EMI

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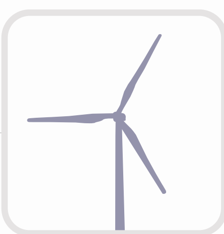
C14: Evaluation of the Energy Opportunities Program: Program Year 2011



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Executive Summary

Introduction

This report presents the outcomes of the evaluation of Connecticut's 2011 Energy Opportunities (EO) Program. The evaluation contractor team (hereafter referred to as "the evaluation team"), led by Energy Market Innovations (EMI), designed this evaluation in collaboration with the Connecticut Consultant to the Energy Efficiency Board (EEB) Evaluation Committee.

During 2011, the Connecticut electric utilities United Illuminating (UI) and Connecticut Light & Power (CL&P) provided incentives for 1,329 projects, reporting an aggregate annual energy savings of 88 GWh. In addition, Southern Connecticut Gas (SCG), Connecticut Natural Gas (CNG), and Yankee Gas provided incentives to 38 customers for natural gas conservation measures and reported an aggregate annual savings of 4.2 million Therms. Projects incentivized through the EO Program consisted of commercial, industrial, and municipal customers willing to engage in retrofits of existing equipment that was operational with at least 25 percent of its useful life remaining.

The EEB designated this study a priority as electric savings from the EO Program provide a large portion of the overall portfolio savings that are bid into the ISO New England (NEPOOL) Forward Capacity Market by these Connecticut utilities; however, the most recent impact evaluation is three years old, evaluating the 2008 program year. This study was conducted to provide more recent evaluation results for this important program.

Description of Objectives

The evaluation consisted of an impact and process evaluation. The overall objective of the impact evaluation was to estimate the energy saved by the program (both electricity and natural gas) and the reduction in electrical peak demand. The overall objective of the process evaluation was to identify how the EO Program could be improved so that it is better able to meet its goals.

Impact Evaluation Objectives

The impact evaluation emphasized high impact measures that account for a majority of the program savings and therefore represented the greatest aggregate risk in regards to progress towards energy savings and demand reduction goals. The evaluation research achieved the overarching objectives outlined below.

- Evaluate the savings impact of lighting projects, non-lighting projects, and natural gas projects, including documenting detailed adjustment factors
- Calculate and recommend "forward-looking" overall realization rates using the 2013 Program Savings Document (PSD).
- Assess the accuracy of methods used by the engineering firms (vendors) in estimating savings for complex "custom" projects and recommend changes, if needed.

Process Evaluation Objectives

The objective of the process evaluation was to identify what is currently working well with the EO program and where improvements can be made so that the program is better able to meet its goals. Based on a review of program documentation and interviews with program administrators, the evaluation team examined the eight specific goals, both formal and informal, for the program:

1. Increase the number of "comprehensive" projects (*i.e.*, projects with more than one end-use type installed[1]).
2. Increase the number of projects that engage in energy savings performance contracts (ESPCs).
3. Increase the number of customers that utilize utility-sponsored financing.
4. Include additional cost-effective equipment as part of the EO program.
5. Identify and develop effective and targeted marketing approaches for key market segments.
6. Encourage customers to develop and adopt strategic energy plans.
7. Encourage customers to participate in ENERGY STAR building benchmarking.
8. Effectively integrate the program into customers' day-to-day business operations.

In terms of these goals, the evaluation research was designed to:

- Assess where the EO program progress is relative to each of the program process goals
- Analyze the major barriers to achieving these program process goals
- Provide recommendations that will assist the program staff to overcome the identified barriers and achieve the stated goals

Methods

To address the objectives above, the evaluation team developed sampling frames and procedures specific to each aspect of the evaluation. Given the difference in the goals of the impact evaluation and process evaluation, the two evaluations employed different methods.

Impact Evaluation Methods

To develop the *ex post* saving estimates, the evaluated savings estimate, the evaluation team used on-site measurement and verification (M&V) for a representative sample of projects as the primary method of data collection.[2] This M&V included conducting project documentation "desk reviews;" selecting the appropriate International Performance Measurement and Verification Protocol (IPMVP) option given the available data and expected variability, and developing site-specific M&V plans based on the selected IPMVP option. Once the M&V plans

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[1] The EO Program defines comprehensive projects as those with installations for more than one-type of end-use.

[2] "*Ex post*" refers to the evaluated or measured savings estimate.

were approved, field staff visited the site to conduct interviews, measure key assumed inputs, and meter long-term usage patterns. Using the collected data, the evaluation team in most cases developed hourly energy use models for the 8760 hours per year (referred to as an 8760 model) to extrapolate measured energy use from a limited measurement period over the year. This provided estimates for both annual energy use and peak demand. These models incorporated all appropriate day-types. In many cases, regression models were also applied to energy and/or power use data with appropriate normalizing variables to estimate ex post savings.

To complete the impact evaluation, the evaluation team first compared estimated *ex post* savings values to reported *ex ante* savings values (estimated savings prior to evaluation) to determine realization rates for each sample project. [3] Next, the team weighted and aggregated these project-by-project realization rates to create an overall, program-level realization rate. Finally, the evaluation team calculated forward-looking realization rates using assumptions in the 2013 PSD, as opposed to the 2011 PSD. It should be noted that this evaluation does not present any recommendations to change the PSD for future years.

The realization rates are the most important output from impact evaluations for several reasons. These are:

1. An estimate of the evaluated savings can be obtained from either the year under evaluation or any more current year where the program's methodology for estimating savings has not changed substantially by multiplying the program's claimed/tracking system estimate of savings times the realization rate from the evaluation.
2. The realization rate provides information as to how well the program is estimating savings and when viewed by energy versus demand, measure or disaggregated by types of adjustment can point to areas where the program might want to investigate the method and assumptions used in estimating a project's savings and program savings claims.
3. Targeting the realization rate, rather than absolute savings estimates, reduces variability from size of facility or scope of measure such that sampling can be accomplished efficiently and impact evaluations cost far less than if the target were the savings estimate.

Process Evaluation Methods

To complete the process evaluation, the evaluation team conducted a database review and interviews with key program staff, program participants, and vendors.

The evaluation team's database review included a detailed review of the program-tracking database, examining it for completeness and consistency in terms of project detail and contact information. In addition, the evaluation team completed qualitative in-depth interviews with 3 program staff, 41 EO program participants from the 2011 program year, and 19 participating vendors. These interviews explored how participants and vendors engaged with the program and each other. Interviewers specifically probed participants and respondents for information

[3] "*Ex ante*" refers to the savings estimate when the project was completed; this is the value in the tracking data.

and feedback regarding comprehensive projects, alternative financing methods (*e.g.*, ESPC, utility-sponsored financing), strategic energy planning, and building benchmarking. The Interview Guides can be found in Appendix B.

After completing the interviews, the evaluation team examined the collected data for key themes, using open coding techniques to analyze the interviews with program participants. As part of this process, the evaluation team identified key trends across interviews and from specific segment subgroups. Outcomes from this analysis were then categorized by their relationship to EO Program goals and evaluations objectives.

Please note that this evaluation interviewed program participants and participating vendors regarding their experience with the EO program and energy efficiency in general. The evaluation team did not include any interviews with non-participants as part of this effort and as such, their perspective is not included in this report. The evaluation team acknowledges that non-participants likely face different barriers than program participants and will reference this limitation throughout the report as appropriate. Upcoming C&I market research will focus on nonparticipating customers and vendors in order to better capture their experience with energy efficient equipment purchases.

Results

The following section summarizes the results of the both the impact and process evaluation. These results are based on the data and analysis as described above.

Impact Evaluation Results

The EO program impact evaluation results presented in this report are based on a sample of 144 projects; 66 of these were lighting, 45 were non-lighting electric, and 33 were non-lighting gas.[4] The tables in this section summarize the impact evaluation principal findings, comparing ex post (evaluated) savings estimates to ex ante (utility program tracking system) savings estimates for annual energy consumption, summer seasonal peak demand, and winter seasonal peak demand.   Greater detail on adjustments made to the savings based on evaluation findings are provided in section 3.2 Impact Evaluation Findings.

Table 1-1 provides a summary of the annual energy savings for the 2011 Energy Opportunities program. The evaluation revealed that the program achieved an estimated 86,640 MWh of annual electric energy savings and 504,551 Therms of gas energy savings, as compared to 88,161 MWh and 603,045 Therms reported in aggregate for all EO programs by the Companies. The **aggregate electric energy realization rate** is 98% with relative precision of ±11% at the 90% confidence level, while the gas energy realization rate is 84%, with relative precision of ± 16%. Breaking down the electric savings, the energy realization rate is 89% ± 9% for lighting

[4] There were 36 non-lighting gas projects in the sample for which the evaluation team conducted on-site data collection. Billing data could not be retrieved for three of these projects, and due to the nature of these projects, reliable estimates could not be made without the billing data.

measures and 112% ± 16% for non-lighting measures. The forward-looking realization rates are also included, showing the realization rates if the *ex ante* calculations had been performed using the 2013 PSD. Only lighting realization rates changed, leading to a change for the overall electric realization rate.

For annual energy savings, it is customary to target ±10% relative precision at the 90% confidence interval in Connecticut energy efficiency program evaluations. The impact evaluation for the 2011 Energy Opportunities program meets this target for lighting, but not for electric non-lighting, gas non-lighting, or electric overall. The precision of these impact findings is lower than the target as a result of high variability in site-specific realization rates, which were much higher than anticipated in the sample designs.[5]

Table 1-1: 2011 Energy Opportunities Program Annual Energy Savings

Sector	Units	Ex Ante	Ex Post	Realization Rate	Rel. Prec. (90% confidence)	Forward Looking Realization Rate
Lighting	MWh	52,261	46,269	89%	± 9%	93%
Non-Lighting	MWh	35,900	40,314	112%	± 16%	112%
Electric Total	MWh	88,161	86,584	98%	± 11%	101%
Gas	Therms	603,045	504,551	84%	± 16%	84%

Table 1-2 presents a similar summary of summer peak demand impacts for electric projects only. These findings show that the program achieved an estimated 13.8 MW of summer peak demand savings compared to 10.8 MW aggregate reported in the Companies' tracking systems. The **electric summer seasonal demand realization rate** is 127% with a relative precision of ±17% at the 80% confidence level. The summer demand realization rate is 115% ± 9% for lighting measures and 168% ± 38% for non-lighting measures, at 80% confidence. The forward-looking realization rates are also included, showing the realization rates if the *ex ante* calculations had been performed using the 2013 PSD. Only lighting realization rates changed, leading to a change for the overall electric realization rate.

For demand reduction values, sampling must achieve statistical accuracy and precision of no less than 80% confidence level and ±10% relative precision (80/10) in order to comply with ISO New England's M-MVDR.[6] Like with electric energy savings, high variability in realization rates prevents the evaluation team from meeting this objective with summer demand realization rates for non-lighting projects and electric overall. In this case, this is driven in part by several missing entries (six for lighting and 1 for non-lighting electric) and also entries of "zero" in the companies' tracking databases for summer demand savings. However, at the

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[5] By the term, "variability," we refer to the degree to which the realization rates were different across projects in the sample. Large variability indicates a wide range of realization rates with high dispersion; small variability indicates a small range of realization rates. Where there were values of 'zero' included in the tracking data and savings were identified, the realization rates were quite high.

[6] ISO New England Inc., ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources (Manual M-MVDR).

minimum value of the range, the realization rates for summer seasonal demand impacts are all greater than 100%. For example, the minimum realization rate at 80% confidence is 112%. This means that we can be confident that the program in aggregate is meeting the expected demand savings, but individual sites are not, with either much lower or much higher demand savings than anticipated. For planning purposes, we recommend using a realization rate of 100% to avoid over-estimation in the event that more projects include estimates of demand savings in the program tracking data.

Table 1-2: 2011 Energy Opportunities Summer Seasonal Demand Impacts (MW)

Sector	Ex Ante	Ex Post	Realization Rate	Rel. Prec. (80% confidence)	Forward Looking Realization Rate
Lighting	8.3	9.5	115%	± 9%	101%
Non-Lighting [a]	2.5	4.2	168%	± 38%	168%
Total	10.8	13.8	127%	± 17%	116%

a. Non-lighting precision bands are much wider than the M-MVDR objective of 10% at 80% confidence, primarily because of sites having missing or zero estimates for demand savings where savings were found by the evaluation. However, even at the low end of the range of expected values, the realization rate exceeds 100%.

In the same manner, **Table 1-3** summarizes the winter peak demand impacts. The findings show that the program achieved 13.1 MW of winter peak demand savings compared to 7.6 MW in the tracking system. The **electric winter seasonal demand realization rate** is 172% with relative precision of ±18% at the 80% confidence level. The winter demand realization rate is 144% ± 10% for lighting measures and 228% ± 46% for non-lighting measures. The forward-looking realization rates are also included, showing the realization rates if the *ex ante* calculations had been performed using the 2013 PSD. Only lighting realization rates changed, leading to a change for the overall electric realization rate.

Once again as a result of high variability in realization rates, driven in part by several missing entries and also entries of “zero” in the companies’ tracking data where winter demand savings were identified, winter demand realization rates do not achieve the M-MVDR objective for confidence and precision. However, at the minimum value of the range, the realization rates for winter seasonal demand impacts are all greater than 100%. For example, the minimum realization rate at 80% confidence is 161%. This means that we are fairly confident that the program is exceeding the expected winter demand savings, but individual sites are not, with either much lower or much higher demand savings than anticipated. For planning purposes, we recommend using a realization rate of 100% to avoid over-estimation in the event that more projects include estimates of demand savings in the program tracking data.

Table 1-3: 2011 Energy Opportunities Winter Seasonal Demand Impacts (MW)

Sector	Ex Ante	Ex Post	Realization Rate	Rel. Prec. (80% confidence)	Forward Looking Realization Rate
Lighting	5.0	7.4	144%	± 10%	125%
Non-Lighting [a]	2.5	5.7	228%	± 46%	228%

Total	7.6	13.1	172%	± 18%	160%
a. Non-lighting precision bands are much wider than the M-MVDR objective of 10% at 80% confidence, primarily because of sites having missing or zero estimates for demand savings where savings were found by the evaluation. However, even at the low end of the range of expected values, the realization rate exceeds 100%.					

Based on these results, the evaluation team identified three main conclusions from this research.

1. **Electric (lighting and non-lighting) measures are performing well for the 2011 Energy Opportunities program.** Electric realization rates near 100% for energy and above 100% for demand show that the Program continues to deliver electric energy and demand savings through large C&I retrofits.
2. **The natural gas realization rates for energy were 84%.** This difference is primarily driven by Energy Management Systems controlling heating systems that did not perform as anticipated in the program documentation, baseline estimates that did not reflect previous site operations, and one project for which the fuel was oil and not natural gas.
3. **Future Energy Opportunities impact evaluations should use significantly higher coefficients of variation for both lighting and non-lighting projects to ensure meeting the desired precision for demand savings.** The evaluated coefficients of variation were much higher for non-lighting sites and for lighting demand than was anticipated in the sample design. The evaluation team used a coefficient of variation of 0.5 as directed by the M-MVDR to determine the necessary sample size for lighting. While this assumption worked reasonably well for energy, it was not adequate for demand. The evaluation team did expect higher variability for non-lighting projects, and, based on previous evaluations of this program and consultation with the EEB, the evaluation team used a coefficient of variation of 0.8 to determine the necessary sample size for non-lighting. Again, however this coefficient of variation estimate was too low; greater variation in the realization rates at many projects resulted in lower precision than anticipated. Updated coefficients and error ratios are included in this report.

Process Evaluation Results

Overall, the evaluation team found that the EO Program processes were operating well. Most participants and vendors that the evaluation team spoke with were satisfied with the Program's operation and reported that the core program components were effective. However, the evaluation team did identify several possible recommendations for improving specific program components. Table 1-4 below provides a summary of process recommendations identified by the evaluation team. These recommendations are offered for consideration by the Companies and are designed to mitigate some of the organizational and market barriers faced by potential program participants.

Table 1-4. Summary of Program Recommendations

Program Component	Recommendation
Comprehensive Projects	• Consider creating long-term perspective and how the program needs to change to put this element into place • Investigate the feasibility of limited energy audits • Consider restructuring comprehensive project terms • Educate vendors regarding the comprehensive project incentive
Energy Savings Performance Contracting	• Reconsider objective of ESPC goal • Continue to support Lead By Example ESPC program
Project Financing	• Reconsider objective of financing goal • Develop marketing materials that demonstrate the benefits of available financing to smaller customers • Educate and support vendors regarding financing benefits
Strategic Energy Plans	• Educate smaller customers on the value of strategic energy planning • Link proposed energy audits to action plans Consider providing an incentive for developing an approved plan
Building Benchmarking	• Raise awareness regarding value of benchmarking • Incorporate benchmarking education on bill • Provide benchmarking support as a service with limited input from customer
Program Awareness and Satisfaction	• Increase access to program customer representatives • Offer energy audits that directly result in an energy plan

1. Overview

This report provides a summary of the final results from the evaluation of the 2011 Energy Opportunities (EO) Program. It contains an overview of the purposes and objectives of the evaluation, the methodology behind the process and impact evaluation research, findings from the evaluation tasks, and recommendations for improving the program.

Purpose

During 2011, the Connecticut electric utilities United Illuminating (UI) and Connecticut Light & Power (CL&P) provided incentives for 1,329 projects, reporting an aggregate annual energy savings of 88 GWh. In addition, Southern Connecticut Gas (SCG), Connecticut Natural Gas (CNG), and Yankee Gas provided incentives to 38 customers for natural gas conservation measures and reported an aggregate annual savings of 4.2 million Therms. Projects incentivized through the EO Program consisted of commercial, industrial, and municipal customers willing to engage in retrofits of existing equipment that was operational with at least 25 percent of its useful life remaining.

Energy Market Innovations (EMI) was directed to implement a comprehensive evaluation of the EO program, consisting of both a process and impact evaluation of the 2011 program year outcomes. Program stakeholders, including the Connecticut Energy Efficiency Board (EEB) and the Program Administrators (PAs), have made this study a priority in part because electric savings from the EO program provide a large portion of the overall portfolio savings that are bid into the Forward Capacity Market by these Connecticut utilities; however, the most recent impact evaluation evaluated the 2008 program year.

The process evaluation reviewed program policies and procedures in practice, the adequacy and design of the program-tracking database, and gathered perspectives from representative program and market actors. Objective qualitative and quantitative research and analysis methods were applied to identify strengths and areas for enhancement to help the program reach its goals. The impact study focused on measuring direct results of the program's activities, evaluating both energy and demand savings against values reported from the program tracking system estimates to determine overall realization rates and areas where *ex ante* assumptions and ascribed savings values differ from those measured in the field.

Program Process Objectives

The overall objective of the process evaluation was to determine how the program is performing in relation to its goals and assess the adequacy of the program-tracking database and its integration with the program. After a detailed review of program materials, the team conducted in-depth interviews with program administrators and the EEB Technical Consultant. These interviews clarified the goals of the EO program and program experience to date, including specific program process challenges and barriers to the attainment of both short- and long-term goals as perceived by its practitioners. These goals included both documented goals in program plans and informal goals stated by program administrators. Based on these information sources, the evaluation team identified the following goals for the program:

- Increase the number of "comprehensive" projects (*i.e.*, projects with more than one end-use type installed)[7].
- Increase the number of projects that engage in energy savings performance contracts (ESPCs).
- Increase the number of customers that utilize utility-sponsored financing.
- Include additional cost-effective equipment as part of the EO program.
- Identify and develop effective and targeted marketing approaches for key market segments.
- Encourage customers to develop and adopt strategic energy plans.
- Encourage customers to participate in ENERGY STAR building benchmarking.
- Effectively integrate the program into customers' day-to-day business operations.

