Evaluating Energy Savings from Industrial Behavior Change in the Context of Market Transformation

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ABSTRACT

The Northwest Energy Efficiency Alliance designed its Industrial Initiative to test the hypothesis that the development of a market for energy management tools, techniques, and technologies for manufacturers would result in a change in corporate decision making, leading to quantifiable energy savings. The 2005–2009 implementation of this new initiative has been a learning process, and the evaluation of the energy impacts has evolved to respond to program changes. Since its inception, the Initiative has undergone significant changes in program logic, organization, and implementation strategy in response to challenges and new learnings. This paper provides an overview of these changes and how the evaluation approach evolved alongside it. The paper details the success and cautionary tales regarding market transformation in the industrial sector.

Introduction

The Northwest Energy Efficiency Alliance (NEEA) is a non-profit organization focused on transforming markets toward energy efficiency, using a wide variety of programs and initiatives targeting the residential, commercial, agriculture, and industrial sectors as well as technologies used across sectors. The region's public and investor-owned electric utilities fund NEEA, either directly or through the Bonneville Power Administration or the Energy Trust of Oregon. In addition, state energy offices, public interest groups and other stakeholders support NEEA through consultative processes and cooperative ventures. This unique partnership has helped make the Northwest region a national leader in energy efficiency. Historically, NEEA's focus has been on developing and implementing "widget"-based programs, intended to establish new energy-efficiency technologies in the market, and transforming target markets by increasing market penetration rates of these new measures.

NEEA's Industrial Initiative (the Initiative) was the first project focused on bringing about market transformation through behavioral changes, specifically by changing the perception of energy and its management within the industrial sector. As a preparatory step for designing the Initiative, NEEA conducted primary research to characterize the Pacific Northwest industrial market and identify barriers to adoption and implementation of energy-efficiency practices. The research findings suggested the suboptimal levels of energy-efficiency investment stem mainly from three sources:

- Absence of corporate energy management policy and practices resulting from an apparent lack of awareness of energy use, energy efficiency, and potential returns at both the corporate and plant levels.
- Lack of technical ability to identify and address energy-efficiency opportunities.
- Low supply chain and trade ally interest in offering energy-efficient products and services.

These barriers form the foundation for the Initiative's overall market intervention strategies and tactical elements. In light of these barriers, the implementation strategy focused on working directly with industrial firms and their trade allies to help mitigate identified market barriers and make energy efficiency an integral part of corporate decision making and plant operations. Specifically, NEEA designed the Initiative to bring about an ongoing process of education, training, and persuasion that seeks long-term

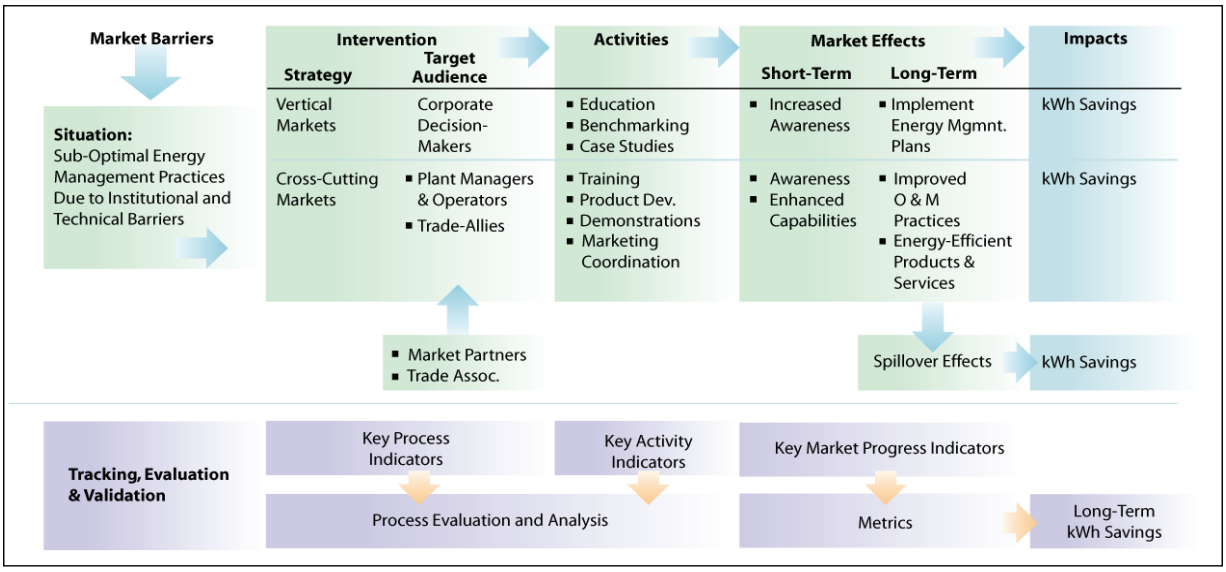
impacts on key industries and leaders, rather than expecting to yield immediate, measurable results typically found in a traditional, technology-focused program. NEEA expected this would result in natural, market-based demand for system-oriented efficiency improvements.

