, results were analyzed, numerous presentations were made, and educational publications such as individual fact sheets were produced. The program is now in a second phase, with additional projects and the addition of the state's large community college network to provide additional demonstration sites and potential markets.

Program Results

Nearly 30 campus demonstration projects have been completed to date and more are in process. The field demonstrations show substantial energy savings and realistic payback periods ranging from under one year to five years, generally in keeping with California campus goals for implementation returns on investment.

Seven lighting innovations and five HVAC products have been demonstrated in a variety of campus building types and uses. Other emerging innovations are also under consideration for additional demonstrations. A complete list and description of current candidate technologies is provided in the Appendix. Products actually demonstrated to date are listed in Table 3.

Table 3. Campus Demonstrations and Number of Units Installed

Technology Demonstrated	Number of Demos	Number of Units
Lighting Innovations:		
Bi-level Stairwell fixture	8	287
Bathroom Vanity Fixture/Switch	2	150
Integrated Classroom Lighting System (ICLS)	4	16
Compact Fluorescent Downlight System	1	100
Hybrid Exterior Entry/Path Fixture	1	100
Load-Shed Ballast	1	110
Low-Glare Outdoor Luminaire	1	9
HVAC Innovations:		
Kitchen Exhaust Hood Demand Ventilation Control	1	n/a
Static Pressure Adjustment (SAV with InCITe™)	3	n/a
Airflow Measurement and Damper Control	2	n/a
Carrier Aeroseal (duct sealing aerosol)	2	n/a
Packaged Rooftop Unit Fault Detection & Diagnosis	3	n/a

New Bridges over "The Valleys of Death”

The first buyers of innovations—the “early adopters”—are typically less risk-averse than others and more motivated by interest in experimentation and potential but unproven value. The R&D version of the “Valley of Death” concept (e.g., Swift 2005) is the transition from R&D to production—the point in the commercialization trajectory at which the product has to move out of the laboratory and into a manufacturer’s initial production and resulting early buyer commitments. Many R&D products fail at this point. From that “early adopter” stage to the far more numerous but also increasingly more cautious buyers in the mass market is another “valley of death.” This PIER program seeks to influence both of these transitions.

In the PIER strategy described in this paper, the bridges are pre-commercialization technology demonstration programs and early purchases on college campuses. Those settings offer a broad range of needs and applications, a sense of long-term energy and environmental obligation, a perspective less averse to risk, and the ability to move directly from demonstration to broader deployment. This in turn can reduce developers’ risks of investment in larger-scale production and marketing, and also encourage other buyers with similar needs to begin a broader adoption of the product. At the same time, the campus focus creates opportunities for building longer term multiple-product demonstration partnerships with R&D organizations such as PIER, substantially reducing costs and time needed for successive demonstration site identification, negotiation, legal agreement, and deployment.

Demonstration Sponsors, Sites and Projects

13 campuses of the University of California (UC) and California State University (CSU) systems plus the statewide UC headquarters have participated in some 30 demonstration projects to date. The majority of those sites have sponsored demonstrations of at least two different PIER products, as shown in Table 4 below. Further projects are now being undertaken on those and other campuses, with the set expanded to include the state's over 100-campus community college system.

Table 4. Demonstration Projects by Campus

Campus	Lighting Innovations Demonstrations	HVAC Innovations Demonstrations	Total Demonstrations per Campus
UC Davis	3	1	4
Sonoma State University	3	0	3
UC Santa Barbara	2	1	3
UC San Diego	1	2	3
CSU Stanislaus	1	2	3
UC Berkeley	1	2	3
UCLA	1	1	2
UC Office of the President	1	1	2
CSU Northridge	1	n/a	1
Cal Poly Pomona	1	n/a	1
UC Riverside	1	n/a	1
UC Irvine	1	n/a	1
CSU San Marcos	1	n/a	1
CSU East Bay	0	1	1

Program Management Efficiency and Economy

For PIER, the estimated RD&D savings due to simplified project siting and administration have been significant, due largely to working relationships established with campus energy managers and their systemwide administrations. Those relationships made it possible to field multiple product demonstrations without dealing with completely different organizations and their individual project managers, standard procedures, and legal staffs. The CIEE program manager estimates that in an average PIER product development process at least 50% of the cost is in the demonstration phase, and as much as 50% of that demonstration phase cost is consumed in the pre-demonstration site search, relationship building, proof of likely value to the site owner, negotiation of terms, and formal agreements among all parties. Informal budget review of this program indicates that its costs for those pre-demonstration administrative activities have been less than half the typical share of the demonstration phase costs.