The evaluation team then operationalized the goals into actionable research objectives that could be explored through the evaluation data collection activities. As directed by the Evaluation Coordinator, the objectives identified for the evaluation were to: (1) assess program progress relative to each of these goals, (2) analyze the major barriers to achieving these goals, and (3) provide recommendations that will assist the program staff to overcome the identified barriers and achieve the stated goal.

Program Impact Objectives

The impact evaluation emphasized high impact measures that account for a majority of the program savings and therefore represent the greatest aggregate risk in regards to progress towards energy savings and demand reduction goals. Given the size of the EO program, the Evaluation Coordinator and the evaluation team split the evaluation research into lighting (in 2012) and all other (non-lighting) end-use groups, including natural gas in the EO program (in 2013). The impact evaluation objectives are outlined below.

- Evaluate the savings impact of lighting projects, non-lighting projects, and natural gas projects to produce overall, statewide savings realization rate relative to both gross and net saving estimates claimed by the programs for 2011 program activity. This rate includes the following adjustment factors:
  - Documentation adjustment—reflects discrepancies in program documentation
  - Technology adjustment—reflects discrepancies between the equipment listed in the program tracking data and the equipment identified in the field
  - Quantity adjustment—reflects discrepancies between the quantity or size of the documented equipment versus the equipment observed in the field

[7] The EO Program defines comprehensive projects as those with installations for more than one-type of end-use.

  - Operational adjustment—reflects discrepancies between the operational conditions identified in the program documentation and what was observed in the field
  - Coincident adjustment—reflects differences between connected and coincident/diversified demand impacts
  - Interactive ("Heating and Cooling") adjustment—reflects differences in savings due to the observed interaction between the installed equipment and other systems
- Calculate and recommend "forward-looking" overall realization rates using the 2013 Program Savings Document (PSD).
- Assess the accuracy of methods used by the engineering firms (vendors) in estimating savings for complex "custom" projects and recommend changes, if needed.

2. Methodology

In order to conduct the process and impact evaluations, the evaluation team developed sampling frames and procedures specific to each evaluation. First, methods used to conduct the process evaluation are discussed, and then methods used for the impact evaluation are described.

2.1 Process Evaluation

The overall objective of the process evaluation was to determine how the EO Program is performing in relation to its goals and assess the adequacy of the program-tracking database and its integration with the program. To accomplish this objective, the evaluation team completed a review of the program database and project documentation and conducted interviews with key program staff, program participants, and vendors. As shown in Table 2-1, the evaluation team completed interviews with three program staff or stakeholder, 41 interviews with PY2011 EO program participants, and 19 vendor interviews.

Table 2-1: Process Evaluation Data Collection Summary

Data Collection Method	Objective(s)	Number of Interviews
Program Staff Interviews	To review the formal, documented goals of the EO program and develop a comprehensive list of informal goals.	Program Administrators: 2
		EEB Staff: 1
		Total Staff Interviews: 3
Participant Interviews	Determine how the EO program can best encourage greater installation of all cost effective energy efficiency measures	Comprehensive: 17
		Lighting Only: 11
		Non-Lighting: 13
		Total Participant Interviews: 41
Participating Vendor Interviews		Participating Vendors: 19
		Total Participating Vendor Interviews: 19
		Total Interviews: 63

For the **program staff interviews**, the evaluation team, working with Evaluation Consultant, identified staff that was integral to program operations and development. The objective of selecting these staff was to identify key stakeholders who would best be able to speak about program goals, including the 2011 program goals, current program goals, and those goals in development.

For the **participant interviews**, the evaluation team stratified the sample by projects with lighting measures, projects without lighting measures (*i.e.*, non-lighting projects), and projects with a combination of lighting and non-lighting measures. From the lighting and non-lighting strata, the team randomly selected enough utility project records to complete 20 interviews each; from the combination stratum, the team randomly selected enough records to complete 10 interviews. The objective of this sample design was to allow the evaluation team to identify any differences between these key groups and identify unique motivations for program participation. This sample was intended for qualitative representation regarding program performance. The survey completion rate was 42% for lighting-only participants and 20% for participants with lighting and non-lighting measures. This relatively low completion rate was the result of some participants being unwilling to participant in the interview given its length despite the incentive offered by the evaluation team. On average, the interviews lasted between 30 and 45 minutes and respondents were informed of the length prior to beginning.

For the **participating vendor interviews**, the evaluation team selected a stratified sample of 30 vendors. The team stratified vendors by their involvement with the program, selecting the top 10 vendors that complete the greatest number of projects as part of the program and a random sample of 20 of the remaining vendors. This sample qualitatively supplemented the findings from the participant interviews. The ability to complete this task was dependent on the availability of trade ally contact information, obtained during the participant interviews, from project records, and from program tracking data maintained by the Companies.

An overview of the specific process for designing interview guides, conducting interviews, and analyzing interviews with program participants and vendors is detailed below.

Program staff interviews

The goal of the program staff interviews was to identify and explore both the formal (*i.e.*, documented in program plans) and informal goals of the EO Program. The evaluation team conducted these interviews both in-person and over the phone and structured them as open-ended discussions regarding program development and goals. The evaluation team then incorporated the results of these interviews into the final research plan to guide the process evaluation research.

Participant interviews

The goal of the participant interviews was to collect data about 2011 participants' experience with the EO program via in-depth telephone interviews[8]. To accomplish this task, the evaluation team first developed a draft topic guide that was reviewed by the Evaluation Consultant and revised as needed. Next, the guide was pretested with three EO program participants, allowing the evaluation team the opportunity to make necessary adjustments. Given that there were only minor adjustments, the pretests were included in the final sample of completed interviews. (All survey and interview instruments can be found in Appendix B.) Once validated, the evaluation team used it as a guide to interview the remaining sampled

[8] The process evaluation focused on 2011 participants in order to identify any linkages between the impact evaluation results and the process evaluation results.

program participants. The topic guide consisted mostly of open-ended questions designed to measure progress towards program goals identified through interviews with program administrators and EEB staff. Interviews with program participants covered all topics of the interview guide, and more in-depth probing questions were explored for those topics most relevant to the participant. The evaluation team conducted these interviews via telephone between November 13, 2012 and January 25, 2013. The interviews averaged 20 to 30 minutes in length. Prior to calling, the evaluation team also identified contacts that represented several accounts (*e.g.*, a franchise with one participant) to ensure that they were only sampled once.

The evaluation team used open coding techniques to analyze the interviews with program participants in order to identify the most salient themes. As part of this process, the evaluation team identified key trends across interviews and findings from specific segment subgroups. Outcomes from this analysis were then categorized by their relationship to EO program goals and evaluation objectives.

Participating vendor interviews

The goal of the participating vendor interviews was to explore the program's progress towards its goals and what barriers may exist to reaching those goals from the perspective of the vendors engaged in the program. Vendors (*e.g*., installers, equipment vendors, project designers, ESCOs) often operate as a proxy "sales force" for the program, so they can offer unique and critical perspectives on effective engagement methods and significant barriers. The evaluation team examined the results of these interviews alongside the participant telephone interviews to identify common and divergent themes.

To accomplish this task, the evaluation team developed a topic guide that was used as a general structure for the interview. This guide consisted mostly of open-ended questions designed to explore the program's effectiveness in attaining its goals as perceived by vendors who are actively participating in the program. Consultant staff experienced in C&I programs conducted the interviews, and the interviewers actively probed respondents for more information on related but unanticipated topics generated over the course of the interview. Likewise, interviewers varied questions depending on the type of vendors being interviewed to ensure that respondents were asked questions most relevant to their organization. Interviews averaged around 30 minutes in length. The evaluation team analyzed interviews with participating vendors with the knowledge of relevant themes from the participant interviews.

2.2 Impact Evaluation

The following section presents the methodologies employed by the evaluation team to conduct the impact evaluation of the 2011 EO program. To meet the impact evaluation objectives, the evaluation team first evaluated the savings impacts from a representative sample of projects, generating *ex post* estimates for energy and demand savings for each sampled project. [9] These *ex post* estimates were compared to the each project's *ex ante* estimates in the program tracking

[9] "*Ex post*" refers to the evaluated or measured savings estimate.

data to determine evaluated realization rates for each sample project's *ex ante* estimate.[10] The evaluation team next weighted and aggregated the project-specific realization rates to create an overall program-level gross realization rate. The Program's *ex ante* estimates were based on the 2011 PSD. The current PSD is the 2013 PSD, 8th Version. The final impact evaluation task was calculating forward-looking realization rates using assumptions in the 2013 PSD.[11]

To support this work, the evaluation team used on-site measurement and verification for a representative sample of projects as the primary method of data collection. This section first discusses the sampling methodology then provides an overview of the approach to data collection, site-specific analysis, and overall aggregation.

Sampling

To conduct the impact research tasks, the evaluation team drew a stratified sample of electric projects and a random sample of natural gas projects from the 2011 program participants for detailed on-site assessments and measurements to evaluate savings. The overall sampling approach for electric projects for the 2011 impact evaluation was similar to that of the 2008 EO Program Evaluation, which stratified projects into lighting and non-lighting categories and then stratified within lighting projects by demand savings.[12]

The impact evaluation sample size was ultimately determined by precision requirements (*i.e.*, desired confidence levels in the evaluated realization rate). The evaluation team computed sample sizes in order to provide results with 90 percent confidence at 10 percent relative precision (90/10), meaning that the team would be 90 percent confident that the values for the population would be within +/- 10 percent of reported point estimates. This level of confidence and precision (90/10) is considered industry standard for energy impact research. Meeting this target would also ensure the study met the level of confidence and precision (80/10) mandated by the ISO-NE forward capacity market for the demand savings.[13]

Since lighting represented such a large percentage of the program savings, the precision goal for that end-use was assumed to be 90/10 while other electric energy end-uses (collectively described as 'non-lighting'), were sampled to obtain relative precision of 15% or better with 90% confidence. Lighting projects were stratified based on annual energy savings in the program tracking data. Due to the varied projects, non-lighting measures were not stratified like lighting measures. The combined sample precision from the lighting and non-lighting evaluations is targeted to meet the overall precision requirement of 10% error tolerance, i.e., relative precision, at a level of 90% confidence. The sampling effort is designed to meet these precision goals based upon an assumption of the variance in the site-by-site analysis from the evaluation data

[10] "*Ex ante*" refers to the savings estimate when the project was completed; this is the value in the tracking data.
[11] The forward looking realization rates can then be placed into the next version of the PSD to work along with the algorithms and assumptions in the 2013 PSD.
[12] KEMA. (2010). 2008 Energy Opportunities Program: Final Impact Evaluation Report. Retrieved from: http://energizect.com/sites/default/files/KEMA%202008%20CT%20EO%20Impact%20FINAL%201006181.pdf
[13] Section 7.2 of ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources. May 6, 2011.

collected. For sampling design the evaluation team assumed coefficient of variation (*c.v.)* that was thought to be conservative estimates of the *c.v*. For lighting, the assumed *c.v.* was 0.5 and for non-lighting, the assumption was a *c.v.* of 0.8.[14]

The actual population and sample counts from the sampling design are shown in Table 2-2.

Table 2-2. Impact Evaluation Sample

Sample	Population Projects N	Sample Projects n
Lighting [a]	857	67
32 to 9,999 kWh	289	14
10,000 - 49,999 kWh	320	15
50,000 - 99,999 kWh	117	15
100,000 - 499,999 kWh	121	17
>=500,000 kWh [a]	10	8
Non-Lighting Electric	282	44
Total Electric	**1,139**	**111**
Non-Lighting Gas	64	33
Total	**1,203**	**147**

a. Lighting projects are shown here are any that included lighting measures. Only lighting measures were assessed as part of the lighting savings. Lighting projects were stratified by annual energy savings, as shown here.
b. A census was attempted for this strata representing the largest lighting projects.

Data Collection and Site-Specific Analysis

For each project, the evaluation team reviewed project documentation, developed a site-specific measurement and verification plan, and conducted site visits. These steps are described briefly below. More detailed methods for both lighting and non-lighting projects are provided in Appendix A.

Project Documentation "Desk Review"

The first step in the evaluation process for each project was a desk review of *ex ante* project documentation. The desk review allowed the analyst to become familiar with the project calculations and descriptions and to check whether the calculations were consistent with the described project and the claimed savings in the tracking system.

Second, the evaluation team used the desk review to review the project calculations. The evaluation team reviewed prescriptive projects (*i.e.*, projects using deemed savings values) to

[14] The coefficient of variation is the standard deviation divided by the mean for the estimate of interest, *i.e.*, realization rate for this impact evaluation. This represents the relative similarity of the estimate across all sample units. Higher coefficients of variation suggest less similar estimates, or a more heterogeneous group.

determine if the completed projects were consistent with the prescriptive measures claimed, and to ensure that the method from the PSD was followed correctly. The evaluation team also reviewed the documentation for custom projects for calculation errors and to ensure that they were completed using applicable engineering fundamentals, appropriate assumptions, and equipment characteristics consistent with the supplied documentation. As part of this process, the analyst, in most cases, replicated the calculations, creating revised *ex ante* savings estimates, to support *ex post* measurement and savings estimates and to identify areas of uncertainty that were then addressed through the site-specific measurement and verification efforts.

In some cases, the revisions to the savings estimates involved substituting verified assumptions into the original calculation. In other cases, where the underlying calculation methods were more complex or it was impossible to determine how the savings estimate was determined, the evaluation team developed an independent calculation of energy savings based on engineering judgment and common energy engineering practices.

Finally, the desk review supported the development of a detailed site-specific measurement and verification plan to verify project savings. Given their complexity, site-specific plans were critical for the non-lighting projects, while most lighting projects did not require project specific plans.

Data Collection

After completing a desk review of the project documentation, the evaluation team worked with the Companies to gather applicable utility billing data, both before and after project installation, to support site-specific billing analysis (IPMVP Option C) and consumption calibrated analysis.

Evaluation team engineers conducted on-site data collection visits in order to:

- Verify that the equipment included in the project was installed as expected and operates as described in the project documentation
- Verify make/model number and relevant performance specifications of equipment involved in the project
- Verify operational parameters such as hours of operation, motor load factors, heating and cooling efficiencies, etc.
- Identify baseline system operation
- Collect instantaneous measurements of equipment performance
- Install data loggers for short or long-term metering

Each site visit included physical inspection of measures and a customer interview to gather information about the project for verification purposes and to gather information about the completed project. The evaluation team used two generally different approaches for inspecting projects with constant loads (*e.g.*, projects with constant speed fans or pumps) versus projects with significant fluctuations in load (*e.g.*, variable frequency drives, building controls). For projects that serve a constant load, spot measurements of critical parameters such as amps, kW, temperatures and flow rates were taken. However, for projects that operate with significant fluctuations, the evaluation team installed data loggers for a period of at least two weeks (often longer, depending upon the expected variation). The evaluation team collected additional data as appropriate to normalize or extrapolate the data taken over a limited sampling time to represent the expected annual operation. These data could include outdoor air temperatures, production levels, facility schedules, or other factors as required.

The evaluation team used metering equipment that complies with the M-MVDR to complete short and long term metering. [15] Each type of metering equipment and its specifications are provided in Appendix C.

Project-Specific Analysis

To determine *ex post* savings, the evaluation team used the data collected through on-site data collection, metering, and/or IPMVP Option C[16] pre-post bill analysis. In most cases, the data were used to develop hourly operating and/or power use profiles for each measure for each unique day-type of a typical year (*e.g.*, weekday, weekend, holiday, as well as any customer-specific day-types), and/or incidence of outside temperature or "*bin methods*" for the post-implementation case.

The evaluation team also developed an estimated pre-implementation operation case for each day-type, typically based on the post-implementation metered data, equipment specification data for pre- versus post-measure cases, and a customer interview used to identify differences in operations before and after the measure was installed. The team then applied these day-types to each day of the year to develop an hourly profile of equipment operation for both the base case (pre-measure) and the post-installation case for an entire year; the resulting profile is called an 8760 model. Using this model, the evaluation team calculated both energy and peak demand *ex post* savings values based on the difference between pre- and post-implementation conditions (*e.g.*, the operational and coincident adjustment). The construction of the profile and analysis was different for non-weather sensitive and weather sensitive measures; each is described below.

Non-Weather Sensitive Measures

For non-weather sensitive measures, the evaluation team used the short-term data collected to relate the operating characteristics (such as power [kW]) of the affected equipment to other parameters such as time of day, day-type, production levels, operating schedules, and other factors germane to the project operation, performance and energy use, as determined through examination of the original calculations as well as through on-site interviews. Typically, multiple relationships were required to sufficiently account for annual expected operating

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[15] ISO New England. (2012). ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources (Manual M-MVDR). Revision 4. Effective June 1, 2012. Retrieved from: http://www.iso-ne.com/rules_proceds/isone_mnls/m_mvdr_measurement_and_verification_demand_reduction_revision_4_06_01_12.doc

[16] The International Performance Measurement and Verification Protocols, IPMVP, were designed to provide protocols for measuring and verifying energy performance on a site basis as a tool for energy program negotiation. It has since been used as a tool to define methods used within the engineering site elements of an impact evaluation. IPMVP Option C basically is pre and post billing regression analysis for one property, as opposed to various types of billing analysis regression methods used in a billing analysis impact evaluation

patterns and variations. The relationships were then annualized based on the expected annual patterns in production, day-type relationships, and other factors to determine the savings for each hour of the year in the 8760 model.

Weather Sensitive Measures

For weather sensitive measures, the evaluation team used the short-term metered data collected to relate the operating characteristics (such as power [kW]) of the affected equipment to outdoor air temperature and humidity levels and/or enthalpy, as applicable. Typically, multiple regression analyses were required for each individual piece of equipment at a site to account for variations in operation for occupied versus unoccupied periods, day-types, as well as any other factor determined to be important. The evaluation team then used the results of the regression analyses to calculate the expected usages and savings for each hour of the year for that measure at that site using typical meteorological year (TMY3) weather data as the driving (independent) variable in the 8760 model.[17]

Overall Analysis

After the development of *ex post* gross savings for each sample site, the evaluation team extrapolated the project-specific results to the population of projects. The evaluation team used the realization rates as the basis for extrapolating estimates. For all projects, the evaluation team weighted the project-level realization rates by the 2011 *ex ante* savings values to account for their relative contribution to the overall savings. In addition, the evaluation team weighted lighting projects with sample design weights to correct for the stratified sampling design and estimated electric savings by strata, using the realization rate. The evaluation team extrapolated the project-level realization rates to the overall program as in the program tracking database.

[17] TMY3 refer to TMY data sets published in 2008 and derived from the 1991-2005 National Solar Radiation Data Base (NSRDB) update. These data sets are an update to, and expansion of, the TMY2 data released by the National Renewable Energy Laboratory (NREL) in 1994.

