# Getting Energy Efficiency Innovations off the Shelf

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**ABSTRACT**

This paper reviews current models for moving new energy efficiency products from lab to market and presents a new market connection approach for such public-sector technology development programs. The new approach is the latest step in the efforts of the California Energy Commission's PIER (Public Interest Energy Research) program to emphasize market connections and encourage the integration of market connection activities into the research phase. In 2002 many of these activities were formalized and given additional structure under the Lighting Research Program (LRP). Beginning with the LRP, a separate consultant component for market connection is included in many PIER building technologies projects to increase the emphasis on issues such as economic viability and competitiveness, marketability, user needs, manufacturer business cases, and value-chain barriers. The PIER project teams have also increased their work with natural allies to reach key audiences. The LRP provides some initial results of this latest refinement of the PIER approach, and the paper assesses its operation and effects.

## The Market Connection Problem

While an energy efficiency innovation often appears promising in concept, prototype, or field test, it may never achieve market success or even make it to the market. Other new products languish for years with minimal market penetration despite their value to the individual users as well as to society. These unfortunate results are not unique to energy efficiency-focused products and services. Innovation process literature has many examples of failed efforts, and it is commonly estimated that most innovative technology ideas and findings never cross "the Valley of Death" to commercial success (Moore, 2002) almost irrespective of their technical soundness.

In the public-sector applied R&D process the situation is somewhat different from private-sector technology innovations. Often the private innovator is the R&D funder, manufacturer, and marketer, whereas the public R&D programs often deal with complex contractual relationships and are not directly connected to the manufacturing and marketing agents who must ultimate adopt and deliver their innovations to the market. This means that a variety of key steps must be explicitly added to the public-sector product value chain to avoid investment in innovations that would otherwise be of limited market value or face insurmountable market barriers. A comprehensive market connection model must be used to manage such risks and gain maximum value from the public R&D investment.

## A General Market Connection Model

A review of some market connection terms and concepts provides a foundation for discussion of alternative approaches and possible advances. Since terms common to market connection activities are not widely understood or have varying meanings to different parties, this paper includes an Appendix with some definitions of key terms as used here. A general model of the R&D product-to-market connection process is also useful to provide a logical structure. Such a general process model can be described in the following sequence of steps, although many variants are possible.

1. Identification of problem, need, or opportunity
2. Solution concept and prototype development
3. Market and economic assessment: costs and benefits
4. Creation of technical product per market criteria
5. Business plan and review
6. Manufacturer commitment(s)
7. Product refinement, testing, tooling, production engineering, support
8. Market strategy: pathways, barriers, intermediaries, key influencers
9. Actions to reduce barriers and strengthen intermediary support
10. Early market education, entry and momentum
11. Transition to mass market ("crossing the chasm")
12. Product variation, market broadening, and life extension

Progress along this path may require some iteration between steps. Among the most important steps are the identification of the key customer benefits, the business case, and the resolution of barriers. It is essential to define the technical and business features and criteria for the final product. The key customer benefits, savings, costs, and required product features should be identified very early in the project. These initial estimates will need to be updated as the research continues.

This model also enables better management of the R&D project because the boundaries of success are defined for both the technical and market features. The pathway to the market can be unexpectedly rocky. There are always barriers to success, and the developer and manufacturer must be alert to finding and overcoming them. Too exclusive a focus on the technical capabilities of the product must be avoided and tempered with respect for the interests of all intermediaries and influencers. All innovations are disruptive, but if too challenging to existing practices and interests of any key actor in the marketplace, risks of failure are greatly increased.

## Alternative Approaches to Market Connection

There are many guidelines and approaches to the problem of moving energy-efficient devices and practices out of R&D programs and into commercial production (cf. Studt 2003, Lovins 1992, Lutzenhiser 2002). This paper focuses on the Lighting Research Program's market connection model, a relative newcomer from the California Energy Commission's Public Interest Energy Research (PIER) program. As background, we present a sample of other current approaches. Information on each of these is readily available from the sponsoring agencies, and other references elaborate usefully on such models (cf. Allen, 2004).

