Evaluating Emerging Technologies Programs: Accelerating the Future

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Abstract

The California Statewide Emerging Technologies Program (ETP) is an information-only program that seeks to accelerate the introduction of innovative energy efficient technologies, applications, and analytical tools that are not widely adopted in California. The ETP works to accelerate a product's market acceptance through a variety of approaches, but mainly by reducing the performance uncertainties associated with new products and applications. This is done primarily through technology assessments, where technologies are tested in a controlled environment in an effort to confirm manufacture claims regarding equipment performance and savings potential. The current program is being implemented by the four California investor-owned utilities (Pacific Gas and Electric, Southern California Edison, Southern California Gas, and San Diego Gas and Electric).

A comprehensive process evaluation was conducted for the 2004-2005 program cycle of the ETP. Although the evaluation focuses on the 2004-05 program, it was also designed to meet the new California protocols that will be used for the 2006-08 program evaluation cycle. This paper will focus on the two complementary components of the evaluation; the development of the logic model and case studies. Specifically, this paper will present the functional logic model that was developed as part of the evaluation, and describe how case studies were used to highlight successful links in the logic and evaluate the progress of the ETP.

Introduction

The California Statewide Emerging Technologies Program (ETP) is an information-only program that seeks to accelerate the introduction of innovative energy efficient technologies, applications, and analytical tools that are not widely adopted in California. The ETP works to accelerate a product's market acceptance through a variety of approaches, but mainly by reducing the performance uncertainties associated with new products and applications. This is done primarily through technology assessments, where technologies are tested in a controlled environment in an effort to confirm manufacture claims regarding equipment performance and savings potential. The current program is being implemented by the four California investor-owned utilities (Pacific Gas and Electric, Southern California Edison, Southern California Gas, and San Diego Gas and Electric).

A comprehensive process evaluation was conducted for the 2004-2005 program cycle of the ETP. Although the evaluation focuses on the 2004-05 program, it was also designed to be consistent with the new California protocols that will be used for the 2006-08-program evaluation cycle. This paper focuses on the two complementary components of the evaluation; the development of the logic model and case studies. Specifically, this paper will present the logic model that was developed as part of the evaluation, including a description of the key linkages between activities, outputs, and outcomes associated with logic model. Based on the logic model, a number of metrics were identified to help assess how well the ETP is satisfying the key linkages. The paper will then discuss how case studies of specific ETP technology assessments were used to collect information pertaining to specific metrics in order to highlight successful linkages in the logic model and evaluate the progress of the ETP.

Because of its unique nature, evaluating the ETP poses a number of challenges. Since the program is involved at the very beginning of the commercialization process, future energy savings cannot be linked directly to the ETP as other energy efficiency programs will be involved with promotion and providing incentives once the technology is included as an eligible measure. Additionally, the ETP is not designed to be a mass marketing program or an R&D program, so traditional metrics for measuring program effectiveness are not directly applicable. Furthermore, the design and implementation of the technology assessments, which are the primary output of the ETP, vary largely depending on the type of technology and the target market chosen for the assessment. Finally, within the ETP the implementation process and organization of the program varies across implementing utilities.

Background

The ETP was created with the purpose of accelerating the adoption of new energy efficiency technologies into the marketplace. While the California Energy Commission's (CEC) Public Interest Energy Research (PIER) program focuses on R&D for energy efficiency, the ETP works to reduce the barriers to adoption for energy efficiency technologies that are already available in the market. The ETP is, therefore, designed to provide a bridge for PIER research projects and other emerging energy efficiency technologies to the market.

The ETP activities focus on the assessment of near-commercial and commercial energy efficient applications with low market penetration. The program targets all market segments. Demonstration projects, conducted at either customer sites or in controlled environments provide design, performance, and verification of energy efficient systems, thereby helping to reduce the market barriers to their wider acceptance. The demonstration projects help to measure, verify, analyze, and quantify the potential demand and energy savings. The results from assessments are then disseminated to energy efficiency (EE) programs, customers, and other relevant parties in order to encourage acceptance of the technology.