3. Detailed Results

The results of the comprehensive evaluation of the EO program outcomes for the 2011 program year consist of both process evaluation findings and impact evaluation findings. The process evaluation provides a review of program policies and procedures in practice, the adequacy and design of the program-tracking database, and discussion of perspectives from representative program and market actors. The impact evaluation provides direct measurement results of the program's activities, evaluating both energy and demand savings against values reported from the program-tracking system estimates to determine overall realization rates and areas where *ex ante* assumptions and ascribed savings values differ from those measured in the field. This section first provides the detailed findings from the process evaluation, followed by the detailed findings of the impact evaluation.

3.1 Process Evaluation Findings

The focus of the process evaluation findings was to examine how the EO Program is performing in relation to its goals by summarizing the experiences and perceptions of program participants and vendors. To accomplish this task, the evaluation team organized findings from the in-depth interviews conducted with program participants and vendors into six program component categories (shown in Table 3-1). Within each of these categories, the evaluation team explored both participant motivations for participating in the program and the reported potential barriers.

Table 3-1: EO Program Components and Program Goals

Program Component	Program Goal
Comprehensive Projects	Increase the number of participants who are completing comprehensive projects[18]
Energy Savings Performance Contracting	Increase ESPC engagement
Project Financing	Increase uptake of utility-sponsored financing
Strategic Energy Plans	Encourage the use of strategic energy plans
Building Benchmarking	Increase the adoption and use of building benchmarking techniques
Program Awareness and Satisfaction	Develop effective and targeted marketing approaches and make the program more accessible to potential participants

[18] The Program defines comprehensive projects as those with measures in at least two end-use categories within one program application.

In addition, the process evaluation includes an assessment of the program-tracking database. This assessment reviews the database for completeness and consistency and is included at the end of this section.

Please note that the evaluation team did not speak with nonparticipating customers. Customers that have not participated in the program may experience different barriers to project financing than participants. Upcoming market research will further explore these barriers.

Comprehensive Projects

As reported by Program Administrators and as stated in filed program plans, a major goal of the EO program was to increase the number of participants who are completing *comprehensive* projects (*i.e.*, projects that include more than one measure type). To achieve this goal, the program currently offers additional incentives for completion of comprehensive projects. The evaluation team explored the motivations of EO program participants for completing comprehensive projects as well as the barriers faced by program participants in implementing these projects.

Motivations for Completing Comprehensive Projects

Overall, the evaluation team identified two main motivations for completing comprehensive projects: (1) portfolio economics and (2) minimizing workplace disruptions.

Among larger customers, a notable value that comprehensive projects provide is the opportunity to package together multiple energy efficient projects that are beneficial to the firm, which when combined together as a package of projects meet the organization's ROI requirements. This is critical, as some energy efficient improvement measures or projects mentioned by large firm participants may not separately meet stringent ROI requirements or timeframes mandated by their organizational standards, while 'bundling' a measure that is not cost effective with others that are may result in a portfolio that meets cost effectiveness. This motivation to think in terms of portfolio economics was strongest amongst larger firms, and those in the municipal, university, school, and hospital (MUSH) markets. As one participant explained, "We'll even do some projects that do not meet the payback requirement if they are beneficial to moving other projects forward."

Another motivation for completing comprehensive projects was the desire to minimize disruptions on operations by completing several projects at the same time. As one participant explained, when they are already inside a building making improvements, they want to do all the projects that could help make the building more efficient. As a result, they may complete additional projects that exceed their ROI and payback guidelines in order to have all complementary energy efficiency upgrades installed in the building at the same time.

Barriers to Completing Comprehensive Projects

Through interviews with EO program participants and vendors, the evaluation team was able to identify factors and potential barriers that impact organization decisions to pursue all cost-effective energy efficiency projects. These barriers to completing comprehensive projects are discussed in more detail and broken down into the following five subtopics.

- Limited Awareness and Expertise
- Specialized Vendors
- High Capital Cost
- Poor Return-on-Investment (ROI)
- Negative Impact on Business Operations

Limited Awareness and Expertise

One factor that impacts many organizations' participation in comprehensive measures is that they have limited awareness and understanding of energy efficiency opportunities for their facilities, which is magnified by the lack of energy expertise. This factor was most prevalent among medium-sized organizations that typically had limited communication with the utility. Unlike large and MUSH market firms, the evaluation team's interviews indicated that medium-size firms rarely have staff dedicated to energy-related work or staff that had an understanding of the available energy efficiency opportunities at their facility. As a result of this limited awareness, many medium-size firms have the perception that they have already made all the improvements they can. Program data indicate that among medium-size firms, it is typical to only complete lighting and HVAC upgrades and not building envelope improvements.

However, one of the most common reasons organizations only implemented HVAC and lighting energy efficiency upgrades was that those types of improvements represented the only practical options for improvements at their facilities. An illustrative example that may be representative for other medium-size firms is an independent hardware store that had upgraded the HVAC unit and lighting, but was at a loss for what other improvements could be completed. At this location, there were not any motors, drives, or building envelope needs that could be addressed, so the two energy efficiency upgrades really were the only opportunities available.

Specialized Vendors

Another barrier mentioned among medium-size firms, is that they generally take an "a-la-carte" approach to completing energy efficiency projects. Part of the reason for this is that most vendors they work with specialize in a particular technology (*e.g.*, HVAC, motors/drives, lighting) and are rarely interested in energy efficiency recommendations that fall outside of their specific specialty – only 7 of the 19 vendors we spoke with completed any comprehensive projects (mostly combinations of lighting and HVAC upgrades). This is a significant limitation for participants who are interested in completing multiple energy efficient measures, as they need to spend additional time seeking out specialized vendors for each potential energy efficiency upgrade.

Challenges with using specialized vendors

From **customer**:
"According to the vendors, there is little if any payback for making energy efficiency recommendations beyond their specialty."

From **vendor**:
"It adds another layer to the project and would just be a distraction."

In addition, according to the evaluation team's interviews with participating vendors, there is little (if any) competitive advantage for them to make energy efficiency recommendations or installing energy efficient equipment beyond their specialty. Several vendors reported that the additional work required to scope comprehensive projects "adds another layer to the project and would just be a distraction," and the effort needed to this would just be "too much of a hassle." As such, many of the vendors do not see the benefit of spending time coordinating with vendors from other industries who could possibly complete additional energy efficient projects.

Working with multiple vendors, however, was not a barrier expressed in interviews with large commercial and industrial participants, as many large organizations already have pre-existing relationships with facility management, engineering or energy consulting firms who are in a position to identify a wide range of potential energy improvements. In addition, these firms often act as a "general contractor" facilitating the installation and upgrades of the various building systems. A limitation of working with engineering or energy consulting firms is that these vendors focus almost exclusively on large firms where there is an economy of scale for energy efficiency projects. In addition, these firms will often enter into long-term relationships with organizations that can offer multiple project opportunities.

High Capital Cost

Across project types, the most critical factor to pursuing energy efficiency upgrades mentioned by participants was the capital cost of the project. Participants described the capital cost as the net cost that the firm would be responsible for after taking into account any initial incentives along with bonus incentives offered for comprehensive projects.

For comprehensive projects, this cost poses an additional barrier. Participants expressed the desire to pursue multiple energy efficiency upgrades, but described that completing all projects within a year timeframe required more capital than is typically available. Larger business participants reported that there is often a budget allocated for energy related expenses, but that large capital-intensive projects would require additional budget allocation requests on the following year's budget. This requires that proposed projects align with the budgeting cycle in order to be considered for approval.

Among small and mid-size organizations (in general, defined as participants that were not large industrial customers, hospitals, municipalities, or educational institutions), the capital cost challenge is often due to limited funds during a single fiscal year. For these organizations, there is rarely specific funding available for energy related projects, making identifying capital for these projects challenging. This lack of specific funding is especially challenging when the allotted program timeline is constrained. While the availability of incentives, including the bonus incentive for comprehensive measures, helps to reduce the capital cost associated with completing multiple projects, it is often not enough to make completing all projects possible within a year. As a result, participants cited capital cost as the most significant barrier to not pursuing comprehensive energy projects.

Poor Return-on-Investment

Along with capital cost, most participants also mentioned that the return on investment (ROI) was a factor that needed to be considered, as large energy efficiency upgrades that are capital intensive tend to have longer ROI timeframes, often as high as 10 years. Across all participants interviewed, a fairly acceptable ROI timeframe was a three to five year payback.

Payback periods that fell outside the bounds of three years generally were more difficult to get leader buy-in and typically needed to meet more stringent business case requirements. Also, one participant reported that ROI guidelines set by corporate

Acceptable ROI timeframes

"A three year payback is ideal, but up to five years could be acceptable for the right upgrade or improvement."

supervisors do take into account the size and type of energy efficiency upgrade. For example, the acceptable ROI for equipment upgrades may be five years, whereas for lighting equipment, the ROI limit would be three.

Negative Impact on Business Operations

Among most firms, the ability to manage multiple large energy efficiency projects concurrently was identified as a challenge to implementing comprehensive projects. The result is that some projects may not be pursued due to other demanding project work at the firm and thus may be delayed into subsequent years. Again, this barrier was especially prevalent among smaller firms, where the limited staff available to pursue and manage energy efficiency projects presented a logistical "chokepoint."

However, as a general rule, energy efficiency projects that meet the capital cost and ROI requirements are generally pursued if they do not have a significant negative impact on non-energy related projects. A representative participant explained it this way, "If there is an upgrade we can do without increasing our monthly costs, I'm an idiot not to do it."

Energy Savings Performance Contracting (ESPC)

Another goal of the EO Program was to increase the number of firms engaged with ESPC as a way to fund additional energy efficiency projects. In an ESPC engagement, energy-saving retrofits are installed and are funded by energy savings produced during the term of the contract. When the contract term is complete, the building owner keeps any retrofitted equipment purchased under the program. Typically, ESPC projects focus on buildings in the municipal, university, school, and hospital (MUSH) market.

During the course of interviews with participants, the evaluation team questioned program participants about their familiarity with the concept of ESPC and potential barriers to engaging ESPC vendors. Only two of the participants interviewed had engaged in an ESPC relationship with a vendor. Participants who had not worked with an EPSC but were likely candidates (ESPC is usually only economical among larger C&I customers) described a variety of barriers that limited the appeal of ESPC for organizations.

One of the dominant themes among participants who were not interested in ESPC was the availability of existing capital or the existing access to debt for implementing energy efficiency projects. For these participants, ESPC is unnecessary because their organizations have sufficient capital to pay for projects "out of pocket," or they have an existing relationship with a financial institution that provides them with the access to capital when they need it. That is, the value proposition of ESPC – guaranteed reduction in energy costs without upfront costs – is lost on these participants.

Reasons expressed for not pursuing ESPCs

"We just pay out of pocket for these kinds of projects."

"We're trying to avoid financial obligations."

"We've looked at it, but it's not a good deal for us."

A small number of participants said that ESPC was not attractive to them because they do not feel that it is "a good deal." The participants who expressed this sentiment worked for larger organizations, and from their perspective, the contractual terms around ESPC were not sufficiently attractive. In addition, participants often viewed ESPC relationships as an undesirable obligation. Though these participants did not identify specific aspects of ESPC that they found undesirable, they reported that they were simply turned off by what they saw as the long-term financial commitment to another financial organization and that in an uncertain economy, this commitment presented too great a risk.

Project Financing

Similar to ESPC, the EO Program seeks to increase the uptake of utility-sponsored financing. In an effort to understand ways in which the program could provide financial assistance to customers for implementing energy efficiency projects, the evaluation team asked participants about their methods for funding and financing the projects they completed through the program. In addition, the evaluation team asked vendors about their relationship with utility-sponsored financing as part of their marketing efforts.

The primary barriers to increasing the uptake of utility-sponsored financing identified by participants are generally similar to the barriers that participants identified for ESPC. One group of participants did not have a need for utility-sponsored financing, as they have sufficient capital or have an existing financial relationship with a bank or bonding agency that provides them with access to capital. Other participants were generally opposed to the idea of financial obligation. As with ESPC, a small group of participants from larger organizations also felt that utility-sponsored financing is not economically advantageous for them and "not a good deal."

In addition to those barriers that exist for both ESPC and utility-sponsored financing, a number of participants were simply unaware of the existence of utility-sponsored financing prior to the interview. Likewise, few vendors reference the utility-sponsored financing as part of their sales process. A majority of vendors did not see a benefit to discussing project financing with their customers. Other vendors did not feel it benefited them competitively or while one vendor believed that utility-sponsored financing provided inconsistent benefits to their customers.

Participants interested in financing, but unaware

"We typically do a combination of out-of-pocket and financing; we would definitely be interested in low-interest financing from the state of Connecticut."

"We were not aware of utility financing, but would definitely consider it."

Please note that the evaluation team did not speak with nonparticipating customers. Customers that have not participated in the program may experience different barriers to project financing than participants. Upcoming market research will further explore these barriers.

Strategic Energy Plans

While another goal identified for the EO Program was to encourage customers to develop and adopt strategic energy plans, which is a formalized strategy to achieve specific energy savings goals over a determined period of time for an organization. Interviews conducted with program participants highlighted specific barriers to widespread adoption of strategic energy plans.

First, approximately two-thirds of those participants interviewed did not have any formal energy plans. This trend was most prevalent among medium size firms. A common response among this segment was that they are always looking for new opportunities to save energy and money, but are unaware of the available opportunities. As a result, for many medium-sized firms, energy efficiency upgrades occur as a reaction either to equipment failure or rebate opportunities, rather than an outcome of a proactive plan. As stated by one participant, customers do not have a formalized plan for energy efficiency, but replace older equipment when things wear out or when the opportunity arises to replace the current equipment with more efficient models at an affordable cost.

Variations in views on strategic energy plans

"We have a corporate goal to reduce CO2 output by 20% over the next nine years, with a mandate that 40% of this reduction be met through energy efficiency improvements."

"No formalized plan, but improvements are pursued as the opportunities arise."

In contrast to medium-size firms, large commercial firm and MUSH market segments tend to have a form of energy plan or target. For large commercial firms, this plan often took the form of either a corporate target on energy reduction or efforts to achieve a building efficiency status, such as LEED certifications. As an example, one large commercial participant reported a corporate goal of reducing CO2 output by 20% over the next nine years, with a mandate that 40% of this reduction be met through energy efficiency improvements.

Building Benchmarking

Another reported goal of the EO Program was to encourage building benchmarking. Building benchmarking allows building owners to assess energy use and gauge performance relative to others in the marketplace. In an attempt to determine the degree to which program participants are aware of and active in building benchmarking, the evaluation team questioned participants generally about the ways in which they track energy use and/or energy costs. These questions were followed by more targeted questions focused on building benchmarking and building benchmarking tools.

Among the participants interviewed, two-thirds of participants reported that they do not have any kind of formal process for benchmarking the energy use of their facilities. Of the third of participants who described doing something in terms of benchmarking, the majority reported that their benchmarking consists primarily of tracking energy costs over time using their utility bills.

Challenges and opportunities expressed

"We [benchmark] internally against other facilities, as well as externally to other peer pharmaceutical companies in the U.S."

"Familiar, but we do not participate. [Benchmarking] could be beneficial in the future."

Several participants at larger organizations said that they sometimes engaged in internal benchmarking, but only two of the 41 participants interviewed reported having used formal building benchmarking software. Both of these participants said that they had used ENERGY STAR Portfolio Manager benchmarking software, and one said that he no longer uses ENERGY STAR because American Public Power Association (APPA) is a better fit for his facilities' needs.

Program Satisfaction

During interviews with program participants, the evaluation team found that the level of engagement with the program varied by the level of access to program staff perceived by program participants. The research team found that customers who had access to specific Company account representatives tended to report high levels of satisfaction with their overall experience with the EO program.

Awareness of programs and satisfaction with experiences

"I'm open to any kind of study or audit that the utility would do. There are probably opportunities, but I'm not aware of all of them."

"Communication can be challenging with limited staff availability at CL&P."

"CL&P has been great; we have a close relationship with them."

However, medium-size customers who did not have direct access to account representatives had much more variation in their experiences with the program. These customers often reported lower satisfaction with their experience due to lack of contact and communication with the Company. One of the medium-size customers interviewed expressed that his frustration stemmed from not knowing whom to call at the Company for assistance with energy efficiency programs. The recommendation he offered was to provide a single point of contact for the programs that business customers with questions on energy efficiency rebates and projects could call. While a number for program information is clearly listed on both Companies' websites, this number leads to an automated voice system; this may discourage potential participants from seeking more information via the telephone. Another suggestion offered by a customer was for the Companies to help business participants identify energy efficiency opportunities and guide them to vendors and financing to complete the projects.

Program Database Analysis

Overall, while the evaluation team found that the program tracking databases were relatively complete and tracked the necessary information, additional detail regarding project scope would assist future evaluation efforts. The remainder of this section provides the evaluation team's assessment of the program tracking databases. The objective of this assessment was to review the completeness and quality of the Program data as these qualities can directly affect the overall effectiveness and accuracy of the evaluation.

First, Table 3-2 provides a summary of the 2011 EO cases present in the utility-provided data files. Overall, there were 1,448 cases in the Northeast Utilities (NU) measures file; 340 cases in the United Illuminating (UI) file. These 1,788 total cases were associated with 1,135 projects (1,017 NU; 118 UI).

Table 3-2. Summary of the Number of Cases by Utility

Utility	Measures	Projects
CL&P	1,331	953
CNG	59	32
SCG	5	1
Yankee Gas	53	31
United Illuminating	340	118
Grand Total	**1,788**	**1,135**

Table 3-3 summarizes the completeness of the data files. Of the 1,448 cases in the NU file, 6 had no account number and 37 had no telephone number—and thus, were necessarily excluded from the sample frame. A total of 13 cases had no measure description, though these cases did have populated measure categories. Of the 340 UI cases, 32 had no telephone number (excluded from sample frame), and 4 cases had no measure description. Most problematic, however, was that even though the quantity field was fully populated, every value was "1," regardless of how many of the measure were installed. While for some measures, this quantity value is likely accurate, for others, it is clearly incorrect (*e.g.*, lighting retrofits).

Table 3-3. Summary of Data Completeness by Utility

Utility	Total Number of Measures	No Account Number	No Telephone Number	No Measure Description	Installed Quantity Missing or =0
NU	1,448	6 (0.4%)	37 (2.6%)	13 [a] (0.9%)	104 (7.2%)
UI	340	0 (0%)	32 (9.4%)	4 (1.2%)	0 [b] (0%)

[a] Though 13 cases were missing measure descriptions, all cases had a measure type code.

[b] Though quantity was fully populated, the information was of limited value as every case had a quantity of 1. While for some measures, this quantity is likely accurate, for others, it is clearly incorrect (*e.g.*, lighting retrofits).

Overall, while all these data issues can have implications for an effective evaluation, the most significant issues were related to the inconsistency and lack of specificity with which measure information was recorded. Inconsistent or vaguely described measures are problematic because most impact evaluation sample designs rely on measure-type stratification. Hence, if the evaluation team is unable to confidently ascertain what types of measures were installed, the sample design may be compromised. In terms of the measure information, much greater consistency and resolution could be recorded in the utility databases. Twenty-five randomly selected example cases of the measure-related information are provided in Table 3-4 (for NU) and Table 3-5 (for UI).