**Solicited Direct R&D Awards (SBIR/STTR).** The Small Business Innovation Research/Strategic Technology Transfer Research program makes competitive awards of direct cost-shared funding for research into selected categories of technology development and transfer to commercial organizations for production.

**Licensing solicitations (NREL).** The National Renewable Energy Laboratory, among others, periodically advertises for firms interested in licensing of its innovations for commercial use. In this approach, the technology is developed at the lab and the commercialization process is later and separate.

**Practical technology support (ATP).** The Advanced Technology Program's approach is to support or co-fund industry R&D efforts. The ATP requires advance proof of economic benefits as well as technical merit, but tends to exclude actual end-use product development, demonstrations, and projects with substantial market risks. The private industrial partners keep any resulting patents.

**Manufacturer cofunding (EPRI).** The Electric Power Research Institute, using pooled member utility funds, typically supports R&D activities within manufacturing firms in order to maximize the likelihood of commercialization. These activities are typically co-funded and are undertaken with the mutual intent to commercialize the resulting product. No formal commercialization plans are required, but a conditional commitment to commercial production is typical.

**Roadmaps (DOE).** The Department of Energy is a leader in the use of goal-oriented technology applications plans, or roadmaps, to identify the full range of activities, their sequencing, funding priorities, and responsibilities for product development and commercialization. *Vision 2020*, the DOE roadmap for advanced lighting technology, is an example of this approach. Its results are being used by both Federal and private research groups to guide and coordinate their R&D investments.

**Technology Transfer Plans (CEC).** The California Energy Commission's PIER (Public Interest Energy Research) program has always placed strong emphasis on market connections and has encouraged the integration of market connection activities during the research phase. This has included placing high value on research proposals that are responsive to specifically identified market issues, integration of market partners on the research team, and building market partnerships with utilities and industry during the research phase. The PIER program originally approached the market connection challenge in various ways, requiring that proposers to its R&D solicitations include a "technology transfer plan" in their projects and conduct activities as needed to assure that the products of the research are practical and of direct near-term benefit to California's energy needs. These requirements have been continuously refined with experience.

## What Goes Wrong

Despite the achievement of technical sophistication and efforts at market connection, there are many ways an energy efficient product or service innovation can fail. Some of the most common are discussed below.

- Lack of early economic analysis and business-case development. This results when products are motivated by technical possibilities, but with abstract and over-generalized applications. The product then becomes an impractical technical capability looking for a problem that can afford it. Although such freedom is properly encouraged in basic scientific research, in product development it can render the result irrelevant to market needs and acceptability. In applied R&D, it is crucial to have a clear vision of the product's ultimate place in a competitive market from the start, with continuous reiteration of the market connection model as the product is developed and refined.
- Lack of early manufacturer commitment. This most often occurs when R&D is directed by organizations other than the ultimate manufacturers. The early development of a business plan is an effective antidote to this problem, since as it develops alongside the product, key business concerns such as cost, market preferences and application, competitive advantages, and pricing are all refined to assure a practical result. Ideally, manufacturers would be directly involved as early in the process as possible, either through cofunding, joint development, or advisory review.
- Failure to build value-chain support. If distributors will not carry the new product (for example, because of excessive inventory carrying costs, warranty-support risks, or installer/user education requirements), it will have difficulty reaching the market. Similarly, if engineering specifiers perceive problems with design time, quality control, or installation/support cost penalties, they are likely to avoid the product even if the distributor carries it. In addition, if the installer is skeptical or confused, the product will be seen as too burdensome. Finally, if all involved do not understand how the products can help meet building code compliance requirements, success is unlikely. For these reasons, case studies of early implementations are often valuable tools.

## The PIER Response: Focusing R&D on the Market

In 2002, PIER's Building Technologies division sought to increase the rate of commercialization of its R&D products by introducing a robust market connection element into several of its technology development projects. The first and largest such effort to date is the Lighting Research Program (LRP), a $5 million multi-participant effort to develop fifteen energy-efficient lighting products and protocols, and also to help position them for commercial adoption. This section describes the LRP and its application of the market connection approach.

