

# Evaluating Emerging Technology Programs: Unique Challenges and Opportunities

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## ABSTRACT

An evaluation is being conducted of Southern California Edison's Emerging Technologies Program (ETP), which makes detailed designs and demonstrations of emerging technologies, and their performance information, widely available. This evaluation is a theory-based evaluation that entails two phases. Phase I involves both a process evaluation and the establishment of various baselines using a variety of market indicators. A Phase II follow-up study will be conducted 18 months later to measure any changes in market indicators. The central research question is how effective is the ETP's approach in educating and changing the behavior of targeted market actors.

This paper describes the results of Phase I, which focused on the construction of a baseline. Identifying the various target audiences and relevant technologies, developing a logic model that adequately reflects the complexity of the ETP, developing a research plan that adequately addresses these diverse target audiences and technologies, and developing market indicators that are relevant to these various market actors all proved challenging.

In Phase I, 367 market actors were surveyed regarding 13 emerging technologies. Both awareness of and behavior towards these emerging technologies were measured. The results indicate that the baseline diffusion of a given technology varies depending on the market actor. One cannot assume, therefore, that a single approach to promoting various emerging technologies among various target audiences will be appropriate. Rather, approaches should be tailored to market actors depending on how far they have progressed through the stages of diffusion for a given technology.

## Introduction

Southern California Edison Company's (SCE) Emerging Technologies Program Element (ETP) is designed and implemented by SCE's Design and Engineering Services group. The ETP, with a program year 2000 budget of 4.6 million dollars, focuses on demonstrating energy efficient technologies that have not yet been widely adopted in specific customer segments by various market actors. The ETP makes the detailed designs of these efficiency options and their performance information widely available. The specific market objectives of the ETP are to:

1. create persuasive demonstrations of the effectiveness of an integrated energy efficiency design approach, targeting building types and sectors likely to emulate the approach, while addressing some of the standard market barriers such as access to energy efficiency expertise, and the general hesitation to step beyond standard practices with emerging technologies;

2. assist the market actors to learn about the efficiency, operation, maintenance, costs, value, comfort, and environmental benefits of innovative, integrated energy efficient designs and emerging technologies; and
3. coordinate efforts with other utilities' Emerging Technologies Programs and the California Energy Commission.

This paper presents the results of Phase 1.

## **Evaluation Objectives**

The evaluation objectives will be accomplished in two phases. The Phase I evaluation objectives are to:

1. document ETP activities,
2. identify specific technologies and integrated designs on which to focus the evaluation,
3. identify the target audiences for each of these technologies,
4. conduct a baseline survey of awareness of these emerging technologies and integrated designs among the general target audiences, and
5. identify ways to improve communication between the ETP and it's various target audiences.

The Phase II evaluation will be conducted approximately 12 to 18 months after Phase I. The evaluation objectives of Phase II are to:

1. conduct a follow-up survey of awareness of these emerging technologies and integrated designs among the general target audiences, and
2. measure any increases in awareness of energy efficient technologies and integrated designs among those who host showcases in their building(s), those who visit showcases or who are exposed to showcases via fact sheets, journals, magazines, and papers presented at conferences.

## **The ETP Program**

In this section, we provide a more detailed description of the ETP by addressing the following eight issues:

1. the working definition of an emerging technology,
2. the means by which information about these technologies is disseminated,
3. the market barriers addressed by these communication efforts,
4. the effort to coordinate these activities statewide,
5. the various audiences targeted by the ETP,
6. the various market segments targeted by the ETP,
7. the various technologies targeted by the ETP, and
8. the program theory.

Each of these eight issues is addressed below.

## Emerging Technology Definition

Central to the design and operation of the ETP is the definition of an emerging technology. Vine (1999) has noted that there is no standard definition of an emerging technology. One definition, recently developed by the Emerging Technologies Coordinating Council, has been adopted by the ETP and thus serves as the working definition for this evaluation:

Emerging technologies range across the entire new product development cycle from early prototypes and demonstrations all the way through to commercially available equipment. Some are stand-alone products, or components, process improvements and software tools. They all have public interest benefits including energy efficiency improvements. However, they have not yet achieved adequate market penetration or acceptance. Note: Utilities are focused on products that have already been commercialized while the CEC is demonstrating products that are nearing the end of their product development cycle.