Although the original intent of the ETP has not changed, the program has changed its focus since inception. Specifically, The 2004-2005 program cycle (the period of our evaluation) was a period of transition for the ETP. Where previously the ETP's focus was to "assess and showcase technologies," the new focus became "accelerate the adoption of new technologies into energy efficiency programs." In other words, utility EE programs were to be one of the primary mechanisms for disseminating ETP results and promoting viable energy efficiency technologies as deemed by the ETP. In response to this shift, many of the processes and coordination efforts implemented by the ETP were also in a period of transition during the 2004-2005 program years.

Analysis Methods

The structure of the ETP evaluation was founded on a theory-based approach. The logic model and theory developed during the initial stages of the evaluation serves as the foundation for the remainder of the evaluation activities. Other evaluation activities, including in-depth interviews and case studies were then designed to assess how the ETP satisfies key components of the model and theory. The benefit of this framework is that the evaluation results all relate directly to key elements and linkages of the program logic and provide a clear path for refining the program in the future based on these findings.

The evaluation of the 2004-2005 ETP program consisted of four primary components:

1. **Documentation of program activities.** The first part of the evaluation involved collecting information from each utility and documenting ETP activities and accomplishments during the 2004-05 program cycle.
2. **Development of a functional program logic model and theory.**. The logic model and theory served as an important tool from which key components and assumptions of the program could be determined. Process interviews and case studies were then conducted to test and assess these key components.
3. **Process evaluation.** The formal process evaluation consisted of a total of 18 in-depth interviews that were conducted with ETP Program Managers, ETP Project Managers, Program Managers from other utility energy efficiency program, representatives from account services, and representatives of PIER. Interview guides were developed with the intent to gain an understanding of how different components of the ETP, as identified in the logic model and theory, function in practice. Specifically, the process evaluation and the interviews focused on:
    - How the ETP identifies new technologies
    - How technologies are screened and selected for assessment
    - Identifying best practices, and
    - How results of the assessments are disseminated, including the use of assessed technologies in other energy efficiency programs.
4. **Case studies.** Eight case studies were conducted of ETP assessments. The case studies provided an in-depth look at how technology assessments are implemented. The case studies had two primary goals. First, the case studies were used to determine what program metrics could be reasonably tracked and how to best track them. The other objective of the case studies was to demonstrate and a method of testing specific links related to the logic model to assess both the progress of individual assessments and the program as a whole.

The case studies in particular provide a unique method for assessing the program effectiveness. The purpose of the case studies was to demonstrate the how specific metrics developed from the logic model could be mapped to actual technology assessments. The progress of individual assessments could then be evaluated based on how well they satisfied key linkages in the logic model. Aggregating the results of the case studies would then allow the progress of the program as a whole to be evaluated.

The remainder of this paper describes the logic model developed as part of the 2004-2005 program evaluation of the ETP and case studies were used to test key linkages between activities, output, and outcomes identified in the logic model.