### The Lighting Research Program

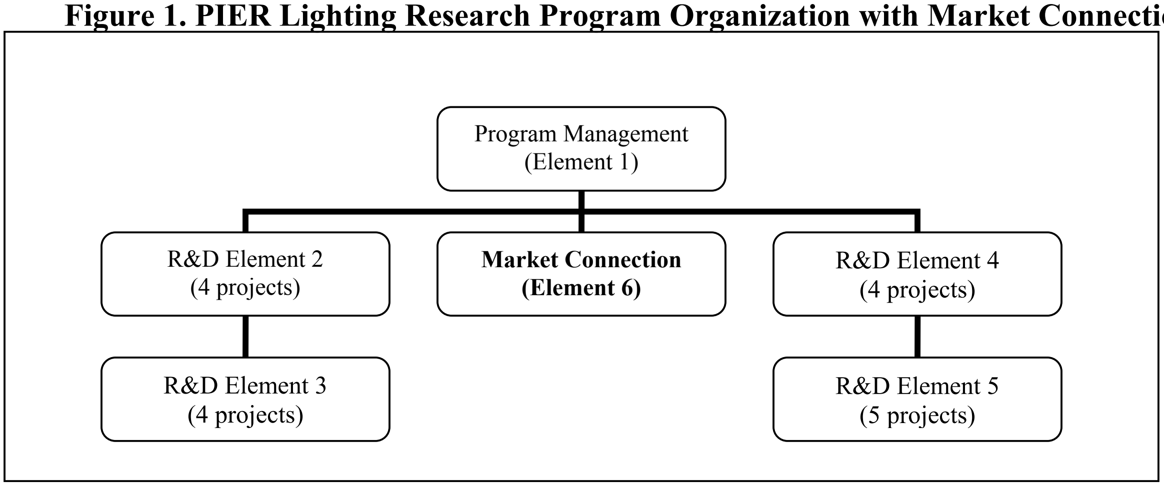
Examples of the LRP’s 15 products under development or market entry include the following:[1]

[1] See www.archenergy.com/lrp for descriptions of the program and all its products.

- A hotel bathroom light switch replacement with built-in occupancy sensor and nightlight for guest convenience without the light being left on for long periods of non-use both at night and during daytime peaks.
- A commercial/institutional building stairwell lighting system with high-efficiency fixtures with occupancy sensors and two lighting levels to meet fire codes yet reduce energy use when the stairwell is unoccupied—which in many buildings is most of the time.
- A classroom lighting system with high reflectance and engineered dispersion to provide excellent light levels and variable-scenario controllability while using well under one watt per square foot of energy.

This paper focuses on the LRP, although PIER has also applied related market connection strategies to other R&D programs. Because of the LRP's large number of R&D projects by different subcontractors, it was organized into groups of 3-5 related projects. Each group, or program element, included an Element Lead person to assure coordination and close project review. The new approach as applied in the LRP involved the addition of a separate program element and specialty subcontractors for market connection. This separate unit was focused on improving R&D product adoption by establishing strategy, developing standard techniques, and supporting market-related efforts both within each R&D project and by the market connection subcontractors on behalf of the whole program. This general organization is shown in Figure 1.

**Figure 1. PIER Lighting Research Program Organization with Market Connection**




In this organization, the Market Connection element supported all the R&D projects with a variety of services. The market connection strategy involved three complementary activity streams, as follows.

1. Early product assessment and feedback to all the R&D projects for viability and market-based refinement
2. Direct market connection support for products ready for market during the program term
3. Industry education and manufacturer connection for later products

**Product assessment and feedback.** To provide initial feedback to the LRP's various product developers, the market connection team reviewed the adequacy of each project's initial market rationale and business case. Results varied widely, and the team identified problems for further consideration by each product developer. To establish a standard level of business case development, a "technology transfer plan" template was created for use by all the individual R&D projects. This template is similar to a business case analysis outline. It provides a comprehensive set of issues that should be addressed to assure that a product's developers have an understanding and at least a tentative solution of the full range of market connection challenges to be faced.