## Communication

The primary means by which customers are informed by the ETP about emerging technologies is through the following 12 types of *showcases*:

1. Small Comprehensive Retrofit,
2. Large Nonresidential Comprehensive Retrofit,
3. Nonresidential HVAC Turnover,
4. Motor Turnover,
5. Process,
6. Commercial Remodeling & Renovation,
7. Commercial New Construction,
8. Industrial/Agricultural New Construction,
9. Residential New Construction,
10. Residential Heating & Cooling,
11. Residential Retrofit & Renovation, and
12. New Construction Codes and Standards.

Since 1993, the ETP has created 121 technology showcases.

It is important to note that the ETP definition of an emerging technology *showcase* can, but does not necessarily involve a customer installation. A showcase can also include a *paper* study, or the results of a *test* conducted at the Refrigeration Technology Test Center (RTTC) a component of the ETP. Given this, the definition of a showcase does not necessarily require that a member of the target audience physically visit a building, which houses a showcase in order to be exposed to the showcase. Members of the target audience who cannot visit a showcase can be exposed to a showcase in a number of ways,

including: 1) a fact sheet<sup>1</sup>, 2) a journal article, 3) magazine article, 4) a technical report, 5) a conference presentation, or 6) the proceedings of a conference.

## **Market Barriers**

The ETP activities are expected to produce both near- and intermediate-term market effects, leading to long-term transformation of the marketplace for energy efficient technologies and design approaches that are new or at least new to a given market segment. It hopes to achieve these objectives by addressing the following five market barriers:

1. Performance uncertainty
2. Information/search costs
3. Asymmetric information
4. Organizational practices, and
5. Misplaced or split incentives.

## **Statewide Coordination**

The California investor-owned utilities are working to coordinate their emerging technology efforts in order to ensure effective linkages between entities involved in either the development or delivery of new energy efficient technologies in California. The keystone of this emerging technologies *statewide* coordination effort is the Emerging Technologies Coordinating Council (ETCC). The ETCC includes program representatives from Pacific Gas & Electric, Southern California Edison, San Diego Gas & Electric, and Southern California Gas, along with a representative from the California Energy Commission. The objective of the ETCC is to seek opportunities to coordinate efforts between each of the utility's Emerging Technologies Program, as well as with the California Energy Commission's PIER program. Each individual utility Emerging Technology Program will consist of activities that may be coordinated with other utilities and the CEC, and activities that are unique to each utility's service territory and customer base. Thus, some unique program milestones for each individual utility program may exist. It is also important to note that the ETP is classified as a cross-cutting program since it supplies technical support to a number of SCE's DSM programs.

## **Targeted Audiences**

The identification of the target audience and the specific technologies to be promoted to these audiences was one of the more challenging aspects of this evaluation. First, we describe the identification of the target audiences followed by a description of the specific technologies that are promoted.

Through a series of meetings with the ETP staff, we learned that the target audience is comprised of a variety of market actors, some of whom are upstream from the end user and who provide such

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<sup>1</sup> A fact sheet is typically a one-page description of the showcase and its costs and benefits. Fact sheets are typically distributed to customer account representatives who can in turn share them with customers. They are also provided to customers upon request and are, in many cases, also provided via the ETP web site.

services as HVAC specification and lighting designs and some of whom are end users such as energy managers in commercial facilities. The target audience can be further characterized as being *directly* affected or *indirectly* affected by ETP activities.<sup>2</sup> Those directly affected are expected to experience more immediate market effects than those indirectly affected. Those directly affected include customers who host showcases, visitors to showcases, workshop/seminar participants, and customers participating in one of SCE' nonresidential or residential energy efficiency programs. Those indirectly affected include any member of the target audience who is exposed to the showcases through such means as journal articles, web sites, and technical reports. Note that the baseline survey, to be conducted as a part of this Phase I evaluation, and a second survey, to be conducted in 2001 as part of Phase II, will focus on the entire target audience, the vast majority of whom will have been indirectly affected by the ETP. Other surveys conducted during Phase II will focus on those directly affected by the ETP.