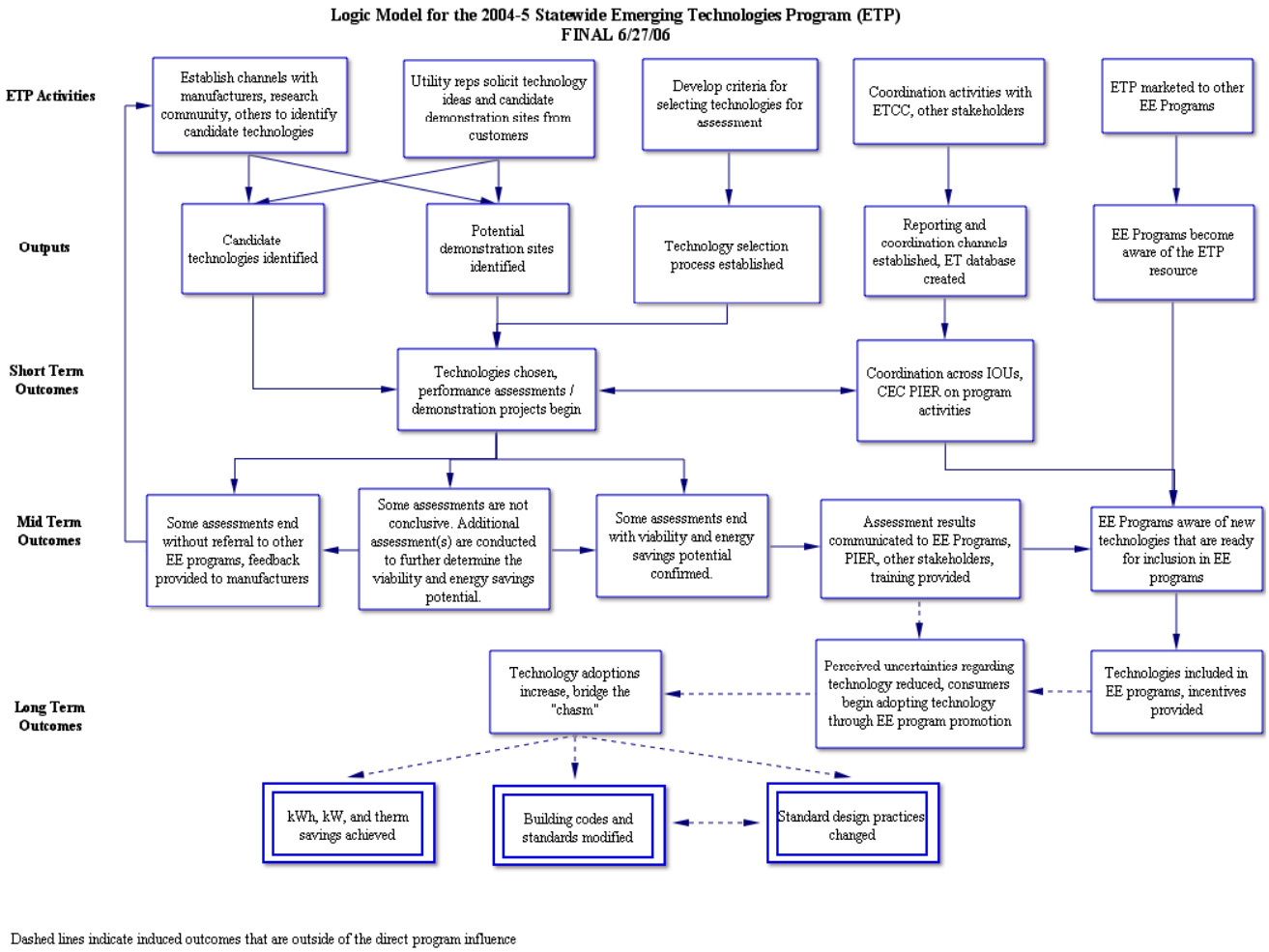
Analysis Results

Logic Model

One of the first tasks of the evaluation was to create a functional logic model for the ETP, shown below in Figure 1. This critical first step would then inform and guide the remainder of the evaluation activities. The intent of the logic model was to dissect the program into its most elemental components in order to create a diagram in which one could easily see the key components of the program and the underlying assumptions. A literature review was conducted and feedback was solicited from ETP program staff to inform the development of the logic model.

When assessing the underlying program logic, it is important to distinguish between outputs and outcomes. For this paper, outputs are defined as the immediate results from specific program activities. These results are typically easily identified and can be counted, often by reviewing program records. Outcomes are distinguished from outputs by their less direct result from specific program activities. Outcomes represent anticipated impacts associated with ETP activities and will vary depending on the time period being assessed. It should be noted that it was outside the scope of this evaluation to test the validity of long-term outcomes.

Figure 1:Logic Model for the 2004-2005 Emerging Technologies Program



In addition to the logic model, a program theory was developed with the purpose or providing additional detail to the specific activities, outputs and outcomes identified in the model. The theory was then used to identify possible metrics that could be used to validate key linkages. Below is a summary of the program theory developed for the ETP.