<u>Database Assessment Summary</u>

As a result of this assessment, the following summary outlines the key findings from our review of the program-tracking database and provides recommendations that can improve the efficiency and accuracy of future evaluation efforts.

Account number: The UI file contained complete and consistent 13-digit account numbers. The NU file contained various 4 to 11-digit numeric and text entries, missing, and clearly erroneous account numbers (*e.g.* 999999999, 123456, CNG Gas, New, etc.).

Recommendation: While consistency across the Companies is not necessary, ensuring account numbers are complete, consistent, and accurate within each utility is important for allowing identification and aggregation.

Project address (street, town, and zip code): The UI file contained complete and consistent addressing. The NU file contained complete but inconsistent addressing (*e.g.* use of Avenue, AVE, Ave, Ave.).

Recommendation: Use consistent US Postal Service addressing standards.[19] Often, because account numbers do not identify unique facilities, addresses are needed to aggregate data. When dealing with thousands of cases, editing and cleaning addresses in order to conduct an aggregation is greatly hampered by typographical inconsistencies. Another, more effective option is to incorporate a premise number into the program databases which uniquely identifies facilities.

Project contact information: In general, both utilities collected first name, last name, position, and email. However, both utilities also presented projects missing phone numbers.

Recommendation: As much as possible, collect phone number, first name, last name, position, and email for all projects. While the databases provided were relatively complete, consistent tracking of these data can increase the cost-effectiveness of any evaluation efforts. For example, referencing a contact name (first and last) and their position makes calling for telephone surveys easier and an email address allows for inexpensive and efficient web-based surveys as a feasible research method.

Project completion or closing date: The NU file contained only the "AFP Date" at the measure level. The UI files contained 12 different dates tracking the progress of measures; for the evaluation EMI used the "install date."

Recommendation: Common project milestone dates should be recorded by both utilities. Comprehensive and detailed project (or measure) tracking information can be useful for informing the improvement of project implementation by highlighting stages where projects are consistently delayed. Some impact methods require installation date and its inaccuracy can create important measurement error.

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[19] US Postal Service addressing standards: (http://pe.usps.com/text/pub28/welcome.htm)

Energy savings (where applicable, kWh, KW, and Therms): Both utility data files contained measure level energy savings values reported in the same units. While not critical for the evaluations, UI reported these as negative values; NU reported them as positive values. Several cases in both files had zero energy savings associated with a measure.

Facility type: The UI data contained specific facility type descriptions. The NU data did not present easily accessible facility type descriptions, but the file did include SIC, NAICS, and an industry-type variable describing the facility.

Recommendation: Because much of the evaluation work occurs at the facility level, a clear, consistent, and comprehensive presentation of the nature of the facility use should be readily available in the data files.

Measure Information: The UI data contained variables representing the project description (descript), measure code (prodnum), a measure description (proddesc), measure type (faciluse), and quantity installed (prodqty). The NU data contained variables for the project description (proj_phase_txt), measure description (meas_dsc), installed quantity (units_instld_qty), and measure type (bnft_type_cd). For both utilities this information was relatively complete, but the information was not consistent across utilities. Also, the quantities reported by both utilities are not adequate for evaluation purposes (*e.g.* at the measure-type level, lighting entries always reported a quantity of 1 regardless of the number of bulbs or fixtures installed).

Recommendation: Present measure level information consistently. Ideally, use consistent measure codes (product codes) and measure type codes (*e.g.*, lighting, lighting controls, other controls, HVAC, compressors, motors & drives, refrigeration, building envelope, hot-water heating, etc.). Ensure quantities reflect the actual number of units of a particular measure installed. Best practice within the program databases is needed for better program management. A thorough internal double-check of reported savings can be conducted if reported savings can be easily calculated from the program databases with measure data and installed quantities. In addition, accurate measure detail and quantity is required for best practices in evaluation where sample design by site and within the site analysis requires this information.

3.2 Impact Evaluation Findings

This section contains the results of the EO Program impact evaluation. The evaluation team first presents a summary of results for the overall EO Program (including a summary of the precision of those results). Then findings are presented for each of the following three project categories: (1) lighting (electric), (2) non-lighting (electric), and (3) gas. In addition to presenting savings for the program and project categories, this section also describes the main drivers in variations between the *ex post* and *ex ante* savings values.

Summary of Results

Based on the sample sites, the 2011 EO Program realization rates for annual energy savings are 98% for electric projects and 84% for gas projects. In addition, the 2011 EO Program realization rates are 127% for summer demand (electric only) and 172% for winter demand (electric only). The resulting totals ex post energy savings are 86,640 MWh and 504,551 Therms. The resulting total *ex post* demand savings are 13.7 MW for the summer seasonal peak and 13.0 MW for the winter seasonal peak. These values are summarized in Table 3-6 below.

Table 3-4. Total EO Program Impact Evaluation Summary

Category	Realization Rate	Ex Post Savings
Electric Energy Savings (MWh)	98%	86,640
Electric Summer Demand Savings (MW)	127%	13.7
Electric Winter Demand Savings (MW)	172%	13.0
Natural Gas Savings (Therms)	84%	504,551

Evaluated Coefficients of Variation and Error Ratios

As noted previously, the evaluation team did not reach the desired precision for demand savings. Table 3-7 presents the evaluated coefficient of variation (*c.v.*) and error ratio (*e.r.)* values. As noted in the methodology, the sample was designed to meet the desired confidence and precision based on the previous assumptions of a *c.v.* value for lighting of 0.5 and for non-lighting of 0.8. Based on site-specific realization rates, the evaluation team re-calculated the *c.v.* and *e.r.* The methods used for this calculation are given in Appendix A.[20] The re-calculated values are shown in Table 3-7. **The evaluation team recommends using these estimates when planning future evaluations and stratifying the sample, where reasonable.**

Table 3-5. Evaluated Coefficients of Variation on Realization Rate and Error Ratios

Strata	Energy		Summer Demand		Winter Demand	
	c.v.	*e.r.* [a]	*c.v.*	*e.r.*	*c.v.*	*e.r.*
Lighting	0.59	0.48	0.66	0.43	1.17	0.46
Non-Lighting Electric	1.37	0.48	1.74	1.22	0.91	0.97
Electric Overall	0.86	0.48	1.23	0.63	1.09	0.57
Gas	0.95	-	-	-		-

a. The error ratios are not the same; they are 0.483 for lighting and 0.478 for non-lighting.

The evaluation team found a greater degree of variation than anticipated and thus had less precision than planned for most of the realization rates. The evaluation team followed guidance

[20] While the evaluation team calculated the c.v. for the purposes of comparing to the expected values and for future evaluations, the relative precision for the electric savings are calculated based on realization rates by strata which relies on weighted squared errors instead of relative errors. The error ratios are provided here as well.

from the M-MVDR and the Evaluation Coordinator when estimating the needed sample sizes. While the estimate of 0.5 was reasonable for lighting for energy realization rates, it was much lower than the real variation in demand.

In addition, the evaluation team identified seasonal demand savings for several lighting and non-lighting projects that did not report any seasonal demand savings in the *ex ante* documentation or the program tracking data. In some cases, there were no estimated savings, and in others, they were set to zero with no documentation. By including the identified demand savings for these sites in our analysis, the evaluation team identified greater realization rates for the EO program but also introduced greater variation in our estimates (leading to higher *c.v.* values for demand savings). In addition, the estimate of 0.8 was too low for non-lighting electric sites, which had *c.v.* value of more than 1.0 in the evaluated sample. Realization rates for non-lighting projects ranged from -252% to 775% for energy savings, and the range is higher for demand savings. Most projects were adjusted either widely positively or widely negatively; the reasons for adjustments are given in the more detailed findings below.

Overall Electric Savings

Table 3-8 shows overall 2011 EO electric savings based on the evaluation findings; they reflect a wide array of adjustments which are discussed in more detail below. The **ex post electric energy realization rate** is 98% with precision of ±10% at the 90% confidence level. The **ex post summer electric demand realization rate** is 127% with precision of ±17% at the 80% confidence level. The **ex post winter electric demand realization rate** is 172% with a precision of ±18% at the 80% confidence level.

Table 3-6. 2011 EO Overall Program Savings (Electric)

Savings Adjustment	Energy		Summer Demand		Winter Demand	
	kWh	%	kW	%	kW	%
Ex Ante Savings	**88,160,537**		**10,801**		**7,562**	
Documentation Adjustment	(1,051,427)	-1%	1,748	16%	688	9%
Technology Adjustment	(513,373)	-1%	(109)	-1%	(209)	-3%
Quantity Adjustment	(2,884,781)	-3%	(512)	-5%	(470)	-6%
Operation Adjustment	7,026,553	8%	2,844	26%	5,374	71%
Heating and Cooling Adjustment	(4,097,552)	-5%	(1,024)	-9%	71	1%
Ex Post Savings	**86,639,957**	**98%**	**13,747**	**127%**	**13,015**	**172%**
Realization Rate	**98%**		**127%**		**172%**	
Relative Precision	± 11%		± 17%		± 18%	
Confidence Level	90%		80%		80%	

Table 3-9 and Table 3-10 summarize the overall 2011 EO Program electric savings for the lighting and non-lighting measures. The majority of 2011 EO savings were in the lighting measure category, while non-lighting measures were too diverse to target for stratification within available evaluation resources. These diverse measures range from energy management systems and variable frequency drives to air dryers and unidentified process improvements.

The **lighting electric energy realization rate** is 89% with precision of ±9% at the 90% confidence level. The **lighting summer electric demand realization rate** is 115% with precision of ±9% at the 80% confidence level. The **lighting winter electric demand realization rate** is 144% with a precision of ±10% at the 80% confidence level.

Table 3-7. 2011 EO Overall Lighting Program Savings

Savings Adjustment	Energy		Summer Demand		Winter Demand	
	kWh	%	kW	%	kW	%
Ex Ante Savings	**52,260,757**		**8,277**		**5,039**	
Documentation Adjustment	(709,643)	-1%	1,799	22%	901	18%
Technology Adjustment	(78,168)	0%	(0)	0%	(4)	0%
Quantity Adjustment	(2,551,350)	-5%	(487)	-6%	(414)	-8%
Operation Adjustment	18,851	0%	390	5%	1,676	33%
Heating and Cooling Adjustment	(2,614,830)	-5%	(472)	-6%	71	1%
Ex Post Savings	**46,325,618**	**89%**	**9,507**	**115%**	**7,269**	**144%**
Realization Rate	**89%**		**115%**		**144%**	
Relative Precision	± 9%		± 9%		± 10%	
Confidence Level	90%		80%		80%	

The **non-lighting electric energy realization rate** is 112% with precision of ±16% at the 90% confidence level. The **non-lighting summer electric demand realization rate** is 168% with precision of ±38% at the 80% confidence level. The **non-lighting winter electric demand realization rate** is 228% with a precision of ±46% at the 80% confidence level.

Table 3-8. 2011 EO Overall Non-Lighting Electric Program Savings

Savings Adjustment	Energy		Summer Seasonal Demand		Winter Seasonal Demand	
	kWh	%	kW	%	kW	%
Ex Ante Savings	**35,899,780**		**2,523**		**2,523**	
Documentation Adjustment	(341,785)	-1%	(51)	-2%	(213)	-8%
Technology Adjustment	(435,205)	-1%	(109)	-4%	(206)	-8%
Quantity Adjustment	(333,431)	-1%	(25)	-1%	(56)	-2%
Operation Adjustment	7,007,702	20%	2,454	97%	3,698	147%
Heating and Cooling Adjustment	(1,482,722)	-4%	(552)	-22%	-	0%
Ex Post Savings	**40,314,339**	**112%**	**4,240**	**168%**	**5,746**	**228%**
Realization Rate	**112%**		**168%**		**228%**	
Relative Precision	± 16%		± 38%		± 46%	
Confidence Level	90%		80%		80%	

Overall Natural Gas Savings

Table 3-11 shows overall 2011 EO Program natural gas savings based on the evaluation findings; they reflect a wide array of adjustments. The **natural gas energy realization rate** is 84% with precision of ±16% at the 90% confidence level.

Table 3-9. 2011 EO Overall Gas Program Savings

Savings Adjustment	Therms	%
Ex Ante Savings	**603,045.45**	
Documentation Adjustment	(16,743.24)	-3%
Technology Adjustment	186.87	0%
Quantity Adjustment	(16,491.66)	-3%
Operation Adjustment	(63,364.22)	-11%
Heating and Cooling Adjustment	-	0%
Ex Post Savings	**504,551.33**	**84%**
Realization Rate	**84%**	
Relative Precision	16%	
Confidence Interval	90%	

Forward Looking Realization Rates

In addition to estimating *ex post* savings from the sample projects, the evaluation team also estimated savings for projects if they had been completed using assumptions from the 2013 PSD instead of the 2011 PSD. Most lighting projects were based off of the PSD and could be re-estimated. Appendix E shows the estimated ex ante values, after documentation adjustments, for each project in the lighting sample along with the primary changes affecting the project. The forward looking realization rates for lighting are estimated at 93% for energy, 101% for summer seasonal demand, and 125% for winter seasonal demand.

As shown in Table 3-12, the vast majority of lighting measures were affected by the change from an assumption of coefficient of performance (COP) of 2.4 in the 2011 PSD changed to 3.5 in the 2013 PSD. A few were affected by other changes, while the remaining 19 measures were not estimated because they did not rely on PSD assumptions, there were no applicable changes, or there were no *ex ante* calculations on which to base an adjustment.

Table 3-10. Applicable changes to lighting calculations for 2013 PSD

Applicable change in Assumptions from 2011 PSD to 2013 PSD	Measures
COP from 2.4 to 3.5	66
COP from 2.4 to 3.6 Cs from 0.600 to 0.599 and Cw from 0.380 to 0.388	1
Cs from 0.600 to 0.599 and Cw from 0.380 to 0.388	1
Cs from 0.900 to 0.904	1
None - Does not use IE	9
None - Exterior	3
None - No ex ante calculations	5
None - Not conditioned	1
None - Refrigerated Cases	1
Total Lighting measures in sample	**88**

Many non-lighting EO Program projects did not rely on prescriptive measures in the PSD but were custom calculations from a vendor or did not have any calculations. Vending miser projects in the sample already relied upon the methods presented in the 2013 PSD, rather than the 2011 PSD. The only changes to the PSD from 2011 to 2013 that are applicable to non-lighting projects in the sample are adjustments to the kWhSF factor for chilled water pumps and hot water pumps. This affects energy savings estimates for two projects in the sample; there is no change to demand savings estimates. The non-lighting realization rate remains at 112% for energy savings with these two projects updated. None of the gas projects relied on prescriptive measures in the PSD, so the gas realization rate remains at 84%.

Electric Savings (Lighting)

This section presents the common themes identified for the adjustments for lighting projects.

Adjustments for lighting were quite different for energy and demand. For energy, the majority of adjustments were downward and split between those for quantity and heating and cooling. For demand, there were substantial upward adjustments for operations and documentation with downward offsets from quantity and heating and cooling. The difference between energy and demand adjustment is largely due to lack of estimates for demand savings in the tracking data.

Crosscutting Themes for Lighting Site Adjustments

The evaluation team identified a number of crosscutting themes among the lighting adjustments that were made by the field team. These themes illustrate how the evaluation team determined the variation between *ex ante* and *ex post* savings. As noted above, the largest adjustment was a result of discrepancies between the reported quantities of equipment installed.

Documentation Adjustments

Documentation adjustments were primarily a result of *ex ante* calculation errors on the part of program vendors in three areas:

- Incorrect PSD factors used (especially on the demand side). A very large portion of the projects used energy interactive factors to calculate demand savings. Additionally, for facilities with constant demand, coincidence factors were still applied in *ex ante* estimates.
- Incorrect equations used to calculate savings.
- Incorrect fixture wattage assumptions.

Technology Adjustments

Technology adjustments were made for lighting when the field team observed different fixtures installed than what was reported in the *ex ante* calculations.

Quantity Adjustments

Quantity adjustments were made when equipment quantities observed by the field team were different than what was recorded in the *ex ante* calculations. The majority of the quantity adjustment (85%) was due to one project, where the majority of the project lighting fixtures were found not to have been installed. Most other projects had relatively small adjustments.

Operational Adjustment

Operational adjustments were made for two primary reasons: differences in hours of operation compared to the *ex ante* calculations and differences in fixture wattages.

Heating and Cooling Adjustment

Many of the lighting project vendors appear to have claimed interactive effect savings incorrectly. Given this, the evaluation team made significant heating and cooling adjustments. The two primary reasons for heating and cooling adjustments were facilities with cooling systems that were more efficient than the PSD assumption and facilities that did not have economizers but where they were assumed to exist.

Electric Savings (Non-Lighting)

This section presents the common themes identified for the non-lighting electric adjustments. Adjustments for non-lighting were across several factors. The most significant changes were upward operation adjustments. These were not quite offset by the downward adjustments in other categories.

Crosscutting Themes for Non-Lighting Sites

The evaluation team identified a number of crosscutting themes among the non-lighting adjustments. These themes illustrate how the evaluation team determined the variation between *ex ante* and *ex post* savings. As noted above, the largest adjustment was a result of discrepancies between the reported quantities of equipment installed. In addition, the evaluation team identified common themes among the circumstances that necessitated the adjustments.

Operation Adjustments

Operation adjustments fell into a number of major categories:

- Differences in observed operating hours compared to *ex ante* assumptions; both greater and fewer operating hours.
- Measured operating characteristics of the equipment that were different than what was assumed in the *ex ante* calculations (*e.g.* compressor air flow, static pressure, operating speeds, etc.)
- Differences between measured operation and the operation assumed in the PSD.
- Incorrectly programmed EMS systems.

In addition to the themes described above, eleven of the projects had measured savings that were different than the *ex ante* savings, but the evaluation team was unable to account for these operation adjustments due to a lack of *ex ante* savings calculations in the project documentation or claimed savings values that differed from the savings calculations contained in the project documentation.

Documentation Adjustments

Documentation adjustments were primarily a result of *ex ante* calculation errors on the part of program vendors. The calculation errors observed by the evaluation team were not consistent and only occurred in five of the projects.

Quantity Adjustments

Quantity adjustments were only made for three projects. In each case, the adjustment was made to account for discrepancies between the equipment described in the *ex ante* calculations and the equipment observed on site by the evaluation team.

Gas Savings

Adjustments for gas project savings were substantially downward for operations. There were also substantial downward adjustments for documentation and quantity.

Crosscutting Themes for Gas Site Adjustments

As with the electric sites, the evaluation team identified a number of adjustment factor themes. These themes are described in detail below.

Documentation Adjustments

Documentation adjustments were primarily a result of ex ante calculation errors on the part of program vendors. The errors observed were primarily calculation errors with conversion factors between hundreds of cubic feet (CCFs) and Therms (100,000's of BTUs). Incorrect calculation inputs into *ex ante* savings calculations (*e.g.* incorrect window area for building envelope, overestimation of condensate amounts, incorrect enthalpy amount) were also encountered by the field team.

- The conversion factor error was encountered in several projects.
- In several projects, enthalpy was used to calculate required heating energy. It is appropriate to use enthalpy in this way when space conditions are controlled to maintain a minimum relative humidity. However, this was not the case. Only space temperature and not humidity was being controlled. Moisture added to the space in the humidification process would add heating load as the calculations indicated.

However, since humidity was not being controlled it is prudent to only take sensible (temperature change) heating savings for the calculation.