In order to focus the evaluation on those ETP activities that consume the largest portion of the ETP technology showcase budget, we conducted a series of interviews with ETP staff to isolate the specific target segments for study. In these interviews with the ETP staff, we attempted to identify those customer segments and target audiences (market actors) who were expected to be the primary focus of the ETP over the next 12 to 18 months. We first identified the following four customer segments:

1. schools,
2. foodservices,
3. supermarkets, and
4. dairy farms.

These segments received approximately 50 percent of the money budgeted in PY 1999 for technology showcases and were likely to receive a significant fraction of future budget allocations.

While there are numerous audiences within the four customer segments, we identified the following seven key audiences or market actors:

1. engineers,
2. architects,
3. lighting designers,
4. energy managers,
5. owners of dairy farms,
6. kitchen designers, and
7. administrators of construction in schools.

These seven target audiences are a mix of end users and those working up-stream from end users. Note also that the ETP has historically targeted dedicated professionals who were on the cutting edge of technologies and design principles (e.g., engineers, architects, and lighting designers). They specifically mentioned several professional organizations that are targeted, including the American Society of (AHRAE), the American Institute of Architects (AIA), and the Illumination Engineering Society (IES).

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<sup>2</sup> Note that, since the ETP attempts to change the attitudes, knowledge, and behavior of all members of the target audience, there are no nonparticipants in the ETP. That is, they are all members of the market that the ETP is attempting to transform.

The next section addresses which technologies will be promoted to the seven market actors within the four market segments over the next 12 to 18 months.

## Targeted Technologies

In interviews with ETP staff, we identified 13 technologies that would receive significant ETP attention over the next 12 to 18 months:

1. reflective night covers in open vertical and coffin display cases,
2. variable-speed drive in centralized condensers with advanced controls,
3. electronically commutating fan motors,
4. electrical lighting and daylighting integration,
5. low-flow hood exhausts,
6. electric steam griddles,
7. hybrid chain-driven charbroilers,
8. National Electrical Code's approved alternative calculation methods for electrical panel sizing,
9. direct/indirect pendant fixtures,
10. natural ventilation,
11. variable-speed drive in milk pumps,
12. metal halide lights with pulse-start technology, and
13. high-volume, low-speed fans for cooling cows to reduce stress.