Installations and Energy Savings

Table 5 summarizes the peak demand, energy, CO2 and energy cost savings of the limited campus demonstration projects completed to date. It is still early in the program's history to expect broad commercial-scale deployments. However, some early evidence is provided by larger joint multi-campus purchase agreements for initial production runs based on campus demonstration project results and their communication across the statewide campus systems.

Table 5. Summary of Energy Savings from Lighting & HVAC Technology Demonstrations

	Qty	Demand Savings (kW)	Energy Saved (kWh)	CO2 (lbs)	Energy Saved per Unit (kWh)	Total Energy Cost Saved ($)
Bathroom Vanity	150	2	6,750	5,434	45	$ 728
ICLS	16	10	49,280	39,670	3,080	$ 5,312
Hybrid Porch Fixtures	100	1	5,700	4,589	57	$ 614
CFL Downlights	100	10	39,000	31,395	390	$ 4,204
Load Shed Ballast	120	3	14,653	11,796	122	$ 1,580
Low Glare Wall Pack	9	2	5,835	4,697	648	$ 629
Bi-Level Stairwell Fixture	287	9	124,549	100,262	434	$ 13,426
Strategic Group Purchase Program - Bi-Level Stairwell	1,275	38	553,310	445,415	434	$ 59,647
Lighting Totals		**74**	**799,077**	**643,257**		**$ 86,141**
SAV with InCITe	6		403,974	325,199	67,329	$ 40,448
Kitchen Ventilation Demand Control	1		35,600	28,658	35,600	$ 6,452
HVAC Totals			**439,574**	**353,857**		**$ 46,900**
Annual Demo Totals		**74**	**1,238,651**	**997,114**		**$ 133,041**
Lifecycle Demo Totals			**18,579,765**	**14,956,711**		**$1,995,608**

The most popular and widely installed technology included in the 2005-2007 PIER Campus Energy Efficiency Program was LaMar Lighting Company's OccuSmart® Bi-Level Stairwell Fixture. This fixture uses an ultrasonic occupancy sensor to detect motion in areas such as stairwells and corridors. During unoccupied periods, the lamps are dimmed to as low as five percent of normal. An adjustable time delay can be used to maximize energy savings based on usage patterns. In the initial demonstration phase, nearly 300 fixtures were installed among eight campuses. The success of those demonstrations ultimately led to an initial multi-campus combined order of 1,275 more units with projected energy savings as shown in Table 5 above.

These demonstration results are only the beginning. Table 6 indicates the estimated savings possible among all the UC and CSU campuses with an aggressive approach to installation of the cost-effective PIER innovations already demonstrated.

Table 6. UC/CSU Systemwide Potential Savings (High End of Range)

	Quantity	Demand Savings (kW)	Energy Saved (kWh)	CO2 (lbs)	Energy Saved per Unit Installed (kWh)	Total Energy Cost Saved ($)
Bathroom Vanity	24,750	248	1,113,750	896,569	45	$ 120,062
ICLS	1,238	773	3,811,500	3,068,258	3,080	$ 410,880
Hybrid Porch Fixtures	4,950	50	282,150	227,131	57	$ 30,416
CFL Downlights	9,900	990	3,861,000	3,108,105	390	$ 416,216
Load Shed Ballast	180	5	21,980	17,693	122	$ 2,369
Low Glare Wall Pack	14	2	8,753	7,046	648	$ 944
Bilevel Stairwell Fixture	12,375	371	5,370,362	4,323,141	434	$ 578,925
Lighting Totals		**2,438**	**14,469,494**	**11,647,943**		**$1,559,811**
SAV with InCITe	150	***	10,099,350	8,129,977	67,329	$ 1,088,710
Demand Vent. Control	45	***	1,602,000	1,289,610	35,600	$ 172,696
HVAC Totals		***	**11,701,350**	**9,419,587**		**$ 1,261,406**
Annual Program Totals		**2,438**	**26,170,844**	**21,067,529**		**$ 2,821,217**
Lifecycle Program Totals*			**392,562,659**	**316,012,941**		**$42,318,255**

Total Avg. Useful Life	15	Years
Avg. Calculated Electricity Rate	0.11	$ /kWh
Energy to CO2 Conversion Factor**	0.805	Lbs/kWh

*Total savings based on current operational costs and economic conditions.