- Several projects had an error where the 1.08 air unit conversion factor in the ventilation energy was included in two places, resulting in that portion of the energy use (and the resulting savings) being overestimated by 8%.
- Three projects had savings values presented in calculations that did not match the tracking system
- Some but not all energy management system installation project calculations were calibrated to billed energy consumption in the baseline case. That is, operating parameters were investigated to achieve an energy model that reflects actual performance and energy consumption year round. These parameters form the basis for the savings calculation. However, for several project calculations, the baseline or starting point energy calculation/model was not consistent with the billed use and this resulted in erroneous savings estimates.
- Other projects had various calculation errors, but these were project specific and not common issues.

Technology Adjustments

There were three cases of technology adjustments. In each case, the adjustment was due to the heating fuel being utilized by the customer. In the first case, the diversity factor was adjusted due to the customer's "pre-project" use of heating oil instead of natural gas. In the second case, the adjustment was made to account for the customer's switch from a 50/50 split between heating oil and natural gas to exclusively natural gas. The final technology adjustment made was to account for a site where the customer was found to be using heating oil exclusively, so there were no gas savings.

Quantity Adjustments

There were three cases of quantity adjustments. In the first case, the *ex ante* calculations were based on an incorrect boiler size that was not reflective of the actual equipment at the customer site. In the second case, only one air-handling unit reported in the project documentation was found to be controlled based on CO2 controls, although three were claimed in the project documentation. In the third case, the quantity adjustment was made to reflect the fact that the customer already had an EMS system in place and was implementing a night setback.

Operation Adjustments

Operation adjustments included all those cases where on inspection, it was found that the operation of the installed equipment substantively differed from that described or assumed in the *ex ante* calculations associated with the project proposal. These adjustments include all of the factors listed below, but also could include many other factors, such as boiler loadings, boiler efficiencies, hours of operation, heat recovery efficiencies, production levels or other project specifics.

- **Setback time:** this type of adjustment was the most common adjustment made to *ex ante* savings. Typically, adjustments were made when the observed operation of the system resulted in longer or shorter periods of building occupation compared to the *ex ante* calculations, or no setback times actually implemented, although the project proposal claimed setback hours.

- **Setback temperature:** similar to setback time adjustments, these adjustments were made when on-site metering and customer interviews showed that temperature setbacks assumed in the *ex ante* calculations were either not implemented at all or implemented to a lesser degree than in the *ex ante* calculations (*e.g.* a 5-degree setback instead of an 8-degree setback).
- **Ventilation:** a number of sites were observed where the *ex ante* assumptions about the amount of ventilation did not reflect the reality of the building operation. In these cases, the *ex ante* assumptions typically assumed that ventilation loads would be reduced as part of the project when in reality, they were not.
- ***Ex ante* calculation errors:** these adjustments were due to *ex ante* calculations that did not correctly account for the equipment at the customer site or operation of that equipment. Examples of this include: incorrect equipment operation hours, incorrect boiler efficiency values, and incorrect compressor heating efficiency values.

4. Recommendations

This section first provides the recommendations from the process evaluation and then from the impact evaluation. These recommendations are based upon the process and impact evaluation of 2011 participants. The evaluation review process indicates that some of the recommended changes or expansions may have already been undertaken or begun by the time this report was produced. All recommendations reported should be taken with that in mind and when examining in detail to view the recommendations of the evaluation report alongside the reports from the utilities and other parties of actions already undertaken or to be done as part of the utilities response to recommendations that are submitted as part of the formal record.

4.1 Recommendations for the EO Program from the Process Evaluation

Through reviewing all process findings, the evaluation team has compiled recommendations to consider for improving various program components. Table 4-1 below provides a summary of process recommendations and are organized into the same categories used to discuss program barriers previously. However, please note that the evaluation team has not completed any estimates of costs or cost-effectiveness regarding these recommendations. Some recommendations may not be reasonable depending on the cost analysis of implementing them.

Table 4-1. Summary of Program Recommendations

Program Component	Recommendations
Comprehensive Projects	• Investigate the feasibility of limited energy audits that would increase awareness of potential comprehensive projects. • Consider restructuring comprehensive project terms to allow for a greater time frame. • Educate vendors regarding the comprehensive project incentive.
Energy Savings Performance Contracting	• Reconsider objective of ESPC goal, as driving demand for energy efficiency may be more appropriate. • Continue to support Lead By Example ESPC program.
Project Financing	• Reconsider objective of financing goal, as driving demand for energy efficiency may be more appropriate. • Develop marketing materials that demonstrate the benefits of available financing to smaller customers. • Educate and support vendors regarding financing benefits as many were unaware.
Strategic Energy Plans	• Educate smaller customers on the value of strategic energy planning. • Link proposed energy audits to strategic action plans. • Consider providing an incentive for developing an approved plan
Building Benchmarking	• Raise awareness among customers regarding value of benchmarking. This should increase demand for energy efficiency, as customers understand the results of the benchmarking process. • Incorporate benchmarking education on bill. • Provide benchmarking support as a service with limited input from customer.
Program Awareness and Satisfaction	• Increase access to program customer representatives • Offer energy audits that directly result in an energy plan.

Comprehensive Projects

The evaluation team recommends making three changes to the EO program. Based on interviews with vendors and program participants, the evaluation team believes that these changes will increase the frequency of comprehensive projects within the EO program. The following section provides more detail on each of these recommendations and is organized into the following topic categories.

- Investigate the feasibility of limited energy audits
- Restructure comprehensive incentive project terms
- Provide vendor education

Investigate the feasibility of limited energy audits

The evaluation team recommends that the program administrators investigate the feasibility of offering qualifying organizations some form of subsidized energy audit. These audits could provide a variety of benefits and specifically mitigate several of the barriers described above, including the limited awareness of the possible energy improvement opportunities at customers' facilities and challenges related to working with specialized vendors. However, questions remain about the potential market of vendors that could provide these audits, the feasibility of completing these audits with program staff, and to what level these audits need to be subsidized by the PAs.

First, a primary benefit of audits is that they could serve as an educational tool informing participants about what potential improvements are possible to increase energy efficiency at their facility. The types of energy audits available for commercial and industrial facilities vary greatly in terms of scope and investment in time and resources. To help provide some structure to the various audit types, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has outlined three progressive levels of energy audits: (Level 1) Walk-through audit, (Level 2) Detailed energy audit, and (Level 3) Investment-Grade audit. Even the first level audit investment can provide facility owners and managers with a better understanding of how their building performs relative to similar facilities and where potential improvements could be made.

Second, an additional benefit of energy audits is that they could integrate with strategic energy planning and building benchmarking efforts and serve as a guide on which projects to pursue first and which projects should be completed concurrently. This aspect of audits would be most valuable for those mid-size organizations that need greater assistance strategically managing their energy consumption. As an example, one program participant explained that there is too much information regarding efficient equipment and too many options available. For him, without an accessible source of information, it was difficult to know which option was best. The value in offering energy audits for organizations is that the results of the audits can provide a foundation for a clear road map for which improvements to pursue next.

Third, recent research on energy audits have found evidence that commercial and industrial energy audit programs can lead to increased measure adoption rates and resulting savings beyond the first year. Specifically an impact evaluation for a New York State Energy Research and Development Authority (NYSERDA) found a long-term measure adoption rate of 65 percent among programs that include energy audits as compared to an industry norm adoption rate in the range of 20 to 30 percent [21]. The 65 percent adoption rate of energy audit recommendations found in the NYSERDA study looked at adoptions occurring at 25 percent within one year, 46 percent within three years, 60 percent within four years and 65 percent within six years after the audit. These findings offer some level of evidence of the value energy

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[21] Paper presented at the 2013 International Energy Policies & Programmes Evaluation Conference (IEPEC) by Jonathan Maxwell, Satyen Moray, and Rebecca Reed Gagnon titled, "*Auditing Audits: Big Savings Found in Long-Term Assessment*."

audits can provide to energy program measures, though cost-effectiveness is still a primary concern for program implementation.

The evaluation team recognizes that providing or subsidizing even "limited" energy audits or technical assessments would require substantial additional resources from the PAs. In addition, the evaluation team does not have enough information to recommend how best to implement this recommendation or whether it would meet the PAs cost-effectiveness tests. However, based on the evaluation team's research and industry experience, possible implementation strategies include no-cost technical assistance provided by in-house program staff or financial assistance for completing third party energy audits.

Restructure Comprehensive Project Terms

The evaluation team recommends that the PAs consider expanding the timeframe for determining which energy efficiency projects qualify for the added comprehensive projects incentive. By providing a longer-term view of comprehensive projects, the PAs could incorporate energy audit reports, strategic energy plans and building benchmarking to encourage continuous energy efficiency improvements. Creating a flexible, long-term framework would allow different facilities to set schedules that work best for them, acknowledging that each facilities has different timelines for renovation, plant layout timelines, and capital financing schedules that impact the optimization of their strategic plans. Feedback from the Companies suggests that these timeframes are already implemented and used based on the individual needs of customers.

This recommendation includes: (1) reaching out to organizations that have completed a single project to ensure they are aware of the additional incentive for comprehensive projects; and (2) extending the qualifying period for comprehensive projects to more than 12 months. Through the interviews, the evaluation team found that medium-sized organizations often were unaware of the additional incentive available by completing multiple measures in a given time period. One suggestion to increase the number of organizations that decide to pursue additional energy efficiency upgrades is to follow-up with any organizations completing their first measure to ensure that they are aware of the availability of the additional incentive for completion of comprehensive measures. A key selling point is that their first project would count towards the multiple measure requirement as long as additional upgrades were installed within an agreed upon timeline. This adjustment to the program could encourage more organizations to decide to commit to and complete additional energy efficiency improvements that were on hold or approve projects that were not currently under consideration.

Second, restructuring comprehensive project terms to allow for greater completion timeframe would help organizations that are planning to implement multiple energy efficiency measures but are limited by annual capital budget funding. An important finding from the interviews is that the dollar value is not the only barrier to comprehensive projects, but also available time resources of staff. As such, the increased timeframe would allow for the budget and labor resources required for project managing multiple energy efficiency improvements to be spread out over several years' worth of capital budget. In addition, participants across all segments reported that extending the time to implement upgrades would also help to reduce the pressure and impact on labor resources and the project management workload.

Provide Vendor Education

The evaluation team recommends that the PAs continue to improve vendors' awareness of the comprehensive project incentive. The research and transaction costs of complete comprehensive projects for vendors might be reduced if the EO Program provided tools, services, introductions with dinners and other activities to increase vendor knowledge about possible teaming vendors with other specialties and products that work with the Program. The Program could also investigate whether there should be comprehensive incentives split into those for customers and those for vendors.

Interviews with participants indicated that the level of awareness of program incentives varies greatly by sector. Large firms often either have an existing relationship with a representative at the utility or ready access to one. This access allows these firms to be kept informed of utility program opportunities. However, interviews indicated that medium-size firms are less connected to the utility in the same way and generally have limited knowledge of incentive opportunities. Likewise, interviews with vendors revealed that very few of the vendors included the comprehensive incentive as part of their sales and marketing approach. As such, additional education regarding the comprehensive project incentive to vendors will likely increase the number of vendors including that incentive as part of their sales approach. This "push" from vendors will increase the frequency of customers completing comprehensive projects as their vendors help guide them through the process. Again, please note that we only spoke with participating vendors; nonparticipating vendors may have differing perspectives on program participation and energy efficiency.

In summary, the evaluation team believes the PAs have an opportunity to link the above recommendations for comprehensive projects together into a holistic approach. For qualified firms, the output of the energy audit could be considered an "energy plan." This energy plan could serve as the foundation for an organization to develop a strategy to implement all cost effective measures that are practical to their facility in agreement with the PAs. Once all measures agreed upon are successfully implemented over a predetermined timeframe, an additional bonus incentive for the completion of the comprehensive projects could be awarded.

Energy Savings Performance Contracting (ESPC)

First, the evaluation team recommends that program designers and implementers should re-consider whether increasing uptake in ESPC should be a goal in its own right. The evaluation team believes that driving demand for increased energy efficiency should remain the target goal and that ESPC is one type of financing tool that can help meet the savings goals. Future evaluations will focus on the barriers to increasing demand.

However, the evaluation team recommends that the PAs continue to support the "Lead by Example" ESPC program that targets municipalities and state agencies. The evaluation team found that many organizations have not considered pursuing ESPCs for a variety of reasons including: (1) pre-existing access to capital, (2) reluctance to increase financial obligations, and (3) the perception among some that ESPCs are not economically beneficial for them. By supporting the existing state program, the PAs can continue to encourage a vibrant market for ESPC in Connecticut from which non-state or municipalities can benefit.

In addition, the previous recommendation regarding providing limited energy audits that target smaller C&I customers would mitigate some of the market barriers identified during our research. By providing these audits to smaller organizations that may not typically be targeted by vendors providing ESPC services, the PAs can encourage the whole building system approach often found in ESPC projects. Celtic Energy, through a contract from Connecticut Light & Power and United Illuminating, developed a comprehensive "best practices" document for ESPCs[22]. Included in the best practices document, is the recommendation for early and active involvement in working with potential participants to identify and explain benefits of the program since the benefits may not be obvious or immediately understood given the complexity of the projects. Energy audits could serve as one avenue for increasing discussions on potential improvement and benefits to engaging ESPCs to complete them.

Project Financing

Again, the evaluation team believes that program designers and implementers should re-consider whether increasing uptake in utility or other Connecticut public program financing should be a goal in its own right. The evaluation team believes that driving demand for increased energy efficiency should remain the target goal and that project financing tools be viewed as one way to help meet the savings goals. With this viewpoint, the evaluators recommend the PAs and program designers review the best ways to maximize the effectiveness of this tool and improve its targeting to offer participants a more customer-specific program and friendly service.

The evaluation team recommends that the PAs provide additional marketing of the utility-sponsored financing in order to raise awareness of this specific program component. While the evaluation team found similar barriers to participating in project financing as mentioned for ESPC, there appears to be an opportunity to increase the awareness of the availability of utility-sponsored financing among smaller customers. In-depth interviews indicated that smaller organizations had limited awareness of financing, but a proportion of them were interested in taking advantage of this offering. As these customers typically did not have dedicated account representatives their awareness of various program opportunities was often limited in comparison to larger organizations. As a result, any strategy to increase awareness of utility-sponsored financing among these customers will need to utilize alternate methods of outreach such as direct mail, email, web, and others.

In addition, interviews with vendors indicated that few vendors were aware of the utility-sponsored financing and of those that were, few included it as part of their marketing and sales approach. As such, any additional education or support that the PAs could provide to participating vendors would again provide a "push" strategy that would encourage greater customer awareness for those where utility-sponsored financing can provide financing otherwise not available for some of all of their desired efficiency elements/projects. Finally,

[22] Best Practices Guide for Energy Savings Performance Contracting (ESPC). http://www.celticenergy.com/assets/files/CT_ESPC_Best_Practices.pdf

while this research did not include any interviews with non-participants, future market research will more fully explore the impact of financing on customers that have not chosen to participate in the EO program.

Strategic Energy Plans

The evaluation team recommends that the PAs provide materials designed to raise customers' awareness of the benefits of strategic energy planning in addition to existing personal interactions by program staff. Interview findings highlighted that among medium-sized customers, there is limited awareness and understanding of the value in developing an energy plan. The evaluation team believes that by providing materials such as case studies or example plans, medium-sized customers would be more likely develop plans and most importantly, follow them.

As discussed above, the evaluation team also recommends that the PAs take a longer term view of "comprehensive projects," by linking any energy audits provided for customers to a clear action plan around improving their organization's energy efficiency, creating a strategic energy plans that would implement energy efficiency upgrades during different stages of a firm's operation. This view could enable the highest level of energy efficiency adoption, albeit over time, and further encourage customers to take a holistic approach to increase their facility's energy efficiency. One of the key outputs from potential energy audits conducted could be a prioritization of energy efficiency upgrades identified and a suggested plan on how to address those opportunities. A key role for PAs could be to facilitate discussions exploring further how strategic energy plans provide a road map for addressing opportunities identified from the energy audits.

Building Benchmarking

Based on the EO Program's stated goal of encouraging building benchmarking among customers, the evaluation team offers the several possible recommendations to increase organizational participation in benchmarking including: 1) raising awareness about the value of benchmarking, and 2) consider offering benchmarking as a service to business customers.

The evaluation team recommends that the PAs consider straightforward methods for supporting customers to benchmark their buildings and operations. Given the number of participants who reported tracking their energy costs via reviewing their monthly bills, customers are at least partially aware of the value of tracking building performance over time. These same customers may be receptive to the idea of taking the relatively small incremental steps towards more formalized building benchmarking. As such, the evaluation team believes the PAs have an opportunity to increase awareness among customers about the values of building benchmarking and the minimal time and effort to perform at least basic building benchmarking.

In addition to increasing awareness of the values of building benchmarking, a potential strategy to encourage benchmarking would be to directly offer building benchmarking to customers as a service. This service could be implemented with a similar model to an audit program, where customers can sign up for a benchmarking consultation or appointment with either utility staff or utility-vetted contractors. Consultations could be structured as a training session for customers on benchmarking software with the expectation that customers could then conduct their own benchmarking going forward. Alternatively, after the initial visit, benchmarking could take the form of a score or rating on customer bills to keep customers engaged. As customers are already reviewing their bills, any simplified benchmarking provided on-bill might serve as a gateway to more comprehensive building benchmarking using industry tools (*e.g.*, ENERGY STAR Portfolio Manager). Through the ENERGY STAR® Portfolio Manager, the Environmental Protection Agency (EPA) has found that buildings that consistently benchmark energy use save an average of 24 percent per year.[23] A key value to benchmarking is that it serves as a tool for customers to assess the current state of building energy use as compared to peer facilities and also track changes and improvements over time.

4.2 Recommendations for the EO Program from the Impact Evaluation

The impact evaluation recommendations are split between those that are for the EO program and those that apply to future evaluation efforts. A number of these recommendations also address the evaluators' assessment of the accuracy of methods used by vendors in estimating savings for complex "custom" projects, recommending changes to some program procedures in order to increase project savings realization.

EO Program Recommendations

Set clear guidance on when vendors should use the PSD and what inquiries and assumptions that should be used in different circumstances.[24]. The use of deemed measure values provides valuable program streamlining and greatly simplifies the application process for both customers and efficient product vendors; as such it removes market barriers and encourages wider adoption of efficient products. However, when misapplied, deemed values can result in erroneous savings estimates. It is important to set clear guidelines and examples to help vendors understand when and how deemed values may be applied in standardized savings calculations, and when a 'custom' engineering calculation is required to justify an incentive payment.

Require sufficient project documentation from vendors as a condition of payment. A significant number of the projects reviewed for this evaluation had insufficient project documentation for the evaluators to check whether the *ex ante* savings reported could be justified using standard calculations or engineering analysis practices. Some had no

[23] Portfolio Manager DataTrends. http://www.energystar.gov/buildings/about-us/research-and-reports/portfolio-manager-datatrends

[24] A long-term goal for the evaluation effort is to help make program estimates more accurate by updating the PSD to include some assumptions to be used depending upon broad categories of building use or customer type or delineate when and how to use customer interview data with the PSD to create more accurate project-specific *ex ante* savings estimates.

documentation. In order to streamline project qualification for Program Administrators and to facilitate ongoing evaluations, program participants should be required to submit program documentation in electronic form, and to provide copies of all calculations in forms readily checked using computer-based tools without manual transcription as a condition for incentive payment.