Initial Implementation Plan

NEEA designed the Initiative to develop demand for energy efficiency products and services from the food processing and pulp/paper markets (referred to within the Initiative as the "vertical market strategy"). As it happened these were the two industrial sectors with the highest energy-intensity in the region. NEEA's initial plan for the Initiative also called for the development of a supply of energy efficient products and services from trade allies that serviced the four most (electrically) energy intensive systems in these markets: motors, compressed air, refrigeration, and pumps. Within the Initiative, the latter activities were known as the "cross-cutting strategy."

NEEA expected that the vertical market strategy would reinforce the cross-cutting strategy by promoting a systems-based approach to energy management at individual facilities that was supported by corporate decision-makers. The intersection of these two strategies was supposed to affect a basic version of Continuous Energy Improvement (CEI), then referred to as Business Practice Services. As shown in the Initiative's logic model (Figure 1), the vertical interventions were expected to generate energy savings through increasing corporate awareness and integrating CEI into day-to-day operations. NEEA expected the cross-cutting interventions to generate energy savings through increasing awareness and capabilities among plant staff, which in turn was expected to result in an improvement in operation and maintenance (O&M) practices and increased use of energy-efficient products and services.

Figure 1: Initial Logic Model (2005)



Based on the nature of the intervention strategies, NEEA expected to see energy savings resulting from the cross-cutting interventions (specifically training) prior to implementing CEI in the vertical markets. In essence, NEEA used training as the quintessential "foot in the door." NEEA hypothesized that if facility staff were offered technical training focused on improving the energy efficiency of systems (e.g., pumps, motors, fans) instead of the traditional, component-focused training, it would provide participants with the necessary awareness and technical skills to take the actions desired.

The Initiative's strategic plan projected savings of approximately 130 aMW[1] during its 10-year planning horizon (2005 to 2015). Targeted savings represented roughly 9% of total electricity consumption in the two target markets and less than 24% of the sector's region-wide energy savings potential. NEEA initially assumed nearly 45 aMW (35%) of these savings would be achieved during the first five years of the Initiative's operation, from 2005 to 2009. Vertical market interventions in the pulp and paper and food processing industries accounted for approximately 60% of these savings. The remaining 40% were expected to originate from cross-cutting interventions (e.g., training, marketing). According to the Initiative's strategic plan, slightly more than 9% of savings were attributed to naturally-occurring conservation resulting from market-driven efficiency gains. The NEEA Board accepted the Initiative's strategic plan and approved funding in July 2004.

Initial Evaluation Plan

NEEA hired Cadmus as the evaluation contractor responsible for conducting the Initiative's process and impact evaluation. Based on the implementation plan, NEEA developed a detailed evaluation plan, documented in the first Market Progress Evaluation Report #i (Quantec, LLC 2007). Given the Initiative's objective of encouraging industrial firms to adopt CEI as a way to manage their energy use and costs, the ultimate measures of the Initiative's effectiveness were actual efficiency gains and resulting electricity savings. In general, the evaluation approach to validating savings was based on a sequential assessment of activities, market effects, and potential energy impacts of intervention strategies. NEEA envisioned validating energy savings for training (and later CEI) based on technical assessments and/or site visits.