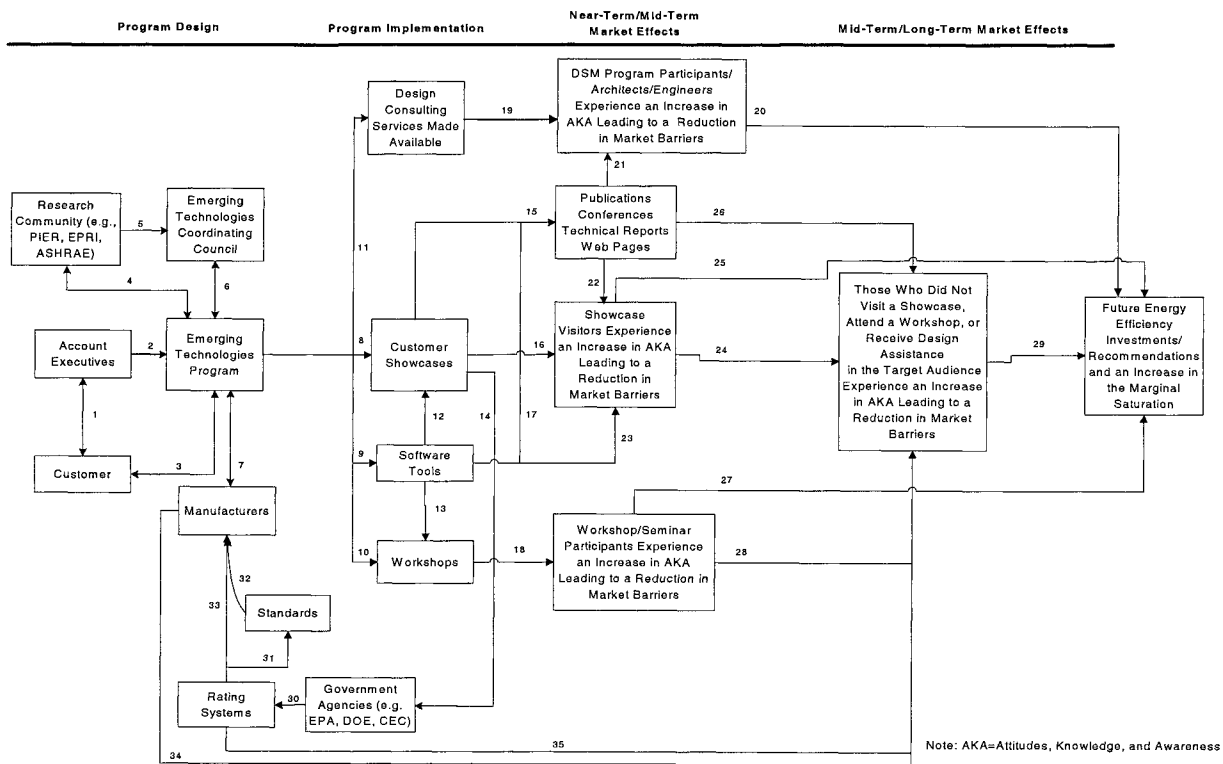
Thus, over the next 12 to 18 months, the ETP will provide members of the seven target audiences with information regarding the applications of these 13 specific technologies in four customer segments. In some cases, a particular market actor was targeted with multiple technologies across multiple customer segments.

## Program Theory

Figure 1 illustrates the program theory (Weiss 1998), i.e., the relationships between the ETP activities, the market actors, and the expected outcomes. As depicted in this diagram, the activities of the ETP are designed to influence members of the target audience both directly and indirectly. Those *directly* influenced include those who actually visit a showcase or attend a seminar or workshop. Those *indirectly* influenced include those who are exposed to showcases via: 1) a fact sheet, 2) a journal article, 3) magazine article, 4) a technical report, 5) a conference presentation, or 6) the proceedings of a conference. To identify appropriate indicators, we examined not only theories of market transformation (Eto, Prahl & Schlegel 1996) but also theories of diffusion of innovation (Rogers 1995; Rogers & Shoemaker 1971).

## Methods

The methods section first presents a brief overview of the sample plan and data collection activities.



**Figure 1.** Emerging Technologies Program Theory

The construction of this sample frame was one of the more challenging aspects of this baseline survey. While there are various approaches to constructing the frame, each with its own set of advantages and disadvantages, a strategy was chosen that involves the use of membership lists of professional associations, SCE billing files, and special lists maintained by ETP staff. Table 1 summarizes the various data sources for the key market actors.

**Table 1.** Key Actors by Data Source

	ASHRAE	IESNA	AIA	SCKD	SCE
Engineers	X				
Lighting Designers		X			
Architects			X		
Kitchen Designers				X	X
Energy Managers					X
Administrators of Construction					X
Dairy Farmers					X

## Recruitment

Data were collected from a sample of members of the target audience using what is called a telephone/mail-survey. This approach involved first contacting prospective members of the target audience by telephone, describing the study, offering a \$20.00 incentive, and asking whether they would be willing to participate in the survey. If the subject agreed to participate, they were given the option of receiving the survey by fax, e-mail, or regular US mail.

## Survey Instruments

There were seven different survey instruments, each tailored to one of the seven market actors. Market actors were asked a number of questions about their awareness and behavior with respect to three specific emerging technologies. Those who were aware of a given technology were asked whether, in the past 12 months, they had installed or recommended the installation of the technology. If they had not, they were asked if they planned to install/recommend the technology in the next 12 months. Those who were aware of the technology were then asked whether, within the past 12 months, they had sought information or received training regarding the technology. They were also asked whether they had explained the benefits of the technology to a colleague and whether they had promoted changes to internal company policy regarding the technology.