Activities. The activities represent the direct actions of the ETP program. The 5 activities listed in the logic model can be grouped into three distinct categories; technology identification, technology selection, and information dissemination. Technologies are identified by the ETP either through specific ETP activities or are brought to the ETP by customers, generally via account representatives. The former method is referred to as "technology push," which is used to describe the action of the program identifying a

technology and then soliciting customers to participate in an assessment of the given technology. In order to identify viable technologies, ETP staff establish channels with various players within the industry. Specifically, ETP staff work with manufacturers, California Energy Commission (CEC) Public Interest Energy Research (PIER) program, research design and technical communities, energy efficiency advocates, and other public agencies to identify technologies. The majority of technologies that the ETP assess can be categorized as technology push. In addition to the technologies identified by ETP staff through market channels, customers and their utility representatives will also identify technologies of interest and pitch the ideas to the ETP, a practice referred to as "customer pull." It should be noted that the evaluation found that the ETP has been successful at identifying more than enough candidate technologies for its assessments.

The technology selection process was identified as another key ETP activity. Technologies are selected based on multiple criteria, including the market and energy savings potential of the innovation, market barriers, incremental cost, measure life , assessment cost, and time required for the assessment. Technologies are also chosen to achieve a mix of market sectors covered by the technologies being assessed. Necessitated by the increased number of active assessments, the ETP began to implement a more formalized selection process during the 2004-2005 program cycle than used previously. The purpose of the selection criteria is to encourage the selection of technologies that have the potential to make the maximum impact on utility energy efficiency programs in the near future.

The remaining two activities identified in the logic model, coordination activities and marketing to energy efficiency (EE) programs, are both related to information dissemination. Each IOU has its own version of the ETP and program implementation efforts and it is important for the IOU's to coordinate and share their knowledge. Coordination is implemented through regular meetings between utilities, joint meetings with the Emerging Technologies Coordinating Council (ETCC), discussions with the CEC PIER program, the ETCC database, and monthly program workbooks that each IOU files with the California Public Utilities Commission (CPUC). It is also critical that assessment results are effectively communicated to EE programs, since they are the primary target audience for the ETP. Energy efficiency program include those programs sponsored by the IOU's along with other third-party programs. The ETP markets the results of the assessments through fact sheets, workshops, trainings, and the ETCC database so that these programs are aware of the ETP as a source for new technologies. In addition, the ETP has been working to incorporate EE program staff into the ETP selection process or other early stages of assessments. This serves to inform the EE programs about what technologies are in the ETP pipeline and also encourages greater communication between the ETP and EE programs.

Short-term outcomes. There are two short-term outcomes identified in the logic model. Following the successful identification and selection of a technology, the ETP begins conducting the actual assessment. Most assessments are done as demonstration projects at customer sites for those customers that are interested in showcasing/promoting a technology. Other assessments may be performed at test centers under controlled environments.

The other short-term outcome is that ETP activities are coordinated across utilities through regular meetings and other communications. In addition, the ETP begins to disseminate information on assessment progress through multiple channels.

Mid-term outcomes. Mid-term outcomes immediately follow the completion of an assessment. Assessments can conclude in three ways. Some assessments show that a technology will have limited market potential in its current state and is therefore not ready to be included as an eligible technology in an energy efficiency program. Although the assessment does not result in a technology moving into an efficiency program, the process does provide valuable information on the technology that is communicated to manufacturers and other stakeholders so that the product can be improved. Completed assessments may show energy savings potential, but by themselves are not conclusive. In theses cases, follow-up assessments

may be necessary to determine the energy savings potential of the technology. Lastly, assessments can confirm the potential energy savings and viability of the technology.

For those technologies that have successfully completed assessments and are ready for wider promotion, the assessment results are communicated to other EE programs and ETP stakeholders. The assessment results are disseminated via fact sheets, workshops, trainings, demonstrations, Energy Centers, and person-to-person contact with IOU EE program managers. If ETP assessment results are effectively disseminated, EE programs should be aware of the new technologies that can be adopted by their programs. In addition, as the ETP increases the number of technologies it recommends to the energy efficiency programs, awareness of the ETP program increases and the ETP is given greater consideration as a resource by the energy efficiency programs.