Per the initial implementation plan, technical training would be one of the intervention strategies. Such training was attractive for a number of reasons: 1) initial market research had shown a significant need for technical training (and the regional coordination thereof); 2) attracting participants would be easy as the Initiative was subsidizing the training cost; 3) participants would provide potential inroads to promote CEI at a corporate level; and 4) savings resulting from training would be relatively easy to track and measure. The evaluation approach is based on the training evaluation model developed by Donald Kirkpatrick, which uses a set of qualitative and quantitative indicators to assess the Initiative's ability to draw participants, transfer key knowledge, and, finally, motivate systems operators to take the desired actions (Kirkpatrick, D.L. 1994). As such, evaluation activities focused on collecting participant data and conducting Web-based surveys three months following a training module to collect participant feedback on the actual impacts of the training (specifically, the extent that implementation of system or operational changes resulted from the training). If the surveys indicated possible savings, evaluation engineers would follow up with the facility, and, if appropriate, conduct a site visit to validate the savings. Based on the time line laid out by the implementation team, NEEA anticipated being able to identify and validate savings through 2006.

First Experiences

In addition to entering the market, the first two years of implementation were marked with a flurry of implementation activities, including: formation of the implementation team; development of training curricula and schedules; establishment of 33 key performance indicators (KPI); development and formalization of organizational structure; development of implementation of the infrastructure needed for communication (database, Web site, etc.); and development of initial marketing materials, messaging, and branding. Another activity was the development of an online project tracking database (known as the

[1] aMW = Average Megawatt. An aMW is equal to 1 MW of consumption for 8,760 hours or 8,760,000 kWh per year. The aMW is a common unit of measure in the Northwest since the Pacific Northwest Power Planning and Conservation Act of 1980 established conservation and energy efficiency as an equivalent source of energy to hydro, thermal and nuclear power.

Industrial Tracking system or ITS) to manage high volumes of communication between Initiative staff, industrial end-users, utility staff and trade allies. As envisioned by NEEA, ITS would serve as a central data entry, warehousing, and contact relations management tool. As such, ITS would not only represent the implementation team's key data repository, but would also provide the evaluation team with data necessary to evaluate progress and estimate impacts.

The first market progress evaluation report (MPER), published in May 2006, identified significant challenges related to ITS, specifically regarding input, tracking, and warehousing of data. Data quality problems and inconsistencies in the use of ITS among implementation staff limited the use of ITS as a data source for evaluation data. Availability and accessibility of key program data for the purpose of evaluating activities and progress remained a serious challenge until 2008 when new NEEA staff began to emphasize the value of tracking data for implementation purposes. As a result, the evaluation team was not able to report progress for many of the 33 key performance indicators (mostly based on activities) identified for this Initiative.

Throughout 2005 and 2006, the Initiative offered 59 training sessions attended by nearly 1,400 participants, representing 410 unique facilities. One of the key challenges in evaluating the effectiveness of the training intervention was the lack of complete data on participant e-mail addresses and/or phone numbers. While the data quality for training participants improved over time, the evaluation team's ability to survey training participants was limited, especially for 2005 and 2006. As a result, NEEA was only able to survey 51% of the participants. While response rates varied by type of training, they ranged from 11% to 24%, with an average response rate of 16%.

Evaluation data indicated that of the 410 industrial facilities that had participated in the Initiative sponsored trainings, 43 reported having taken energy saving actions due to participation. After completing initial screenings over the phone, the evaluation contractor conducted 21 on-site visits and another 11 document reviews. In all, the evaluation contractor was able to validate energy savings at 18 plants (Table 1).

Table 1. Summary of Training Impact and Site Visit Activities by Industry for Unique Plants

Training Type	Number of Plants Participating in Training	Plants Indicating Action	Number of Completed Site Visits[2]	Plants with Validated Savings
Pulp and Paper	24	3	2	1
Food Processing	126	15	23	12
Other	260	25	7	5
Total	**410**	**43**	**32**	**18**

Once sites with savings potential were identified, actual validation of the achieved savings proved challenging for two reasons: 1) the data quality and quantity available from the program database was insufficient and frequently missing altogether; and 2) the Initiative did not develop a plant- or measure-specific savings estimates (ex post) for evaluation to validate. These challenges stemmed from a fundamental misperception on the part of the implementation team. While NEEA is a market transformation organization, its funders have a keen interest in near term energy savings. Because the implementation team considered its primary focus to be market transformation, as gauged by penetration and adoption rates, it did

[2] For three plants, Cadmus did not receive necessary data to complete the site visit evaluation. Thus, the total number of site visits completed as of August 2007 was 21, including two at the same plant.

not prioritize collecting and tracking detailed data to support the estimation and validation of energy savings. This misperception hampered efforts to validate savings.