Consider improvements to program processes for application review to mitigate documentation errors (Related to 2. above). Program enhancements to support improved project documentation while reducing the effort for Program Administrators to qualify projects should be implemented. Required submission to each utility EO program of standard measure calculation templates and spreadsheets for common measures in Connecticut is an example of a program change that would assist with this.

Consider 'Pay for Performance' for at least part of incentive on larger complex projects. When large or complex projects apply for incentives, especially those with interactive measures such as energy management systems, Program Administrators should consider withholding a substantial portion of total incentives pending proof of savings over an agreed period, such as six months or a year. Proof could include such options as third party commissioning or an approved measurement and verification plan. The 'proven' portion of incentives might also be allocated pro-rata to the verified savings.

Require documentation on EMS projects that includes the programming for controls and implementation. Regardless of equipment, the effectiveness of energy system controls projects is limited by the control programming. To capture the savings predicted in a controls measure requires that the controls strategies and settings be carefully matched to the specific application. In several of the projects reviewed, this appears not to have happened, because despite adding equipment capable of more effectively controlling building HVAC operations to reduce energy, little or no change was observed. This problem (which the evaluators observe is widespread in the industry) could be mitigated by requiring submission of controls logic and proposed controlling parameters as part of controls measures as a requirement for incentive payment. An alternative would be required commissioning and 'pay for performance' as described above.

Evaluation Recommendations

Use *c.v.* values found in this study for future EO evaluations. The evaluation team found that the realization rates for projects in this program were highly variable. The actual *c.v.* for the non-lighting projects in the sample were much higher than the a priori estimate of 0.8, based on the previous evaluation of this program and the 1.0 estimate suggested by the ISO-NE M-MVDR. This is discussed in detail in the report. The evaluation team recommends adjusting these *c.v.* values to those found in this evaluation for future studies. Such an adjustment will result in a greater emphasis on non-lighting project sites, which have higher variability.

Focus more resources on non-lighting projects, especially EMS measures. Given the relative complexity and diversity of the non-lighting projects, more resources need to be directed to gathering data from and analysis of these projects. This is especially true for large projects and/or those involving building energy management systems. The facility-wide energy interactions require that billing data calibrated models of the facilities be built, and these require many hours of skilled engineering analysis.

Focus on more recent participants for process evaluations to ensure relevancy. Consider or test undertaking process evaluations on more recent participants. This recommendation is made with the understanding that impact evaluations must be conducted on earlier participants in order to have sufficient post-retrofit consumption data to obtain reliable results.

Appendix A: Detailed Impact Methods

This appendix provides more details on the approach used for the impact evaluation. First, the method to calculate the final relative precision is presented followed by specific approaches to data collection and analysis used by the evaluation team for lighting and non-lighting projects.

A.1 Relative Precision

The evaluation team used the assumed coefficients of variation (*c.v.*) of 0.5 for lighting and 0.8 for non-lighting projects in order to determine the necessary sample size a priori to meet a relative precision (r.p.) of 10% with confidence of 90% for energy and 80% for demand.

After collecting data, the evaluation team re-calculated the *c.v.* and the relative precision of sampling studies based on the measured realization rates using the following equation:

$$r.p. = \sqrt{1-\frac{n}{N}}\,\frac{z \times c.v.}{\sqrt{n}}$$

Where:

x = sample mean
s = standard deviation
n = number of samples in a finite population
N = total number of units in the population
z = the appropriate z-value for the confidence level

$$c.v. = \frac{s}{x}$$

Note that the equation includes the finite adjustment factor of $\sqrt{1-\frac{n}{N}}$.

The evaluation team determined the sampling precision using stratified ratio estimation. Stratified ratio estimation combines a stratified sample design with a ratio estimator; in this case, the ratio estimator, *B*, is realization rate, or the percent of observed savings relative to reported tracking savings. The ratio for any given site, b_i, is determined as $e_i = y_i - bx_i$; where y is the evaluated savings and x is the tracking savings. Case weights, w_i, are used to weight each project. The standard error of the sample ratio, b, is calculated as:

$$se(b) = \frac{\sqrt{\sum_{i=1}^{n} w_i (w_i - 1) e_i^2}}{\sum_{i=1}^{n} w_i x_i}$$

The relative precision is then determined by the following equation:

$$r.p. = \frac{se(b) \times z}{b}$$

The error ratio for use in future sample designs was calculated as shown, assuming γ =0.8.

$$\hat{e}r = \frac{\sqrt{\left(\sum_{i=1}^{n} w_i e_i^2 / x_i^{\gamma}\right)\left(\sum_{i=1}^{n} w_i x_i^{\gamma}\right)}}{\sum_{i=1}^{n} w_i y_i}$$

A.2 Lighting Data Collection and Analysis

The primary method to verify savings estimates for lighting projects in this evaluation is International Performance Measurement and Verification Protocol (IPMVP) Option A, Partially Measured Retrofit Isolation.[1] Data were collected during site visits and then analyzed for direct and interactive effects.

Lighting Data Collection

For lighting data collection, a site visit was performed for each sample project. Each site visit included four steps: customer interview, installed measure verification, metering, and HVAC system inspection. Each of these steps is described here.

Customer interview

The customer was interviewed during the site visit to provide additional information regarding the use of the lighting, the hours of facility operation, and the HVAC system. Specific data gathered through interviews are identified along with that activity.

Installed measure verification

The project measures were verified for installation and inspected to ensure consistency with the project documentation, including lamps, ballasts, etc., as well as lighting controls, such as: occupancy sensors, time clocks, photocells, and daylighting controls where the project included them or they are relevant to lighting operation. In addition to verifying that the project measures were installed, the verification inspections were used to collect power consumption information. Lamp and ballast information for the installed lighting, as well as the removed lighting, was collected to the extent available. The lamp and ballast information was then used to stipulate fixture power consumption, using manufacturer literature. If the lamp and ballast information was not available, and it was possible to take spot measurements of fixture demand for the installed fixtures, spot checks of demand were taken using a NIST-calibrated Fluke 1735 power analyzer. This information was used to provide base-case and post-case power consumption information for the fixtures that were retrofitted or removed with the completion of this project.

Metering

In order to determine the hours of use for the fixtures, meters capable of logging lighting On/Off state, lumens, and/or power were installed during the site visit depending on what

[1] See the Non-lighting data collection and analysis section for a summary of IPMVP Options.

data were required for the evaluation. For each site, the number of loggers necessary to accurately determine the hours of use of the lighting involved in the project was based on circuit configuration and the predicted variability of the lighting operation, as determined by the field engineer through the onsite interview process. Specific metering equipment used in this evaluation, along with their purpose, includes:

- HOBO® UX90-002 Light On/Off loggers – to monitor the operational status (on/off) of the lights.
- HOBO U12-012 lumen level loggers – to monitor the operational status (on/off) of the lights.
- HOBO U12-012 external channel loggers with split-core current transducers of appropriate sizes –to monitor the current supplied to the lights where all or a significant portion of the lights are powered by dedicated and independent circuits (no other equipment or outlets on the circuit).

For sites that involved the installation of occupancy sensors, the customer was asked if there were any lights in the facility that operated in the same manner as the occupancy sensor controlled lighting did prior to the installation of the occupancy sensors. If so, loggers were also installed to monitor these lights, providing proxy base-case operating data for the lighting controlled by the installed occupancy sensors. If no lighting in the facility was operated similar to the controlled lighting prior to the completion of the project, the customer was interviewed to determine the base case operation of the lights.

All loggers installed were launched from a computer with a UTC-calibrated clock, and were deployed with a sampling interval no greater than 5 minutes, for a minimum of 3 weeks. Special care was taken to identify emergency or security fixtures that operate 8,760 hours per year or an alternate schedule.

The customer was also interviewed to verify the facility hours of operation. Specifically, the customer was interviewed to determine if the operation of the lighting during the metering period was "typical" or if there were variations to the expected operation that were not captured. These variations could include seasonal variations, shut-downs due to maintenance, power outages, or any other variations to operation that should be considered. This information was used to remove any atypical operation from the metered data, as well as to assist in the extrapolation of the metered data to the expected annual operation.

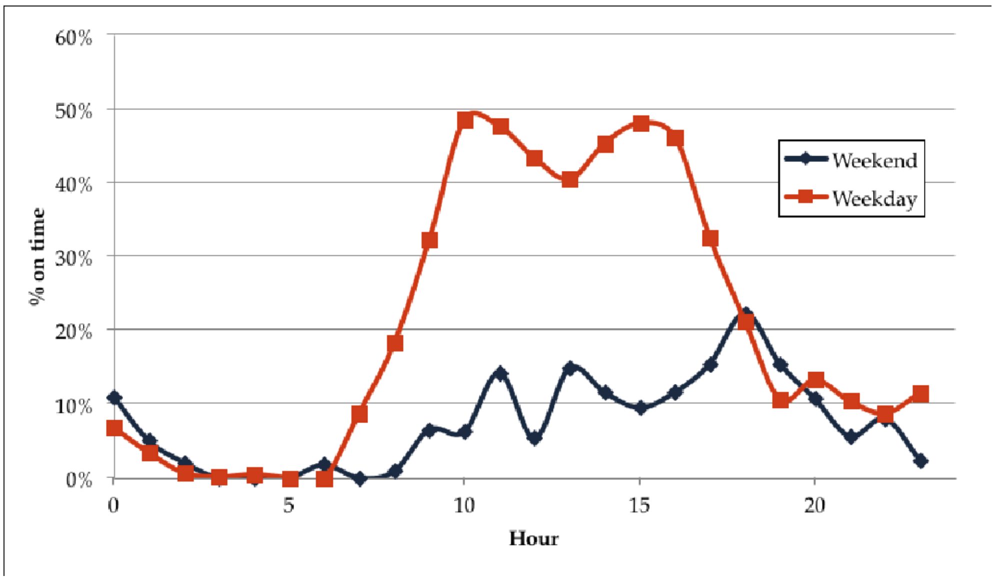
HVAC system inspection

In order to verify interactive effects on energy use between lighting and heating and cooling systems, whenever possible the make and model numbers for the heating and cooling equipment were recorded. The make and model numbers were used to verify operational efficiency data, such as EER, COP for heating or cooling, or kW/ton, as well as the presence of an economizer. The customer was interviewed to determine the operational parameters for the heating and cooling equipment as well, such as temperature setpoints for both occupied and unoccupied periods, economizer operation and controls, daily and weekly operating schedules, as well as expected annual heating and cooling operation, either through the collection of annual schedules for the dates that cooling plants are typically started and stopped, or temperatures above which cooling equipment is expected to operate.

Lighting Savings Analysis

The data collected from metering was used to create average weekly operating profiles (one for each logger). An example profile is provided in Figure 1. The weekly hourly operating profiles are applied to an entire year with due consideration of weekday, weekend and holiday operations, resulting an hourly profile of equipment operation for both the pre/base case and the post-installation case for an entire year. The resulting profile is called an "8760 model." The 8760 model is used to estimate *ex post* savings, which are the sum of savings resulting directly from the lighting measures and also indirectly through interactive HVAC effects.

Figure 1. Example Lighting Profile



Direct Lighting Savings Analysis

The annual energy savings for each project's measures were determined by combining the 8760 model of lighting fixture hours of use with the fixture demand change from the pre- to post-case. The peak demand savings were estimated as the expected demand reduction during the peak and seasonal peak hours, which are a function of both time of day and outdoor air temperature. Additional details on peak definitions are given in Appendix D.

Interactive Effects Analysis

The interactive effects were calculated using the 8760 model, where the cooling energy effects are accounted for in each hour of the year. Specifically, the cooling effects are calculated using the demand formula from the PSD, where the cooling interactive effects factor is calculated as:

$$F_d = 1 + \frac{G}{COP}$$

Where:

- F_d is the cooling interactive effects factor

- G is 0.73 and is the percent of the energy of the lighting that results in heat rejected to the space, as defined by the PSD
- COP is the efficiency of the cooling system as determined based on observations and/or PSD assumptions

Interactive savings were calculated separately for the occupied and unoccupied period as defined for each project. Interactive savings only occur if the lights are operating during the specific hour and the outside air temperature is above the selected balance point for either the occupied or unoccupied hours. These criteria and calculations are intrinsic to the 8760 model The balance point for each period is selected for each project based on the specific site conditions, dependent upon space setpoint temperature, internal gains, and economizer operation and included in the model.

A.3 Non-Lighting Data Collection and Analysis

For the non-lighting projects, the specific approach taken to evaluate each project was determined based on the type of technology, *ex ante* calculation methodology, and available information, as well as the expected magnitude of the savings. Therefore, this section outlines the overall approach taken towards non-lighting projects, rather than the specific approaches taken for individual projects.

Non-lighting data collection

Non-lighting data collection varied by project. For each project, the evaluation team reviewed project documentation, developed a site specific measurement and verification plan (SSMVP), and conducted site visits. Each of these steps is described here.

Project documentation review

The first step in the evaluation process for each project was the desk review of *ex ante* project documentation. The desk review first allowed the analyst to become familiar with the project calculations and descriptions to ensure that the calculations were consistent with the described project and the claimed savings in the tracking system. The analyst was also able to review the calculations and identify areas of uncertainty that would then be addressed through the measurement and verification efforts.

Second, the desk review was used to review the calculations. Prescriptive project documents were reviewed to ensure consistency with program prescriptive measure specifications, and that the method from the PSD was followed for calculating savings correctly. Non-prescriptive, or custom, savings calculations were reviewed for calculation errors and to ensure that they were completed using accepted engineering practices, appropriate assumptions, and equipment characteristics consistent with the supplied documentation.

In some cases, the revisions to the savings estimates involved simply substituting verified parameters into the original calculation. In other cases, where the underlying calculation methods were flawed or inappropriately applied, an independent calculation of energy savings was developed based on engineering fundamentals, accepted energy efficiency practices and judgment.

Finally, the desk review supported the development of an SSMVP to inspect and monitor key data to confirm project savings.

Site Specific Measurement and Verification

Prior to performing an onsite inspection, an SSMVP was written for each site. The SSMVP included the results of the *ex ante* project review as well as a description of the measures involved in the project, the method used to calculate savings in the original analysis, and any comments regarding the analysis or adjustments made to the analysis as a result of the desk review.

The SSMVP also included a description of the various parameters used to determine the savings, and described the data collection efforts and the measurement and verification plan to be undertaken to verify the project savings. Specifically, the SSMVP addressed the following areas:

- Verify that the equipment included in the project is installed as expected and operates as described in the project documentation
- Verify make/model number of affected equipment
- Verify operational parameters such as hours of operation, motor load factors, heating and cooling efficiencies, etc.
- Verify baseline system operation
- Collection of instantaneous measurements
- Installation of data loggers for short or long-term metering

Special care was taken to ensure that the data collection efforts focused on factors of uncertainty that would have significant impacts on the actual energy savings. Additionally, the SSMVP described the IPMVP approach(es) to be utilized for each project. The four IPMVP approaches are described in the table below.

IPMVP Option	Used For	Examples
A. Retrofit Isolation with Key Parameter Measurement	Calibrating energy models where metering all points is cost-prohibitive for the amount of savings, or not possible.	Spot check on lighting power plus logging hours of usage; using an on/off logger to estimate packaged air conditioning unit load.
B. Retrofit Isolation with All Parameter Measurement	Determining loading and duty cycle for measures that have significant savings and where all significant parameters can be metered.	Determining the duty cycle of a variable frequency drive; Measuring the duty cycle and output of a large chiller.
C. Whole Facility	Projects that are expected to save at least 10% of facility / meter consumption.	Multiple measure / comprehensive facility projects such as retrocommissioning, new control systems, or major system replacements or upgrades.
D. Calibrated Simulation	New construction primarily, or major retrofit projects and complex projects that are expected to save less than 10% of the facility / meter consumption.	New construction and retrocommissioning projects where the quantity of affected equipment and systems results in prohibitively expensive alternative M&V methods.

The specific approach taken was determined based on the project type as well as the expected savings levels. For example, Option A, retrofit isolation with parameter measurement may be used for a specific measure; however, if the impacts are significant enough such that results should be apparent on billing data, analysis on billing data (Option C) would also be conducted as a cross-check. Similarly, if Option C, whole building energy billing analysis, is the primary means of M&V, Option A or B could be used to verify savings from specific measures with a significant impact on the total billed savings. A more comprehensive list of examples for applying IPMVP methods is included in the table below.

Measure Category	IPMVP Option A	B	C	D	Comments
High-efficiency lighting equipment	✓				Lighting hours key unknown
Lighting controls (occupancy sensors)	✓				Lighting hours key unknown
Lighting controls (daylighting)	✓				Lighting hours key unknown
High-efficiency HVAC equipment	✓	✓			Packaged / residential may use hours to calibrate. Direct measurement of power and output for large equipment like chillers.
HVAC Diagnostics	✓	✓			Typically spot check input power and output and calibrate model for run time.
HVAC Quality Installation	✓	✓			Data sets such as outputs from diagnostic tools may be used as analysis inputs.
High-efficiency motors	✓	✓			Need loading and run time for steady state or continuous loading for varying loads.
Variable-speed drives		✓			Duty cycle required. Needs continuous direct monitoring for calibration.
Building envelope measures			✓	✓	Too complex for custom calculations. Calibrated simulations or billing regression needed.
Weatherization			✓		Measure effectiveness (infiltration) is very difficult to measure.
New construction whole building performance				✓	Comprehensive sets of measures require simulation. Few components with little interaction could use Options A/B.
Refrigeration measures	✓	✓	✓	✓	Measures vary significantly. Method depends on measure.
Process measures	✓	✓	✓		Measures vary significantly. Method depends on measure.
Appliances	✓	✓			Direct measurement for quantification of use needed.
Water heater and hot water measures	✓	✓			Flow rates measured directly. Use measured with temperature measurements. For larger facilities water heating may be metered separately.
Retrocommissioning	✓	✓	✓	✓	Measures and total impacts vary tremendously.

A. Retrofit Isolation with Key Parameter Measurement
B. Retrofit Isolation with All Parameter Measurement
C. Whole Facility
D. Calibrated Simulation

Non-lighting site visits

Similarly to lighting site visits, each site visit included physical inspection of measures and a customer interview to gather information about the project for verification purposes and to gather information about the completed project.

For projects that operate mainly at a steady state, spot measurements of critical parameters such as amps, kW, temperatures and flow rates were taken. Examples of these projects may include constant speed fans and pumps, or process heating or cooling systems that serve a constant load. Such projects were analyzed primarily using IPMVP Option A or Option B.

For projects that operate with significant fluctuations, power data logging was completed for a period of at least two weeks. Additional data was collected as appropriate to normalize or extrapolate the data to the expected annual operation. These data could include outdoor air temperatures, production levels, facility schedules, or other factors as required. Examples of such projects would include most compressed air systems improvements, variable frequency drives, and controls projects. These projects are primarily analyzed using IPMVP Option A or Option B.