How to measure such awareness was challenging. For example, consider those ETP projects that involve a daylighting design. Since all or nearly all members of the Illumination Engineering Society (IES) are likely to be familiar with the daylighting concept, one would expect that to measure the awareness of daylighting among IES members would reveal very high levels of awareness with little room for improvement. However, ETP's contribution is that it has applied mature daylighting principles to market segments that have relatively little exposure to the benefits of daylighting. Thus, it was important to measure awareness of daylighting among specific market segments in specific applications, such as architects involved in school design. Another example is variable speed drives. While this technology has achieved significant penetration in the industrial process sector, it has not, until very recently, been applied in the dairy industry. Accordingly, questionnaires were designed to recognize these nuances when measuring awareness.

The sample was treated as a stratified random sample with each market actor being considered as a stratum. In total, 367 questionnaires were completed across the seven market actors.

## Results

All seven market actors were combined into a single file and analyzed. Recall that 13 different technologies were addressed overall, with each market actor within each market segment being asked about a unique set of three technologies. In all, the 367 respondents were asked 1,101 (3 x 367) questions about new technologies. When analyzing overall awareness and behavior, we are reporting percentages of "yes" responses to all 1,101 technology-awareness/behavior questions. These percentages reflect awareness and behavior with respect to *any* technology. The overall results across all seven market actors are summarized below.



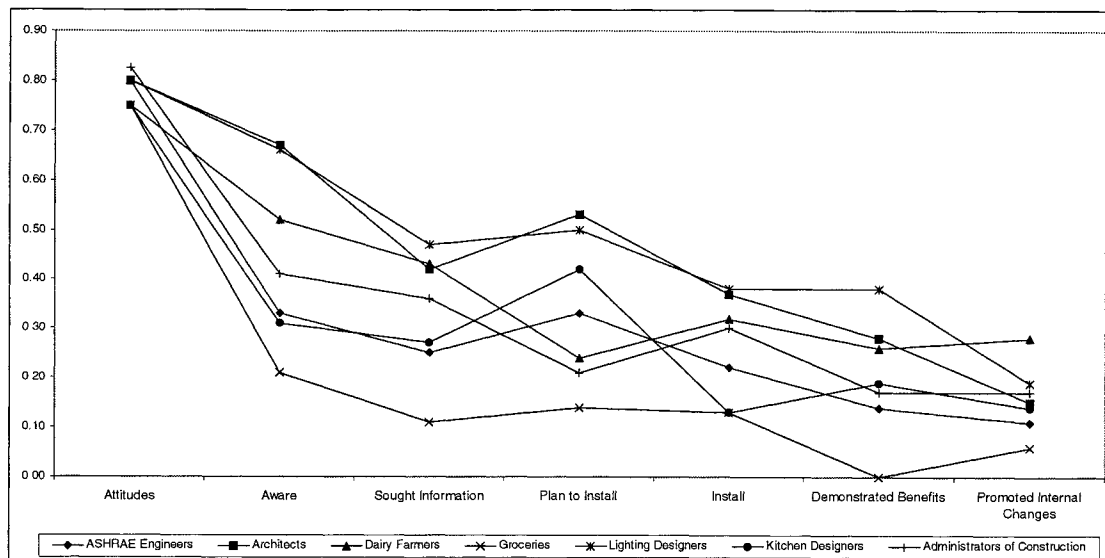
- Forty-four percent indicated that they were aware of the emerging technologies, 50 percent indicated that they were not aware and 6 percent indicated that they did not know whether they were aware of the technology.
- Of the 70 percent who indicated that they had not installed/recommended or did not know if they installed/recommended a technology, 25 percent indicated that they were planning to install/recommend a technology within the next 12 months.
- *Of the 44 percent who are aware of the emerging technologies about which they were asked, 36 percent indicated that they had sought information within the last 12 months about emerging technologies.*
- *Of the 44 percent who are aware of the emerging technologies about which they were asked, 14 percent indicated that they had received training within the last 12 months regarding the emerging technologies.*
- *Of the 44 percent who are aware of the emerging technologies about which they were asked, 24 percent indicated that within the last 12 months they had demonstrated the benefits of emerging technologies to a colleague. In fact, if one had already installed or recommended the installation of the technology, the odds of demonstrating the benefits to a colleague were nearly 12 times greater than one who had not yet installed or recommended the technology.*
- *Of the 44 percent who are aware of the emerging technologies about which they were asked, 16 percent indicated that within the last 12 months they had promoted changes to internal company policy regarding emerging technologies.*
- Attitudes toward energy efficiency are very high.
- The lowest market barrier is organizational practices while the highest is performance uncertainty. The fact that performance uncertainty is the greatest barrier underscores the importance of demonstrating emerging technologies, through showcases.