Given the lack of data and NEEA's desire to quantify savings related to the Initiative, the NEEA evaluation staff and contractors began collecting measure-level data and developing initial savings estimates by end use. Based on data collected from the initial set of site visits, less than 1 aMW was validated for the first year-and-a-half of implementation (Table 2). All savings were related to technical training.

Table 2. Savings (aMW) Validated for 2006

Operations and Maintenance	Incented Capital Projects	Un-incented Capital Projects	Total
0.27	0.53	.01	**0.81**

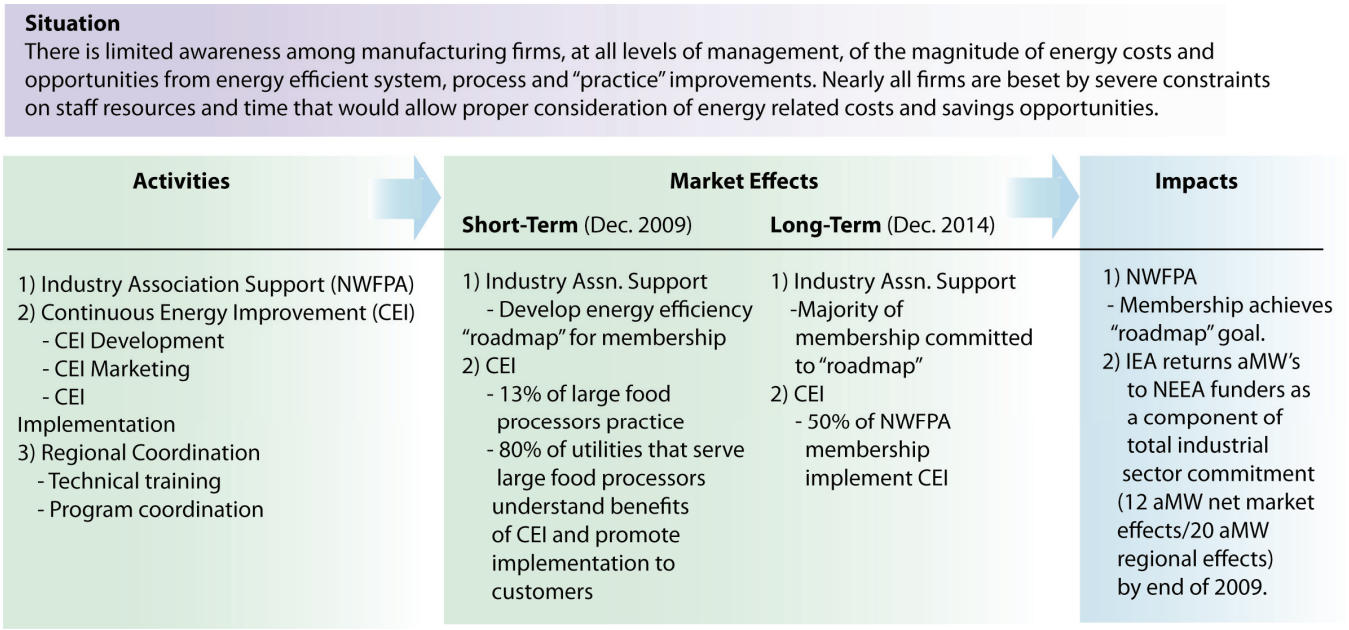
Retooling and Switching Gears

Following retirement of senior NEEA implementation staff in late 2006, new management began a detailed and systematic review of short- and long-term objectives and goals, target audiences, and the Initiative's entire implementation strategy. This review was due to an increasing interest, on the part of NEEA's funders, to assure that any energy savings from behavior change could be quantified and claimed towards the funders' conservation goals. In addition to acknowledging the need and process of program evaluation and actively collaborating with the evaluation team, new management also began to embrace evaluation as a possible source of timely data and information. In response, the evaluation team began producing management briefings on key findings shortly after the completion of each data collection activity. The review was both a reaction to challenges faced by the Initiative during the first two years of its implementation and an effort to better align the Initiative's implementation strategy with NEEA's Business Plan. The review effort included conducting additional market research and assessing alternative implementation methods, procedures, and staffing. This effort culminated in a market-specific logic model for the Initiative. At the conclusion of this work, Initiative management made a number of major changes to its implementation strategy, including the following:

- Focus exclusively on the two vertical markets and eliminate efforts in the cross-cutting markets.
- Development of CEI.
- Development of market-specific offerings containing a strong value proposition.
- Shifting from "come one come all" technical training to comprehensive mentored training with follow-up and one-on-one mentoring.
- Replacement of an ad-hoc approach with the standardized product-focus approach commonly used by manufacturers.
- Revision of the regional savings goal from 45 aMW to 20 aMW by 2010.
- Strong focus on data collection and data quality to support savings estimates.