Long-term outcomes. Long-term outcomes represent the ultimate goals of the ETP. Upon successful completion of a technology assessment, the technology should be handed off to an EE program for deployment. After the handoff of the technology to EE programs, the ETP is not longer directly involved with influencing the later outcomes. With the greater exposure of established EE programs, their reputation of promoting proven technologies, and the availability of financial incentives the adoptions of the ETP technologies will increase. In the language of the diffusion of innovation literature, through the assistance provided by these programs, demand for the ETP technologies will eventually bridge the "chasm" between the "Early Adopters" and the "Early Majority". As adoptions increase and consumers become more confident in the technology performance, the technologies will be incorporated into customers' standard design practices. As a result, building codes and standards will be modified to reflect the higher efficiency standards and energy savings are achieved that would not have occurred without the ETP.

Based on the logic model and program theory, a list of potential program indicators was developed that could be used to validate specific program outcomes. The various indicators help demonstrate that key linkages in the logic model are functioning as expected in practice. Once the metrics are identified, they can then be used to track program progress over time and validate the underlying program theory. Examples of some of the indicators identified for the ETP are provided in Table 1.

Table 1. Examples of Possible Program Metrics From the ETP Logic Model

Outcomes	Possible Program Indicators
Technologies chosen Technology assessments / demonstrations begin	Number of technologies chosen Energy savings and market potential of selected technologies Number of assessments started Number of end uses covered Number of market sectors covered
Coordination across IOUs, CEC PIER on program activities	Number of assessments that came out of PIER Information shared between IOUs Funding leveraged from other sources
EE Programs aware of new technologies that are ready for inclusion in EE programs	Awareness of new ET technologies among EE Program managers Information provided (savings and cost calcs) that is needed for EE Program inclusion

Outcomes	Possible Program Indicators
Technologies included in EE programs	Number of ETP technologies adopted by EE programs Number of units of ETP technologies deployed by EE programs Energy savings by EE programs associated with ETP technologies

Case Studies

The case studies had two primary purposes. One of the goals of the case studies was to determine what metrics could be tracked for every assessment that would serve as indicators for the progress of the assessment, and when aggregated for all assessments, serve as indicators of overall program progress. The ETP poses a number of challenges that make it difficult to establish such indicators. Outcomes of ETP assessments may be satisfied in a wide variety of ways that are highly dependent on the specific nature of the assessment. Each technology that is assessed has a specific market niche, which determines the specific barriers to market adoption, and therefore the specific kind of information needed to overcome these barriers as well as the manner in which the results are presented and the audience that they are presented to. Since the ETP assessments can be conducted on virtually any kind of technology, and span any market segment, aggregate program impacts are particularly difficult to determine.

In order to overcome these difficulties we needed to know which metrics would be common across all assessments and how to best track these metrics. This required having an in-depth understanding of how ETP assessments are implemented in practice. The case studies served as a way to conduct a detailed examination of how the ETP actually implements technology assessments, from the identification of a technology to the dissemination of the results. By conducting case studies on a variety of technology assessments conducted by different utilities, we were able to determine what metrics the program could reasonably track for all assessments.

The other goal of the case studies was to test specific links in the logic model and determine if case studies are an effective way of doing so for future evaluations. As part of each case study, data pertaining to specific program metrics, such as those presented in Table 1 were tracked to the extent possible. This information was then used to assess the progress of the specific technology assessment The metrics tracked from each case study were then aggregated to assess overall program progress.

Eight case studies were chosen based on conversations with ETP staff at each utility. The case studies were selected to show a range of technologies, end uses, and utilities during the 2004-2005 program period. The 8 case studies covered the following technologies:

- Variable speed dust collection
- Professional wet cleaning
- Optical demand defrost
- Integrated classroom lighting system for relocatable classrooms
- Bi-level stairwell lighting
- Super T8 lamps and electronic ballasts
- Fiber optic lighting in low temperature reach-in refrigeration display cases
- Efficient Computer Power supplies (80 Plus program)

Data for the case studies were collected by conducting in-depth interviews with the individuals where were involved with the implementation of the given assessment, including ETP program and project

managers, EE program staff, and the manufacturers of the assessed technology. Documents such as assessment selection forms, final reports, and fact sheets were also reviewed.