**Conversion Factor based on California Climate Action Registry Values

***Demand reduction effects of the HVAC technologies were unclear and conservatively estimated at zero

Next Program Steps

The PIER Campuses program is continuing to expand and involve more demonstrations of an increasing range of newly developed PIER technologies. The original campuses are considering demonstrations of additional emerging PIER products. The demonstration and early-adoption activities are also spreading to other campuses including those of the state's community colleges.

Routine Large-Scale Deployments

The same campus energy managers who have been hosts of PIER product demonstrations are also responsible for much larger-scale deployments of energy efficient products and practices to meet campus and systemwide environmental and cost-savings goals. Their PIER experience builds confidence in the products, which they might not otherwise risk adopting. As the new PIER products move into commercial-scale production and more competitive pricing, those initial participants are actively considering routine large-scale deployments in both their new buildings and retrofit programs in existing buildings.

Development of Ongoing Demonstration Sponsor Agreements

Campus hosts of the initial demonstrations are working with the PIER/CIEE program managers to develop standing agreements for further demonstration projects. These agreements will cover all general agreement terms, conditions, and responsibilities, making it possible to implement new projects relatively easily and quickly by requiring agreement only on the specifics of each new project. This approach substantially reduces solicitation and negotiation costs for all parties, capitalizing on the original relationships and trust to encourage continued joint efforts with PIER.

Transfer to Other Potential Building Environments

To further expand the program, PIER is now actively reaching out to other organizations with campus-type facilities such as private colleges, major governmental facilities, and commercial campuses and business parks. Obvious examples include the state's Department of General Services (which builds and manages state properties) and Public Works departments in major cities. Federal agencies with similar missions are also candidates. Major energy services companies are also targets, as are large commercial office and R&D campuses. The principal strategy here is to make those large-scale users aware of the PIER demonstration results and the availability of proven new high-efficiency products, in order to add mass-market momentum to the market entry of those products. A secondary purpose is to cultivate additional demonstration partners in those diverse environments.

Conclusions

There were substantial time and cost savings due to this approach. As noted in the previous section, the Campus Energy Efficiency Program's managers and sponsors believe that this campus-focused process has generated substantial savings in R&D administration. Those savings are primarily in the form of expedited site selections and demonstration partnerships, with the strong partner relationships formed through multiple projects leading to simpler and faster administrative processes and requirements.

The R&D products demonstrated proved to be cost effective and practical. The specific demonstrations and analytical findings of this program have been successful in proving the value of those R&D products. Those results, in association with the program's campus alliances and market education activities, are leading to broader campus applications as well as increasing awareness and interest among other user groups.

The PIER strategy was effective in increasing the visibility and credibility of the R&D products demonstrated. The typical obstacles to R&D product commercialization were of course still in force with this project's technologies: Developers and other potential commercial producers were still cautious about selecting products for production and marketing with their scarce resources, potential users were still wary of committing to new products, and regulators, utilities, code officials and other participants in the commercialization process still had to carry out their own responsibilities in assuring practicality and cost-effectiveness of the products. However, at this still-early stage of the PIER campus program there is evidence of its advantages in streamlining the development of credibility for the products involved. Several manufacturers have responded with production commitments and funding, campuses have joined together in initial larger-scale purchases to reduce costs, and utilities are beginning to adopt and promote some of the technologies.

This continuing campus partnership approach to demonstrating new R&D products so far appears to be a useful option for organizations with multiple commercial energy efficient innovations facing the challenges of moving from laboratory to market. The approach is now being used by PIER for a broader range of products, and could also be employed in partnership with other major governmental agencies and private organizations with large and varied facilities at the local as well as state levels.

References

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