In documenting its new approach, Initiative management abandoned the initial program logic model and developed market-specific logic models. Figure 2 shows the Initiative's new logic model for the Food Processing Sector.

Figure 2: Revised Logic Model for Food Processing Sector



Regarding the evaluation of savings for year two of the Initiative, evaluation data indicated training continued as the primary source of savings. In 2007, the Initiative conducted a total of 19 technical training sessions. A survey of participants for whom data were available yielded 37 completed surveys (15% average response rate) of which nearly 57% indicated having made some changes to optimize their systems following the training. In a few cases, however, the implementation team had provided the evaluation team with anecdotal information on instances where plants had realized energy savings from implementing CEI's early stages. To identify this category of savings for validation, the evaluation team compiled a list of potential sites based on results of the training follow-up surveys, a review of the data available in ITS, and suggestions from the implementation team. In all, the evaluation contractor conducted 26 on-site visits and/or detailed document reviews and validated savings at 10 of 26 sites. Table 3 provides an overview of savings validated for 2007.

Table 3. Savings (aMW) Validated for 2007

Operations and Maintenance	Incented Capital Projects	Un-incented Capital Projects	Total
0.25	0.13	0.29	**0.67**

The process of developing the savings estimates highlighted continuing problems in data tracking, both by individual plants and by the Initiative. The implementation contractor found the Initiative was unable to document specific projects and behavior changes, but, more importantly, was often unclear about where their efforts bore fruit. This problem was particularly acute with O&M measures, as their non-traditional nature made documentation and tracking all the more important in measuring their energy effects. However, for a limited number of cases, evaluation was able to collect necessary data to estimate O&M-related savings, including the compressed air leak tag program or from documented motor shut-offs. In light of the limited number of observations at this stage of implementation, it is unclear to what degree the estimates are representative or indicative of the typical influence of CEI on O&M-related savings. The general objective of the evaluation is to validate (capital and O&M) savings resulting from the

implementation of CEI at all participating facilities. However, despite targeting a census for savings validation, the ultimate size of the participant pool will determine whether the savings estimates validated for this program can be used for extrapolation.

Pursuing CEI as the Primary Driver for Energy Savings

As documented in the Initiative's logic models, the Initiative's goals are to engage 13% of the large[3] food processor market and 10 pulp and paper mills in CEI by the end of 2009. As reported in MPER#4 in June 2008, the Initiative had exceeded its market penetration goals in the food processing market by having facilities representing nearly 20% of the target market actively engaged in implementing CEI. Evaluation data documented that highly engaged participant food processors were implementing multiple elements of CEI as a standard business practice (e.g., tracking their energy use, developing and implementing action plans, and undertaking increased numbers of energy-efficiency projects). In contrast, the Initiative was making relatively slow progress in the pulp and paper market, with only four plants at more advanced stages of implementing CEI. As documented in MPER#4, some of the primary reasons for the lack of penetration in the pulp and paper market include the early lack of market focused messaging, depressed market conditions, corporate buyouts and high staff turn over rates, as well as increasing competitive and lack of a strong industry association partner akin to the Northwest Food Processors Association. The report further documented energy savings resulting from implementing CEI during 2006 and 2007. Despite the challenges in one of the two target markets, Initiative management continued to reduce its reliance on training as a primary generator of savings; rather, they focused the majority of resources on persuading industrial facilities to adopt, implement, and sustainably practice CEI.

Given this strategy shift in early 2008, Cadmus adjusted its evaluation plan to cease collection of training-related data and focus resources on validation of CEI-related savings. Specifically, that shift resulted in adopting a longitudinal approach to engaged plants. As such, each plant would be targeted yearly by a detailed survey focused on collecting data about the implementation of CEI at the plant and corporate levels. In addition, evaluation would periodically telephone plant energy champions or other plant personnel to assess the status of projects as well as to collect information about changes in O&M-related practices attributable to CEI. If this information indicated a possibility for savings, evaluation (in coordination with the implementation team and the local utility) would schedule and conduct an on-site visit.