The case studies were designed to follow the flow of the logic model by focusing on three general topics associated with each assessment; technology overview, technology selection, and assessment implementation and results dissemination. Within each topic, specific metrics were collected that were then mapped to the logic model. A description of each topic along with the associated metrics is given below.

Technology overview. The case studies provide a general overview of the environment in which the technology was designed to compete in. This includes a description of the base-case technologies and a description of the emerging technology at the time the assessment began, including a discussion about the development phase of the technology. Specific metrics associated with the overview of the technology include:

- Developmental stage of the technology
- Examination of barriers to market adoption
- Estimated energy savings potential of the technology
- Number and characterization of the manufacturers of the technology

Technology selection. The case studies describe how and why the technology was chosen for an assessment. They also include a discussion of the potential benefits and barriers of the emerging technology. Specific metrics associated with the technology selection include:

- How the technology was brought to the attention of the ETP
- A formal application process, including an analysis of the target market, market potential, potential energy savings, and end use energy efficiency program
- Role of energy efficiency program staff or other parties in the selection process

Assessment implementation and results dissemination. The case studies provide a description of the demonstration site, as well as to discuss the roles of the various parties involved with the assessment. In addition, the case studies provide details about how the assessment was conducted and challenges that arose during the implementation of the assessment. The case studies also examine how the assessment results were communicated to relevant parties and what steps were taken, if any, to incorporate the technology into an energy efficiency program. Lastly, the case studies provide a description of the current status of the technology.

Metrics associated with the implementation and results dissemination include:

- Number of sites considered for the assessment
- Number of sites used for the assessment
- Number of technologies included
- EE program involvement in the assessment
- Any other collaborations with the assessment
- Co-funding from other sources
- Whether or not the manufacturer modified the technology based on ETP findings
- Measured energy savings potential
- Whether or not the technology was referred to an energy efficiency program
- Creation and availability of a final report
- Presentation made by ETP staff regarding the assessment
- Development of promotional materials based on the assessment
- Awareness of the assessment and results on the part of energy efficiency programs

Table 2 shows how specific metrics taken from a case study (ICLS for relocatable classrooms) were mapped to the indicators from the program logic model. The ICLS assessment conducted by PG&E was in many ways a model assessment as it helped demonstrate the program logic model by highlighting successful links between ETP activities, outputs and outcomes. For example, since the technology was originally developed as part of a PIER project, this demonstrates the link between the research community and the identification of technologies. The technology was actually brought to the attention of the ETP by PG&E's School Resources Program (SRP), which is an energy efficiency program targeted towards schools. The SRP was also responsible for the implementation of the assessment. This guaranteed that the energy efficiency program would have direct access to all assessment results. The assessment concluded that the technology provided both energy savings and performance benefits. At the time that the case study was conducted, PG&E was in the process of including the ICLS into its energy efficiency programs. This helps confirm one of the final links in the logic model, involving awareness of the technology by energy efficiency programs and the inclusion of the technology into a program.

Table 2: Evaluation Metrics from the ICLS Case Study

Outputs	Indicators Observed in Case Study
Technologies chosen Technology assessments / demonstrations begin	Technology and demonstration successfully selected with input from School Resources Program Assessment begun Market potential estimated at 90,000 existing Relocatable Classrooms in California and 2,500 to 4,000 expected to be built each year with potential savings of 60-65 percent compared to existing lighting equipment, or about 1.6 million kWh/year.
Coordination across IOUs, CEC PIER on program activities	Assessment followed up on previous PIER study in regular classrooms PG&E's School Resources Program (SRP) managed overall study
Some assessments end with viability and energy savings potential confirmed	Assessment showed ICLS offered energy savings and performance benefits Savings calculations developed by the ETP based on assessment results, ready for use in EE Program.
Assessment results communicated to EE Programs, PIER, other stakeholders, training provided	Final report is being completed SRP was directly involved with assessment and therefore was intimate with results Results presented to Consortium of Energy Efficiency, Coalition of Adequate School Housing (CASH), Community College Facilities Coalition (CCFC). Four major lighting manufacturers have approached PG&E to learn more about the ICLS assessments
EE Programs aware of new technologies that are ready for inclusion in EE programs	PG&E is incorporating the ICLS as a deemed savings measure with a rebate to be adopted by the mass markets energy efficiency program