With the technical support of the market connection consultants, all R&D project managers completed early draft tech transfer plans that were reviewed by CEC program management to identify potentially serious concerns and take appropriate corrective actions. These plans became working documents for continued use and refinement. A final version of each plan will be completed later in the program to provide continuity and support to potential manufacturers after the program ends.

**Market connection support for ready products.** PIER's implementing legislation requires that the program focus on the development of practical products but avoid direct marketing of specific products. This requirement reflects the State's concern that PIER not act in ways that unfairly favor a particular manufacturer or otherwise distort the private free market for lighting products. The new market connection approach meets this requirement by assuring that program-developed new technologies be completely open for duplication or improvement by private industry, even though some PIER innovations may be developed by a competitive private manufacturer acting as a subcontractor. In addition, the lighting industry is closely involved in the LRP's peer-review committees, and a program website (www.archenergy.com/lrp) is maintained with all interim reports and news available to the professional community and the public. In this approach, the market connection work is an integral aspect of the product R&D effort rather than as direct marketing; it helps to improve the product, making it more likely to succeed in the market and to be replicated freely by others.

To provide maximum market connection support to production-ready LRP products during the program, the program leveraged its resources by building alliances for industry outreach with other key market actors such as the Alliance to Save Energy, Building Owners and Managers Association, International Facility Management Association, U.S. Department of Energy, National Electrical Manufacturers Association, Association of Energy Engineers, American Council for an Energy Efficient Economy, New York State Energy Research and Development Authority, Northwest Energy Efficiency Alliance, U.S. Environmental Protection Agency, American Institute of Architects, various lighting professional groups, and California utilities. Through these allies, information is channeled to key audiences on product status and availability for lighting specifiers and manufacturers. Other efforts include product demonstrations, presentations, press releases, work with utilities to provide installation incentives, and identification of building and energy code opportunities and constraints. Case studies and a sophisticated computerized design tool for one product (for identifying combined daylighting/dimming controls placement and specification) are also being provided by the market connection team.

**Industry information and education.** For lighting R&D products not ready for market by the end of the LRP's two-year term, the objective was to assure that their R&D momentum and potential value not be lost due to lack of visibility. The market connection team used papers, presentations, and news releases through selected professional society allies to assure that potential further developers and manufacturers are aware of product development status, potential, and opportunities. The final technology transfer plans or business cases were a key resource for this, and their economic business cases will be available on the program website at the conclusion of the project (www.archenergy.com/lrp).

### LRP Market Connection Results to Date

Several of the LRP's products were based on earlier research efforts and were ready for market introduction halfway through the program's two-year term. Most of these products involved developer-manufacturers, and the principal market connection effort for those products has been in business-case development and direct support of the manufacturer's efforts to find demonstration sites, understand the market, assess benefits and economics, and gain utility incentive support. Several of these products are being released commercially in 2004. These include the bathroom light control, stairwell bi-level light fixture, and classroom lighting system cited earlier as well as several ENERGY STAR pin-based CFL table lamps and retrofit recessed CFL downlights.

The remaining products are in varying stages of development, but are less likely to reach commercial status within the LRP's term. Examples include outdoor lighting fixtures with activity sensors and LED background lighting, an addressable step-down ballast for remote office lighting load management, and an LED desk lamp. These have been the subject of continuous review and assessment by the market connection team and program management, with emphasis on product refinement to maximize commercial potential and make connections with potential manufacturers where none are already involved. In these projects the continuing refinement of the tech transfer plan is also important as a documentation of business cases for later consideration by the industry.