The extensive representation of energy management systems (EMS) in the Connecticut EO program population and evaluation sample presented a compelling case to use IPMVP Option C, whole building billing analysis, in combination with Option A, partially measured retrofit isolation, for these projects. This is often the best approach for measurement of energy management system performance. The rationale for using Option C is that the EMS typically has direct impact on (is controlling or interactive with) the entire facility, including both all new measures and preexisting energy systems, and because the savings claimed as a percent of pre-implementation energy consumption are typically quite high for such projects. Also, it is usually impossible to determine what the baseline HVAC operating sequences or system conditions and functionality was prior to implementation in these projects. Therefore, unless the *ex ante* savings estimates are very low as a percent of pre-implementation energy consumption, Option C is typically the most suitable. The use of Option A in combination with Option C serves to:

- Confirm savings are due to properly functioning energy management systems operating in accordance with project documentation where Option C results are reasonably close to *ex ante* estimates,
- Where Option C results diverge from *ex ante* estimates, determine why this is the case (i.e. identify which measures or systems under EMS control are not operating as expected).
- To isolate and remove any affects due to minor changes in facility operation/equipment or other energy efficiency projects that were completed around or near the time of the project completion but not as part of the project scope.

In summary, Option C provides the best estimate of savings for EMS measures at a reasonable resource use, while Option A either corroborates that savings are due to effective energy management system deployment, or it helps explain why savings are not reasonably consistent with the *ex ante* estimates.

Instantaneous measurements of demand were taken using a NIST-calibrated three-phase RMS power meter. Short and long term metering was completed using equipment consistent with the relevant sections of the M-MVDR.

Non-lighting savings analysis

Non-lighting site-specific analysis is conducted in the same general way as for lighting. The data collected through measurement are used to develop hourly operating and/or power use profiles for each measure by day-type (e.g., weekday, weekend, holiday, as well as any customer-specific day-types, and/or in relation to incidence of outside temperature [so-called 'bin methods']) for the post-implementation case, to whatever degree of resolution is needed and practical. The evaluation team also developed an estimated pre-implementation operation case for each day-type based on the post-implementation metered data, equipment specification data, and any customer interviews. The day-types were then applied to each day of the year to develop an hourly profile (8760 model) of equipment operation for both the pre/base case and the post-installation case for an entire year. Using the 8760 model, the evaluation team calculated both energy and peak demand *ex post* savings values based on the difference between pre- and post-implementation condition (e.g., the operational and coincident adjustment). This was done for both electric and gas projects, producing overall energy impacts and peak demand results. Although peak gas demand is not specifically required in the evaluation it is a valuable by-product of this analysis strategy.

The construction of the profile is different for non-weather sensitive and weather sensitive measures; each is described here.

Non-Weather Sensitive Measures

For non-weather sensitive measures, the short-term data collected was used to relate the operating characteristics (such as kW), of the affected equipment to other parameters such as time of day, day-type, production levels, operating schedules, and other factors specific to the project, as determined through examination of the original calculations as well as through on-site interviews. Typically, multiple relationships were required to sufficiently account for annual expected operating patterns and variations. The relationships were then annualized based on the expected annual patterns in production, day-type relationships, and other factors to determine the savings for each hour of the year in the 8760 model.

Weather Sensitive Measures

For weather sensitive measures using IPMVP Option A and Option B, the short-term metered data collected was used to relate the operating characteristics (such as kW) of the affected equipment to outdoor air temperature and humidity levels, as applicable. Typically, multiple regression analyses were required for each individual piece of equipment to account for variations in operation for occupied versus unoccupied periods, day-types, as well as any other factor determined to be significant.

The results of the regression analysis were then used to calculate the expected usages and savings for each hour of the year, including the peak period for peak demand, using TMY3 data in the 8760 model.

Evaluating weather sensitive measures with Option C involves a somewhat different approach. Project documentation is reviewed to best determine when the energy management system was installed and became functional. In addition, site staff were interviewed to determine if any changes to the facility (building, occupancy, fuel change, etc.), not directly related to the project being evaluated occurred during the energy bill sampling period being used as the basis for Option C analysis. This is done to ensure that changes unrelated to the measure(s) under study (exogenous) can be eliminated from the analysis. This was performed using interviews, verification reports, calculation dates, and invoicing information from the project file.
Three to four years of electric and/or natural gas billing data was used for these evaluations. For most projects, there was a year to a year and a half of data available before and after energy management system deployment. This provided a representative sample of data to assess performance before and after implementation.

Billing data were weather normalized using actual weather data from the nearest weather station over the billing periods according to the utility meter read dates. Energy use per degree day (heating or cooling as appropriate) was developed using regression techniques to determine the functional relationship between energy consumption and degree days for the evaluated billing period both pre and post project implementation. The difference represents savings as a function of degree days. Savings for a "typical meteorological year" (TMY), were then applied to this function to determine savings under normal conditions.
For the Option A and/or Option B portion of an analysis of an energy management system, parameters from the program-provided documentation were verified on site. Some of these were fixed parameters such as building shell features. Other parameters were varying and these typically included percentage of outdoor air, and building temperature setback (heating)

and set-forward (cooling). These parameters were targeted for inspection, metering and/or data logging as appropriate.

In some cases it was clear why savings were not being achieved. One representative example involved deployment of demand-controlled ventilation, which was intended to limit ventilation levels to roughly match the need for fresh air per person in the space, based on measured carbon dioxide levels. Program documentation indicated a very low ventilation rate prior to implementation: 5.0%, and this was proposed to be cut in half to 2.5% for energy savings.

However, the HVAC systems to which this strategy was applied needed to cool some spaces at all times, including internal spaces during even the coldest weather of the year. This control strategy overrides the ventilation air minimum requirement and therefore, the system never operated in the range of ventilation rates noted in the project proposal documentation. In this case, the cause of no *ex post* savings being found was identified using the Option C approach and verified with the Option A approach.

To determine peak demand impacts for energy management systems using primarily billing data, the projects were first evaluated for energy savings year-round, using the combination of IPMVP options described above. Once savings were verified or adjusted as appropriate, and related to a specific degree-day function, peak weather conditions found in the TMY records and were applied to these energy models to determine the demand impacts under these conditions.

Appendix B: Data Collection Instruments

The evaluation team used two interview guides, which are included here for reference: EO Participant Interview Guide and EO Vendor Interview Guide

B.1 Energy Opportunities (EO) Participant Interview Guide

(Interviewer Note: this text is only a guide. However, as part of each introduction, EMI will identify our firm and provide assurance of confidentiality.)

INTRO1: My name is **<NAME>** calling on behalf of **<COMPANY>**. May I please speak with **<CONTACT>?**

The Connecticut Energy Efficiency Board has asked that we speak with customers that have participated in the Energy Opportunities program offered by **<COMPANY>** to ensure that the program is meeting customers' needs. This is not a sales call. Our records indicate that your organization participated in the Energy Opportunities program in 2011 and installed **<LIST EQUIPMENT>**. Are you the person who is most knowledgeable about your organization's participation in this program?

[IF NOT RIGHT PERSON, ASK FOR RIGHT PERSON UNITL THEY ARE REACHED, AND REPEAT SCREENING SCRIPT AS NECESSARY]

INTRO2: Great! The Connecticut Energy Efficiency Board really values your opinions and I have a few questions about your organization's participation in the Energy Opportunities program. This should take about 30 minutes and as a thank you, we'll send you a $25 Amazon.com gift card upon completion of the interview. Is now a good time or should we schedule a time to conduct this interview? **[PROCEED OR SCHEDULE CALL AS NEEDED]**

First, I'd like to you let you know that everything we discuss today will be confidential and your responses will not be revealed to anyone outside of the research team.

General Questions & Targeted Marketing

First, I'd like to find out a little more about your organization and your experience with the Energy Opportunities program.

Q1: What was your main reason for participating in the Energy Opportunities program? Were there any other reasons?

Q2: In general, what do you think are the most important benefits of completing projects that improve the energy efficiency at your organization's facilities?

Q3: And what are some challenges your organization faces when trying to complete projects that reduce your energy bills or increase your energy efficiency? (IF NEEDED: For example, were there any challenges in completing the project that received assistance from the EO program?)

Q4: Can you explain the decision making process that your organization goes through when considering energy efficiency or energy cost reduction projects? How do you identify which projects to pursue?

Q4a: Where do you get information on equipment, and product and/or service options?

Q4b: Do you feel like you have all the information you need to be able to make decisions? If not, what is missing?

Q4c: At you organization, is there a set payback period or other financial requirement for energy efficient equipment upgrades? If so, what is it? Can you bundle equipment upgrades and/or services that look better financially with those that are less attractive to meet these requirements?''

Comprehensive Projects

CP1: There are many factors that organizations consider when making decisions about projects to improve their energy efficiency.

Can you tell me how important you believe each of the following factors are when your organization evaluates whether or not to implement a project that improves its energy efficiency:

Overall cost ____
Project payback period or other financial qualification____
Minimizing your energy bills ____
Quality of equipment ____
Effect on employee comfort/health ____
Effect on organizational productivity/operations ____
Recommendation of a contractor ____

CP3: (IF NOT ALREADY MENTIONED) Do you typically work with an external contractor to assist you with any part these projects?

IF CP3=CONTRACTOR
CP3b: Do you ask your contractor for specific recommendations about additional equipment you could install that would reduce your energy costs or improve your energy efficiency? IF NEEDED: Did they suggest anything without you requesting it?

IF Q3b=YES
CP3c: What do they suggest (probe on key systems that are missing)?

CP3d: As part of this project, did you ask the contractor to consider all the building systems as part of those recommendations or focus on certain systems? If just certain systems, which ones? Did the contactor make any suggestions on the scope of the project?

CP3e: Did the recommended project falls within your required payback or other financial guidelines? If not, what changes to the recommended project did you need to make in order to meet those guidelines?

CP3f: What factors do you consider when deciding whether or not to move forward with the contractor's additional recommendations? Did you have all the information you needed to make the decision? If not, what additional information would you need?

CP3g: Have you installed any of the additional recommended equipment? (IF YES) What did you install?

CP3h: Beyond the recommendations made by the contractor, are there any other energy efficient upgrades that you think could be made to your facility?

IF CP3=INTERNAL
CP4: Why do you decide to complete all the work internally?

CP4a: In addition to what was installed as part of the EO program, did you identify any other energy efficiency improvements you could install as part of this project? If so, what did you identify?

CP4b: Do you try to identify opportunities to reduce your energy costs across all your building systems or did you focus on certain systems? Which systems were not considered? Why?

CP4c: Of those opportunities you identified, what have you install?

CP4d: How did you identify which equipment you should install as part of this project? Did you have all the information you needed to make the decision?

CP4e: How did you decide whether or not to move forward? What criteria was the decision based on? Did this project fall within your financial performance requirements?

CP4f: Do you feel you made all the energy efficiency-related improvements you want to? If not, what other improvements would you want to make?

ALL
CP5a: (IF NOT ALREADY MENTIONED) The Energy Opportunities program offers additional financial incentives for projects that include more than one type of equipment (e.g., lighting and lighting controls or HVAC and motors). (IF NEEDED: These are known as "comprehensive projects.") Prior to today, how aware were you that the program offered these additional financial incentives?

CP5b: How would you define a "comprehensive project?"

CP6: Have you considered completing or have already completed a project that meets the program's criteria for a "comprehensive" project? If not, why? If completed, what did you complete? If considering, are you planning on completing this project? If not considering, why not?

CP7a: Does your organization consider any of the benefits from upgrading multiple building systems at once? What benefits do you consider? Which are most important? IF NOT MENTIONED, PROBE ON THEIR FAMILIARITY WITH UTILITY INCREASED INCENTIVE.

CP7b: Related, what do you believe prevents your organization from upgrading multiple building systems at once?

CP8: Besides taking advice from internal staff or hired contractors, what other sources of information do you use to help make decisions about ways to decrease your energy costs or which energy efficient projects or improvements to pursue?

ESPC Engagement

One method for financing your organization's energy efficiency projects is to enter into an energy savings performance contract or ESPC.

ESPC1: How familiar are you with Energy Savings Performance Contracting?

<u>**IF AT LEAST SOMEWHAT AWARE:**</u>
ESPC2: (If state or municipal organization) Were you aware that the State of Connecticut offers an ESPC program that would assist you with this process?

ESPC4: Did an ESPC vendor approach you? If so, which one?

ESPC5: Can you describe your understanding of the energy savings performance contracting model?

ESPC6: What do you see as the main benefits of using energy savings performance contracting to design, manage, and finance energy efficiency improvements to your facility? IF NO BENEFITS, PROBE ON WHY NOT.

ESPC8: What additional information/assistance would be valuable in making decisions related to the ESPC?

ESPC9: Have you implemented any projects using an ESPC? If so, please describe the project (probe quantity/types of measures).

<u>**IF ESPC9=YES:**</u>

ESPC9a: What, if any, benefits did your organization get/receive from participating in an ESPC?

ESPC9b: What notable challenges did the ESPC present to your organization, if any?

ESPC9c: What would you change, if anything, about the ESPC financing model or process?

ESPC9d: Would you like more information about any aspects of energy savings performance contracting? If so, what aspects?

IF ESPC9=NO:
ESPC9f: (IF ESPCs ARE AT LEAST SOMEWHAT BENEFICIAL) Have you considered implementing any projects as part of an EPSC? If no, why not? If yes, what has prevented your organization from moving forward with these projects as part of an ESPC?

IF ESPC1=NO:
An energy savings performance contract is a design, management, and financing model that organizations can use to perform energy efficiency upgrades on their buildings often with no up-front costs. The costs of the efficiency upgrades are paid for through guaranteed savings on future energy bills.

ESPC10: (If state or municipal organization) Were you aware that the State of Connecticut offers an ESPC program that would assist you with this process?

ESPC11: Is this a tool that could be valuable for your organization? If so, explain?

ESPC12: How likely is it that your firm would participate in energy savings performance contracting in the future?

ESPC13: What would prevent your firm from engaging in an ESPC project model?

Project Financing

USF0a: Typically, how does your organization finance energy efficiency projects or projects that are designed to reduce your energy costs?
Why do you choose those methods over other financing methods?
If financing from outside source, what kind of interest rates do you typically have on these options?

USF0c: How do the financial incentives offered by the program impact the decisions you make about energy efficiency improvements or projects?

What if anything would you change about the incentives offered by the program?

USF1: (IF NOT PREVIOUSLY MENTIONED) Has a lack of financing ever stopped your organization from completing a project? What about completing larger or more comprehensive project? If so, what kind of project was canceled or reduced in scope? (**IF NEEDED**: That is, did you reduce the scale of a capital project because of financing concerns?)

USF2: As one part of the Energy Opportunities Program, **<COMPANY>** can make available a number of financing options, including low-interest loans, to help pay for the cost of energy efficiency improvements at customer facilities.

Prior to today, how aware were you of these utility-sponsored financing opportunities?

USF3: Does this type of utility-sponsored financing model make sense for your organization?

USF4a: If interested, how would this financing affect your organization's decision-making process? (IF NEEDED: for example, does it change the type or size of energy efficiency improvements you are able to consider?)

IF AT LEAST SOMEWHAT AWARE:
USF5: Where did you first hear about utility-sponsored financing?

USF6b: What, if anything, would you change about the utility-sponsored financing offered by the EO program?

USF7: Have you used utility-sponsored financing to complete any projects? If so, please describe the project (probe quantity/types of measures).

USF6a: Would you like more information about any aspects of utility-sponsored financing? If so, what aspects?

IF USF7=YES:
USF7b: To what extent was the opportunity to use utility-sponsored financing a significant factor in deciding to pursue/implement these projects?

USF7c: Would you have pursued the project without utility-sponsored financing?

USF7d: What, if any, benefits to your organization did you get/receive by using the utility-sponsored financing? What were the benefits?

IF USF7=NO:
USF8: What were your organization's reasons for *not* using utility-sponsored financing?

ALL
USF9a: How interested do you think your organization would be in using utility-sponsored financing in the future?

USF9b: (IF NOT ALREADY ADDRESSED) What, if anything, might prevent your company from using utility financing?

USF10: Is there anything else that would make utility-sponsored financing more appealing to your organization or increase your likelihood of using it? If so, what?

Strategic Energy Plans

SEP1: Does your organization use an organized plan to decide on what energy cost or energy efficiency projects to pursue? I call that a "strategic energy plan"?

IF PLAN EXISTS:
SEP2: What prompted you to create an organized plan regarding your organization's energy use?

SEP3: Who is responsible for making the energy plan for your organization? Are they also responsible for its execution?

SEP4: Is anyone else involved in the review and implementation of the plan? If so, who (probe for role, not specific staff)? Is it regularly reviewed? If so, how often?

SEP5: What factors are considered when developing an energy plan?

SEP6: How is progress toward its goals assessed?

SEP7: What, if any, benefits has your organization received due to developing and/or implementing an energy plan?

SEP8: Have you implemented any projects due to your organization's use of the energy plan? If so, please describe the project (probe quantity/type of measures).

SEP8a: Would you have installed this equipment if you didn't have an energy plan in place?

SEP9: Are there currently any factors preventing you from implementing your plan? If so, what are they?

IF NO PLAN:
SEP12: How does your firm make decisions about energy usage or ways to controls your energy costs? ?

SEP13: (IF NOT ALREADY ADDRESSED) How familiar would you say you are with the process of developing an energy plan?

SEP14: Is there anything that prevents you from developing and adopting an energy plan?

ALL (IF NEEDED)
SEP15: Is there any type of assistance the EO program could offer to encourage or help with a formal energy plan. If so, what?

SEP16: Is there any type of assistance vendors/contractors could offer to encourage or help with a formal energy plans, and if so, what?

Building Benchmarking

Some people use systematic ways to evaluate their buildings' current energy performance against what they are doing now or compared to the performance of similar types of buildings. By setting priorities and tracking energy consumption over time, this process can be used to identify opportunities for energy efficiency improvements, measure the impact of efficiency measures, and inform energy management or strategy plans. I call this process "building benchmarking."

BB1: How aware are you of the building benchmarking process as a practice?

<u>IF AT LEAST SOMEWHAT AWARE:</u>
BB3: Have you conducted any building benchmarking within your organization? If so, what form did it take?

<u>If BB3=YES:</u>
BB3a: What did you do? (Examples include energy use intensity (EUI) analysis, Portfolio Manager, building modeling and more informal language – include all descriptions)

BB3b: Did you use any benchmarking tools? (If yes) Which ones? (If not) Are you aware of the benchmarking tools available?

BB3c: At your organization, who was involved with the building benchmarking process? Was it internal staff or an external staff? If internal, what were their roles? If external, what type of organization provided the assistance?

BB3d: Which management roles review benchmarking results? Do they find the results useful?

BB3e: How has your organization benefited as a result of conducting building benchmarking?

BB3f: Have you implemented any energy efficiency projects due to the results of your building benchmarking? If so, please describe the project (probe quantity/type of measures).

<u>If BB3f=YES</u>
BB3fa: Would you have completed this project without the results of the building benchmarking?

BB3fb: How, if at all, have you used the benchmarking to monitor the impact of your energy projects?

BB3g: Is there any type of assistance the EO program could offer to encourage or help with building benchmarking, and if so, what?

BB3h: Do you have easy access to utility billing data in forms that support benchmarking?

BB3i: What types of utility-supplied energy benchmarking tools and/or data would be helpful to you?

<u>IF NOT BENCHMARKING:</u>
BB4a: What factors prevent you from benchmarking the energy consumption of your organization? Do you think your organization would benefit from benchmarking?