The results from the 8 case studies were aggregated to show how the case studies could be used to evaluate how key outputs identified in the logic model are being satisfied. Table 2 shows an example of how

the aggregation can be done. Since only 8 case studies were conducted, is not meant to reflect overall program performance, but is meant to demonstrate how case studies could be used to conduct the "aggregation analysis" as required by California's 2006-2008 Process Evaluation Protocols. The aggregation analysis, as defined by protocols, must analyze all program activities in order to determine the extent that the program objectives have been met. As shown in the table, the metrics collected during the case studies were general enough that they universally apply to the diverse range of technologies and end uses associated with the assessments, yet specific enough that they provide a way of assessing specific program outcomes are achieved through program activities. For example, from the aggregate analysis we can see that the 8 case studies covered 5 different end uses. This suggests that the ETP is covering a broad range of market segments, which is considered a strength of the program. In addition, the aggregation shows that less than half of the assessments actually went through a formal selection progress. This would suggest that the program needs to improve its use of a formal selection progress, which was one of the recommendations made by the evaluation.

Table 3. Example of Metric Aggregation From Case Studies

Outputs	Indicators Observed in Case Studies
Candidate technologies identified	8 technologies identified 5 end uses covered 9 measures included in assessments
Potential demonstration sites identified	22 sites identified 20 Considered for these case studies.
Technology selection process established	3 technologies went through a formal review process established by the utility 6 of the 8 case studies for which potential was estimated had a combined savings potential of 659 million kWh a year.
Reporting and coordination channels established, ET database created	4 assessments have information in the ETCC database
EE Programs become aware of the ETP resources	1 assessment were initiated by EE Programs 2 assessments had EE Program managers involved during the assessment

Summary and Conclusions

The theory-based approach used to evaluate the 2004-2005 ETP was found to be an effective way of dealing with the inherent difficulties associated with evaluation the program. The most important element with such an approach is obviously the development of a functional logic model and program theory, which provides the foundation for such an evaluation. From the logic model, three broad categories of activities were identified which, taken together, were critical for the success of the ETP. These three categories are technology identification, technology selection, and information dissemination.

The use of program metrics that directly relate to the logic model and program theory was demonstrated as a viable method for assessing overall program progress. The advantage of this method is that it provides a relatively straight forward way of assessing outcomes that can be difficult to quantify otherwise. As a result, strengths and weaknesses of the program are highlighted by the extent that the program activities validate the key links in the logic model. While the case studies did provide a way of

tracking metrics associated with individual assessments, they are time consuming and only a few case studies are likely to be completed for any evaluation cycle. A more streamlined method would involve taking some of the metrics identified during the case studies and incorporating them into the standard documentation associated with each assessment and completed by program staff. For example, the technology selection applications can be used to record metrics such as idea origination, potential energy savings, market potential, end uses, and other preliminary information. The final report should incorporate many of the metrics that are associated with the results of the assessment. This would allow the aggregation analysis to be done more efficiently using program data (with follow up discussions and interviews as needed) rather than relying on the more time consuming case studies. It would also enable all of the assessments to be included in the aggregation rather than the select few chosen for the case studies.

This is not to say that the case studies should not play a role in future evaluations. We found that the case studies were an effective way of examining how specific program processes are actually implemented. For example, during the ETP evaluation, it was determined that while a formal selection process was an important component to the program, the IOUs were just beginning to implement such processes during the 2004-2005 program cycle. The case studies provided an opportunity to examine the various selection processes utilized and if they are taking into account important criteria. As the selection processes become more established, it will be important to follow up to determine how effective the selection criteria are for selecting optimal technologies. The case studies, therefore, are more appropriate for assessing specific program processes than for quantifying overall program progress.