The LRP market connection effort has led to a broad range of improvements in the program's products, their visibility within the lighting, construction, and property management fields, the adoption of utility incentives to encourage product success, and manufacturer interest and agreement to produce those products. The market connection initiatives originated not only with the market connection specialists but with everyone involved in the LRP. In fact, a major benefit of the PIER market connection strategy was that it seemed to raise the priority of market connection considerations and activities among all participants. This created a committed "market-focused culture" among the researchers.

## Conclusions

Early experience with the new PIER market connection approach suggests several emerging conclusions. Requiring early yet thorough "technology transfer" plans (the PIER term for business case) has proven to be valuable in screening products for practical economic application, indicating necessary changes, and even canceling or redefining specific R&D projects. The new tech transfer plan template/outline developed in the PIER Lighting Research Program has provided a comprehensive prototype for such efforts and has proven to be a practical tool. The plans have also served as a basis for improved effectiveness with potential manufacturers. Finally, the tech transfer plan requirements appear to have broadened the perspective and approach of some LRP researchers as a permanent improvement in R&D practice.

We have also observed that the separation of the product R&D responsibilities from the planning and coordination of the market connection efforts assures a continuing priority on practical market considerations and needs. Without such a focus, R&D projects can easily minimize such market-related considerations in favor of a more exclusive emphasis on refinement of the technology, with the result that the product may be stranded without adequate production interest, support of key intermediaries, or momentum toward the market. With independent market connection planning and coordination, all parties including the technology developers can participate actively in a variety of coordinated market connection activities, from tech transfer planning to market research, manufacturer engagement, and barrier-breaking.

While the PIER market connection model appears to have significant benefits, it does not automatically solve all the problems of shaping and moving a new energy efficiency technology to market. Every R&D project is different in its market connection needs and opportunities, and every R&D project manager and team bring different market connection perspectives and abilities to the effort. Each case requires a creative adaptation of the market connection model, principles, and techniques. But the PIER program's initial efforts in more strategic and focused market connection support provide a useful model for broader consideration and evolution. With such approaches, energy efficiency R&D should produce more useful technologies and practices that get off the laboratory shelf and into the marketplace.

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## Appendix: Terminology

Terms related to making the leap from the laboratory bench to the market shelf are not always consistently defined by stakeholders. Here are the key terms and definitions as used by the authors of this paper.

**Market connection:** The process of moving an innovation from concept or lab into commercial production or sale. Market connection activities may include a combination of efforts such as gaining manufacturer commitments, using market research to make an original concept more marketable, addressing the concerns of potentially hostile intermediaries or decisionmaker influencers, and identifying the most promising introductory markets, audiences and messages. Market connection is strategic: It should involve a comprehensive assessment and response to the fit of the product and market, pathways to that market, the barriers, and potential allies and mechanisms. Technology transfer (licensing, etc.) and market transformation (altering the purchase decision context) are aspects of market connection.

**Market barriers and incentives:** Barriers are the existing forces that can impede a product's acceptance. They can include the conventional beliefs, preferences, regulations, practices, costs, competition, and self-interests of various market actors. Incentives can include energy code mandates, tax incentives, utility rebates, and other inducements.

**Intermediaries:** Those who work along the pathway to market. They can be either barriers or allies. and include distributors, testing organizations, regulators, contractors, technical educators, and anyone else who must deal with a new product or service before it reaches the actual buyer and user.

**Influencers:** This term refers to a specific type of intermediary: people who directly influence the buying decision. Various specifiers, marketers, consultants, and the buyer's own users, operators, and staff may be influencers. Their attitudes about a new product are crucial to its success.

**Market pathways:** (also referred to in marketing as the "value chain" since each successive step adds value to the product.) The chain or alternative chains of steps through which an innovation must be moved to get to the buyer. For example, a market pathway for an already-developed innovation might begin with pilot testing by the developer, development of a business case, securing of one or more manufacturers, successful production engineering, and market testing. Later steps can include education of distributors and specifiers, approvals by relevant code officials, securing of utility rebates, early case studies, inventory building and prestocking, market announcements, and continuing support to specifiers, buyers, and users.