One can place the results reported thus far into a diffusion of innovation framework. The questions asked regarding each of the thirteen technologies can, for the most part, be mapped into the five stages of the innovation-decision process: I. Knowledge; II. Persuasion; III. Decision; IV. Implementation; and V. Confirmation. Awareness of an emerging technology can be considered as Stage I. Seeking additional information and planning to install can both be placed in Stage III<sup>3</sup>. Installing is part of Stage IV and demonstrating the benefits of the technology to others and promoting internal changes in one's organization can be considered part of Stage V.

As one moves from Stage I through Stage V diffusion of the innovation increases. When one examines the answers to the six questions, certain patterns emerge that suggest that certain market actors are further along in the diffusion process with respect to their specific technologies. We should note that one's general attitude toward energy efficiency could be viewed as preceding one's awareness of any particular energy efficient technology. In Figure 2, we plot, for each market actor, the mean attitude score as a proportion of 4 (the top of the scale) and the proportion who respond positively to each of the six questions.

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<sup>3</sup> Receiving training was dropped from the diffusion of innovation discussion since in some cases such as grocery stores there is no training per se for some of the technologies such reflective night covers in open vertical and coffin display cases.



**Figure 2.** Diffusion, by Market Actor

As one can see from Figure 2, the seven market actors are in different stages of diffusion. First, note that with respect to attitudes toward energy efficiency, while there are differences (occasionally significant) across market actors, these differences are small and of no real practical importance. Next, one clear pattern is that architects and lighting designers are more aware of their respective technologies. In addition, they have a greater tendency to plan to recommend emerging technologies to their clients, to actually recommend these technologies to their clients, and to demonstrate the benefits of the technologies to their colleagues. Another pattern is that dairy farmers and administrators of construction have a greater tendency to be aware and to plan to recommend emerging technologies to their respective organizations. Another pattern is that ASHRAE and kitchen designers have less of a tendency to be aware and to plan to recommend emerging technologies to their respective organizations. A final clear pattern is that energy managers in grocery stores have progressed the least along the diffusion chain.

What are the implications of these differences for program strategies to increase the penetration of emerging technologies? Many possibilities for changes in Program design must be worked out with ETP staff. However, we will mention a few. For example, for architects and lighting designers, more technical assistance could be provided to increase installation rates. To increase the rate at which they share this information with their colleagues, one could provide these market actors with additional information in the form of brochures and Uniform Resource Locators (URLs)<sup>4</sup> that point to the various ETP web sites and technical reports. Or, for energy managers in groceries, one could focus more effort on simply making them more aware by providing tours of relevant showcases and more information about the various ETP web sites.

<sup>4</sup> Think of the URL as a networked extension of the standard filename concept: not only can you point to a file in a directory, but that file and that directory can exist on any machine on the network, can be served via any of several different methods, and might not even be something as simple as a file: URLs can also point to queries, documents stored deep within databases.

## Conclusions

The differences in awareness and behavior across market actors may suggest the need for a different service focus, at least for some market actors. For example, architects and lighting designers are more aware of their respective technologies. In addition, they have a greater tendency to plan to recommend emerging technologies to their clients, to actually recommend these technologies to their clients, and to demonstrate the benefits of the technologies to their colleagues. That is, they are more active at each stage of the diffusion chain. As a result, because the most basic objective, making these customers aware, has already in large part been achieved, the ETP could focus more of its resources on increasing installation rates through the provision of technical assistance.

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