Shifting Roles

From 2005 to 2008, Cadmus engineers derived post-installation estimates of energy savings for individual energy-efficiency measures. While outside the traditional role of an evaluation contractor, the lack of sufficient measure and savings data in the Initiative' program database made a traditional validation approach impossible during the first three years of implementation. However, NEEA's strong focus on objectively documenting and validating the Initiative's impacts as well as its repeated evaluation findings of poor data quality prompted Initiative management to begin a major assessment and overhaul of its data collection and warehousing processes and tools in early 2008. Since then, the Initiative has spent significant resources on improving the amount and quality of data collected from participating facilities. The effort, currently ongoing, has significant scope as, in the case of many plants, it requires a detailed reconciliation of data included in the program database, data collected by the evaluation team as part of its periodic follow-up surveys and site visits, and identification of previously undocumented measures.

In light of the continuously improving measure-level data as well the hiring of industrial engineering staff, starting in 2009, the responsibility for developing first savings estimates will now lie

[3] Food processors with more than 250 employees in the region.

with the implementation team. Thus, the role of the evaluation contactor will be to work with the implementation contractors and facility staff to standardize estimation procedures and validate final calculations. In preparation for this shift in responsibilities, the implementation team has worked on developing savings estimates and compiling the supporting calculations and documentation necessary to validate savings claims. While this effort will continue for some time, as of December 2008, the implementation team started providing the evaluation team with 20 formal savings claim memoranda[4] as well as a large number of other measures for which the Initiative is claiming savings (but where less detailed documentation is available). Finally, the implementation team provided the evaluators with a list of measures expected to be implemented in the future. While this list was significant, the quality of the savings estimate (as well as the associated documentation) varied widely. To categorize Initiative savings by certainty and level of rigor, Cadmus developed three savings categories:

- **Validated:** Savings evaluated through a site visit and a review of calculations, or through a professional assessment. In some cases, validation could qualify as monitoring and verification (M&V). For purposes of this update, validated savings reflected all savings validated for 2006 through 2008.
- **Claimed**: Energy savings quantified by the implementation team, but which had not yet been verified or validated.
- **Future**: Savings the evaluation contractor expected would occur, though the time frame was unclear.

Based on our review of available data, the evaluation contractor validated a total of 4.04 aMW[5] (Table 4) in electric and 1,057,414 therms (Table 5) in gas savings associated with Initiative activities from 2006 through 2008.

Table 4. Electric Savings (aMW) by Market (2006–2008)

	Validated Electric Savings (aMW)			
	O&M	Incented Capital	Un-incented Capital	Electric Total
Food Processing				
2006	0.15	0.49	0	**0.64**
2007	0.21	0.01	0.27	**0.50**
2008	0.44	1.06	0.02	**1.52**
Total	**0.81**	**1.57**	**0.29**	**2.66**
Pulp & Paper				
2006	0.01	0	0	**0.01**
2007	0.04	0.11	0.01	**0.17**
2008	0.55	0.09	0.57	**1.21**
Total	**0.60**	**0.20**	**0.58**	**1.39**
Grand Total	**1.41**	**1.77**	**0.87**	**4.04**

[4] Each savings claim contains a bottom-up analysis, and, in eight cases, the savings claims included the statistical top-down analysis.

[5] MPER#5 reports savings from only the food processing and pulp and paper markets. Please note that savings reported in MPER#4 included 0.16 aMW from customers outside of the two vertical markets targeted by the Initiative.

Table 5 presents the same overview for gas savings, with 2008 marking the first year the evaluation contractor validated this type of savings for the Initiative. Except for future savings, food processing accounted for all validated and claimed gas savings to date.

Table 5. Gas Savings (therms) by Market (2008)

	Validated Gas Savings (therms)			
	O&M	Incented Capital	Un-incented Capital	Gas Total
Food Processing	68,750	0	988,664	**1,057,414**
Pulp & Paper	0	0	0	**0**
Total	**68,750**	**0**	**988,664**	**1,057,414**

Looking Forward: Estimating and Evaluating Energy Claims

Starting in 2009, the Initiative's implementation contractor will assume responsibility for developing *ex ante* savings estimates as well as for providing the evaluation team with specific savings claims. Depending on the type of measure, Initiative management has proposed a combination of top-down and bottom-up savings estimates. The following overview of the proposed approach presents a more detailed description of each type of savings estimate:

1. Using data provided by the implementation team, NEEA contractors will develop a site-specific, time-series, multiple-regression model to develop top-down energy savings estimates, using a conventional pre-post specification, which explains energy consumption as a function of production and other explanatory variables. These estimates are considered top-down.
2. NEEA contractors will provide a detailed inventory of all measures (capital and O&M) implemented at a given site since engagement with the Initiative.
3. Contractors will develop *ex ante* estimates of savings for the installed measures. Together, these estimates will provide a bottom-up estimate of savings for each site.
4. Contractors will review savings claims from the bottom-up analysis and compare them to those of the top-down analysis to derive a savings realization factor.
5. Based on comparison of the two analyses, NEEA contractors will determine what portion of identified savings, if any, are attributable to the Initiative, and will document this savings claim in a detailed memorandum.

Building on this process, the evaluation team's adopted the following approach to validating savings claims:

1. Upon receipt of the bottom-up and top-down savings reports, evaluation staff will conduct an initial review of both documents.
   - The primary focus for the review of the bottom-up reports will be to assure all required documentation for measure-level savings estimates is available. If necessary, evaluation engineering staff will use information provided in the report to locate the documents in the program database.
   - The review of the top-down reports will be conducted by evaluation staff experienced in conducting statistical analyses and will focus on reviewing the applicability of the models and the reasonableness of the estimated parameters.

- Following the completion of the initial review, the evaluation team will communicate any outstanding issues and/or any additional data that may be required to the implementation team.

2. Based on the savings claims and types of measures involved, evaluation engineering staff will decide if an on-site visit is required for verification of measure installation and CEI, or if a telephone interview is sufficient.
3. If an on-site visit is necessary, evaluation staff will coordinate with the NEEA Evaluation Manager and the local utility to set up the visit.
4. Following data collection, either from on-site visits or the telephone interviews, evaluation engineering staff will develop a response to the implementation team's savings claims that outline, in detail, the amount of savings that could be validated based on available data.

The evaluation team will collaborate closely with NEEA staff to ensure the evaluation approach dovetails with the implementation team's process to ensure a rigorous and defensible validation of savings.

Lessons Learned

The following key lessons emerged from NEEA's experience:

1. Develop detailed program theory and logic models before going into the field. While NEEA spent considerable resources on research and planning, the 2004/2005 strategic plan lacked a formal program theory and logic model. Also, the initial program plan did not contain detailed success criteria such as key performance indicators or market progress indicators. Even though a subcommittee of NEEA's Board instituted 33 "key performance indicators" about a year into implementation, 29 of which were activity (rather than impact) oriented. The lack of a detailed program theory and success indicators resulted in several problems, including a lack of focus on utilities as key implementation partners and avoidable confusion among implementation staff about key implementation strategies and inconsistencies in approaching the market. Finally, the lack of a logic model hampered an effective evaluation of the Initiative during its early years.

2. Setting up effective data collection and tracking procedures should be a key element of early implementation activities. Throughout the first three years of implementation, the lack of effective data tracking tools and procedures as well as inconsistent usage of data tracking tools among implementation staff resulted in many challenges. One of the biggest problems resulting from ineffective and insufficient data tracking was an inability to quantify savings or even clearly document the Initiative's influence at a given site. The Initiative continues to struggle with tracking and documenting savings from engaged facilities.

3. *Calculating savings is a function of continuous improvement.* Based on CEI's conceptual underpinnings, actively managing energy usage includes ongoing tracking and monitoring of energy use and other specific key performance indicators. However, especially during the early stages of implementation, energy use and savings data as well as detailed measure-level information were not being consistently collected by the implementation team. Because there was no clear way to track savings, NEEA gave evaluation the responsibility of determining savings at engaged facilities. This was problematic for several reasons: first, no one was evaluating the evaluator; second, the Initiative did not have to confront the underlying problems with data collection and tracking savings at facilities; and third, the evaluation team might have missed possible sites with savings because it did not find them in its reviews of possible sites to visit.

4. Complete an evaluability assessment at the outset of implementation. Many of the challenges faced by the Initiative may have been avoided by completing a comprehensive evaluability assessment at the outset of the Initiative. Evaluablity assessments analyze whether process and impact assessment

data will be available for evaluation and make recommendations for data tracking and M&V. Therefore, program managers understand early in the implementation process which data they need to collect.

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