BB4b: (IF NOT ALREADY MENTIONED) Do you have staff that would be able to conduct the building benchmarking?

BB4c: (IF NOT ALREADY MENTIONED) What type of benchmarking do you think your organization would be most interested in?

BB5d: Are you familiar with the available benchmarking tools?

BB6: (IF NEEDED) What, if any, assistance could the EO program provide that would encourage your organization to pursue some sort of building benchmarking option?

Satisfaction & Program Accessibility

EXP1: We're almost done; just a couple of questions about your organization and the program overall. First, how many employees does your organization have?

EXP2: (IF NOT ALREADY IDENTIFIED AS ENERGY MANAGER) Do you have an Energy Manager or someone in charge of your organization's energy use?

EXP3: How did you first hear about the Energy Opportunities program?

EXP4: In general, how satisfied are you with your overall experience with the EO program (probe for reasons)?

EXP5a: Let's talk about a couple of specific aspects of the program (for each, probe for reasons).

EXP5b: Overall, how satisfied would you say you are with the EO program staff? With who did you most frequently interact?

EXP5c: What about the EO application process? How satisfied are you with the application? The time it takes to complete it? The information it requires?

EXP6: What other assistance would you like to see offered by the EO program?

EXP7: How likely is it that your organization will participate in the EO program again?

EXP8: What do you think were the most useful or valuable parts of the EO program?

EXP9: What improvements, if any, would you like to see in this program?

EMAIL: Those are all the questions I have for you. Again, as a thank you, I'd like to send you a $25 Amazon.com gift card. Can I get your email address?

I want to thank you very much for your time!

B. 2 Energy Opportunities (EO) Vendor Interview Guide

(Interviewer Note: this text is only a guide. However, as part of each introduction, EMI will identify our firm and provide assurance of confidentiality.)

INTRO1: My name is **<NAME>** from Energy Market Innovations calling on behalf of the Connecticut Energy Efficiency Board and **<COMPANY>**. May I please speak with **<CONTACT>**?

The Connecticut Energy Efficiency Board has asked that we speak with contractors that have participated in the Energy Opportunities program to help ensure the program is meeting everyone's needs. <u>This is not a sales call.</u> Our records indicate that your company conducted projects for the Energy Opportunities program in 2011. Are you the person who is most knowledgeable about your company's participation in this program?

[IF NOT RIGHT PERSON, ASK FOR RIGHT PERSON UNITL THEY ARE REACHED, AND REPEAT SCREENING SCRIPT]

INTRO2: The Connecticut Energy Efficiency Board really values your opinions and I have a few questions about your company's participation in the Energy Opportunities program. This should take about 20 minutes and as a thank you, we'll send you a $25 Amazon.com gift card upon completion of the interview. Is now a good time or could we schedule a time to conduct this interview? **[PROCEED OR SCHEDULE CALL AS NEEDED]**

First, I'd like to you let you know that everything we discuss today will be confidential and your responses will not be revealed to anyone outside of the research team.

Introduction

First, I'd like to find out a little more about your experience with energy efficient equipment.

F1b: What are the major services your firm provides to your customers in terms of energy efficiency? What is the most common efficiency measure you typically install or recommend for customers?

F5b: In general, what do you think are the main benefits <u>to your customers' businesses</u> in implementing EE projects?

F5c: What barriers, if any, do you think your customers face when considering additional energy efficiency projects?

Comprehensive Projects

CP1: Has your company completed "comprehensive" projects, that is projects that include more than one type of equipment? (IF YES) Do these projects typically include all building systems or do they typically focus on specific building systems such as lighting, HVAC systems, or something else? (NOTE: specific organizations may have different terminology for these projects. Replace as necessary.)
What types of equipment or improvements do these projects typically include?

IF COMPLETES COMPREHENSIVE PROJECTS:

CP3: When first discussing projects, do you actively recommend "comprehensive" projects or do your customers tend to request that you tell them everything they ought to do? Does the customer typically have an idea of what kind of improvements they would like completed or are they looking for advice from you about which improvements to complete? (PROBE FURTHER AS APPROPERIATE.)

IF TRADE ALLY RECOMMENDS:
CP4: What are the common types of equipment you typically recommend as additional measures? Which are most common and which would you consider "secondary" or less common? Why are they less common?

Do these recommendations include all building systems? If not, why not?
Are there energy improvements that you might identify but not recommend or promote to customers? What are they?
Why wouldn't you recommend them? How do you decide which improvements to recommend to customers?

CP5: How does your company approach selling projects that include multiple energy improvements to customers? (Probe for business practices) What types of equipment are the hardest to sell? What approaches work best?

CP5c: Do you feel like you are able to talk to customers about the value of combining energy efficiency improvements that are very cost-effective with improvements that may be less cost-effective? Are customers interested in this type of "stacking" or portfolio approach?

CP6: Generally, how receptive are your customers to your recommendations for expanding these projects?

CP7: Do customers typically follow all of your recommendations?

If not, what reasons do customers typically give for not following your recommendations?
What would you hear frequently?
What opportunities are frequently "left on the table?"

CP8: And what prevents your company from recommending that customers complete all available opportunities for reducing their energy costs? (If lack of demand/interest is mentioned, probe for specific information such as "why do you feel customers aren't interested in equipment/reducing their energy costs further?")

IF CUSTOMER REQUESTS

CP9a: Are there common types of equipment your customers typically request as additional measures? Do these requests usually include all the types of building systems or applicable technologies? If not, what are customers leaving out?
Are there energy efficiency improvements that you might identify but not recommend or promote to customers? What are they?
Why wouldn't you recommend them? How do you decide which improvements to recommend to customers?

CP9b: What, if anything, prevents your company from recommending "comprehensive" projects more often?

IF NOT INVOLVED IN COMPREHENSIVE PROJECTS

CP10: What, if anything, prevents your company from completing "comprehensive" projects or projects that include multiple types of energy efficiency improvements? (Probe for barriers)

ALL

CP12: During the project process, who else is typically involved besides your firm and the customer? (PROBE FOR ROLE, NOT SPECIFIC PERSONS) What type of influence do these people have on the decision-making process?

CP9: Do you ever combine measures with longer paybacks with measures with shorter paybacks to meet your customers' payback requirements? What are the typical financial requirements customers need in order to move forward with a project?

CP10: To what extent do the current incentives offered through the EO program encourage your customers to install multiple types of equipment instead of just focusing on one system or type of equipment? To what extent do you think the incentives encourage customers to make all of the possible energy improvements at their facilities?

CP11: Have you noted any increase or decrease in your customers' general interest in comprehensive projects? What about completing projects that include all of the potential energy improvements?

CP12: What, if anything, do you think could be done to better promote comprehensive projects? And what is needed to make sure those projects include all potential energy improvements?

Project Financing

USF0a: How do your customers typically finance their energy efficiency projects or other projects designed to reduce their energy costs? Which are most frequent?

How do the financial incentives offered by the program work with these options?

USF0b: How influential are the EO program incentives on your recommendations for energy efficiency improvements to customers? How influential do you feel they are in the customers' decisions to upgrade to energy efficiency equipment?

Are they a significant part of the sales process?
How could they be improved?

USF1: As one part of the Energy Opportunities Program, <COMPANY> can make available a number of financing options, including low-interest loans, to help pay for the cost of energy efficiency improvements at customer facilities.

Prior to today, how aware were you of these utility-sponsored financing opportunities?

IF AT LEAST SOMEWHAT AWARE:
USF2: Do you actively inform customers about utility-sponsored financing options when proposing a job?

IF USF2=YES:

What types of customers are most interested in utility-sponsored financing?

USF5: What effect do the financing options have on the type of projects completed by your customers? (Probe for effect on size, measure-type, and efficiency.)

USF6: How significant is the availability utility-sponsored financing in encouraging customers to implement a project?

USF7: When is the offer of utility-sponsored financing most important? (Probe for certain project size, extent, type, etc.)

IF USF2=NO
USF8: Why do you not include utility-sponsored financing as part of your proposals to your customers?

ALL
USF9: (IF NOT ALREADY MENTIONED) What barriers, if any, might your company face when promoting utility-sponsored financing of energy efficiency projects?

USF10: (IF NOT ALREADY MENTIONED) What, if any, barriers might your customers face when selecting utility-sponsored financing?

USF11: Overall, how interested do you think your customers would be in using utility-sponsored financing in the future?

USF12: Is there anything else that would make utility-sponsored financing more appealing to your customers and increase your likelihood of recommending it? If so, what?

Marketing

M1: Does your company actively promote energy efficiency to your customers? What about the EO program?

IF M1=YES

M2a: How does your company go about marketing and promoting energy efficiency to your customers? (Probe for business practices and mediums, e.g. types of materials face-to-face, flyers, phone calls, etc.).

M2b: Are there particular types of customers you find more receptive to energy efficiency than others, and if so, what types of customers?

M3: Do you customize your customer promotions based on any characteristics such as industry, size, location, etc.? IF YES: How?

ALL

M6. What , if anything, do you need to better recommend or sell more energy efficiency improvements?

General Feedback

GF1a: We're almost done; just a couple of questions about your firm and the program overall. How many staff are employed by your organization?

GF1b: About what proportion of your company's 2011 revenue came from providing energy efficiency improvements for your customers?

GF1c: Roughly, what proportion of your company's 2011 work (in terms of revenue) specifically involved the EO program?

GF2a: In general, how satisfied are you with your overall experience with the EO program (probe for reasons)?

GF4: (IF NEEDED) What other assistance would you like to see offered by the EO program?

GF5: How likely is it that your company will encourage customers to participate in the EO program again (probe for reasons)?

GF6: What do you think were the most useful or valuable parts of the EO program?

GF7: And finally, what changes, if any, would you like to see in this program?

EMAIL: Those are all the questions I have for you. Again, as a thank you, I'd like to send you a $25 Amazon.com gift card. Can I get your email address?

I want to thank you very much for your time!

Appendix C: Metering Equipment Compliance

The metering equipment used in this evaluation meets the requirements of the M-MVDR.[2] Each of the specific types of metering equipment used in this evaluation is described below.

1.1 Hobo UX90 Light On/Off Logger

The Hobo UX90 light on/off logger is a state logger that records the time and determine light state (on/off) when a change in state is determined, based on observed light level. When installed, the Hobo UX90 must be launched from a computer that has the clock synchronized to a NIST time source and programmed with a logging interval of no less than once every 15 minutes. For this evaluation, all loggers installed were launched from a computer with a UTC-calibrated clock, and were deployed with a sampling interval no greater than 5 minutes, for a minimum of 3 weeks. Per the manufacturer specifications, the UX90 loggers have a rated time accuracy of ±1 min/month. This meets the requirements of the M-MVDR.

1.2 Hobo U12-012 Lumen Level Loggers

The Hobo U12-012 Temp/%RH/1 external channel/ lumen level logger is a status logger that records the dry bulb temperature, % relative humidity, information made available by 1 external devices, and lumen level at a preset time interval. When installed, the Hobo U12-012 must be launched from a computer that has the clock synchronized to a NIST time source and programmed with a logging interval of no less than once every 15 minutes. For this evaluation, all loggers installed were launched from a computer with a UTC-calibrated clock, and were deployed with a sampling interval no greater than 5 minutes, for a minimum of 3 weeks. Per the manufacturer specifications, the U12-012 loggers have a rated time accuracy of ±1 min/month. This meets the requirements of the M-MVDR. Because the Temp/%RH/lumen level will not be used to correlate to demand, but instead is used at a "threshold" variable indicating light status, the lumen level accuracy requirement is not subject to the M-MVDR requirements and is not addressed.

1.3 Hobo U12-013 External Channel Status Loggers

The Hobo U12-012 Temp/%RH/2 external channel logger is a status logger that records the dry bulb temperature, % relative humidity, and information made available by up to 2 external devices at a preset time interval. When installed, the Hobo U12-012 must be launched from a computer that has the clock synchronized to a NIST time source and programmed with a logging interval of no less than once every 15 minutes. For this evaluation, all loggers installed were launched from a computer with a UTC-calibrated clock, and were deployed with a sampling interval no greater than 5 minutes, for a minimum of 3 weeks. Per the manufacturer specifications, the U12-012 loggers have a rated time accuracy of ±1 min/month. This meets the

[2] ISO New England. (2012). ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources (Manual M-MVDR). Revision 4. Effective June 1, 2012. Retrieved from: http://www.iso-ne.com/rules_proceds/isone_mnls/m_mvdr_measurement_and_verification_demand_reduction_revision_4_06_01_12.doc

requirements of the M-MVDR. Because the temperature/%RH will not be used to directly calculate demand they are not required to meet the ±2% accuracy set forth by the M-MVDR for proxy variables.

1.4 Dent Elite Energy Logger

The Dent ElitePro kW logger is a status logger that records the average kW over a predetermined time interval by measuring the total kWh for the stated time interval. When installed, the Dent ElitePro logger must be launched from a computer that has the clock synchronized to a NIST time source and programmed with a logging interval of no less than once every 15 minutes. Per the manufacturer specifications, the Dent ElitePro loggers have a rated time accuracy of ±5 sec/week. The Dent ElitePro combined with SCT Amp Current Transformers have a combined rated accuracy of ±1.5% within 10% to 130% of SCT Amp Current Transformer rated current. This meets the requirements of the M-MVDR for both ±2 min/month time accuracy and ±2% kW accuracy.

Appendix D: Peak Period

There are several values for demand impacts. This section first presents definitions of the demand values and then presents the methods for estimating demand impacts for lighting and non-lighting.

D.1 Peak demand definitions

Per the requirements of this evaluation, four values for electric demand reductions and two values for gas demand reductions are presented for each project. The six demand values are:

- Summer Peak—This is the average demand reduction during the summer 1:00-5:00 PM period during non-holiday weekdays in June, July, and August
- Winter Peak—This is the average demand reduction during the winter 5:00-7:00 PM period during non-holiday weekdays in December and January
- Summer Seasonal Peak—This is the average demand reduction during the summer hours that the ISO New England Real-time System Hourly Load is equal to or greater than 90% of the most recent "50/50" System Peak Load Forecast for the Summer Season, including June, July, and August
- Winter Seasonal Peak—This is the average demand reduction during the winter hours that the ISO New England Real-time System Hourly Load is equal to or greater than 90% of the most recent "50/50" System Peak Load Forecast for the Winter Season, including December and January
- Peak Day—This is the daily CCF reduction for the average coldest day per year for the past 30 years.
- Extreme Peak Day—This is the daily CCF reduction for the coldest day in the past 30 years.

D.2 Peak demand estimate methods

For the purposes of this evaluation, all peak demand reductions were calculated using an 8760 hour modeling approach, with the expected demand reductions being calculated for each hour of the year. Using this approach, the summer and winter peak demand reductions can be determined by averaging the non-holiday weekday peak hours as defined previously.

However, the determination of the seasonal peak is determined on the hourly system load, and if that system load is greater than or equal to 90% of the expected 50/50 peak load forecast. Therefore, the times and dates for this condition cannot be so easily defined. It has been shown that system load is found to be related to both the time of day, as well as weather conditions.

Seasonal Peaks

This section provides greater detail on the seasonal peaks: summer seasonal peak and winter seasonal peak.

Summer Seasonal Peak

The Total Heat Index (THI) and Weighted Heat Index (WHI) are forecast variables used by ISO New England to relate system load and weather conditions. Both attempt to account for temperature and humidity levels. In addition, WHI includes a "history" component to account for weather conditions in the previous two days. THI and WHI are calculated as:

THI = 0.5 x DBT + 0.3 x DPT +15, where

THI = Total Heat Index

DBT = Dry Bulb Temperature (°F)

DPT = Dew Point Temperature (°F)

and

WHI = 0.59 x $THI_{di\text{-}hi}$ + 0.29 x $THI_{d(i-1)\text{-}hi}$ + 0.12 x $THI_{d(i-2)\text{-}hi}$, where

WHI = Weighted Heat Index

$THI_{di\text{-}hi}$ = Total Heat Index for current day and hour

$THI_{d(i-1)\text{-}hi}$ = Total Heat Index for previous day at the same hour

$THI_{d(i-2)\text{-}hi}$ = Total Heat Index for two days prior at the same hour

For this evaluation, in order to determine the summer seasonal peak hours, the non-holiday weekday hourly system load profile from the ISO New England Hourly Zonal (SMD) report, was correlated to both Total Heat Index (THI) and Weighted Heat Index (WHI), where the THI and WHI were based on Hartford (Brainerd), CT weather conditions. The resulting relationship, showing only temperatures 75°F and above, is given in Figure 2 below.

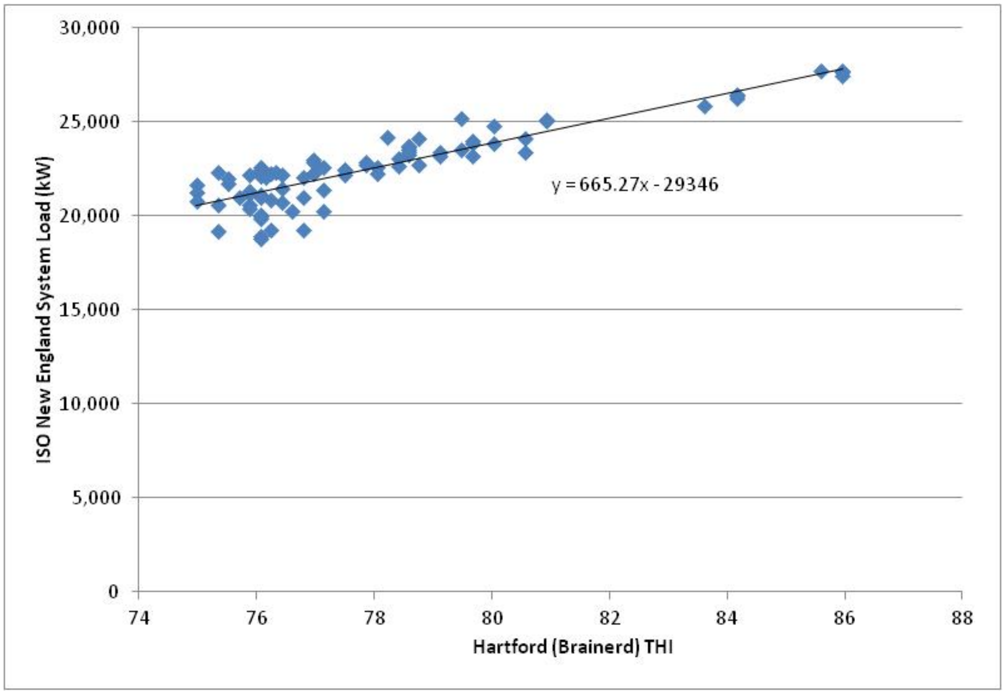


Figure 2 System Load as a function of THI

Based on the 2011-2020 Forecast Report of Capacity, Energy, Loads, and Transmission report, the expected 50/50 system peak load for the summer condition was expected to be 27,550 kW.[3] Therefore, 90% of the 50/50 system peak load for the summer condition is met when the system load was 24,975 kW or greater. Based on the WHI relationship developed above, this is expected to be met when the THI conditions are 81.6°F or greater. Therefore, hours used to determine the peak for the purposes of this evaluation were the hours when the THI was at or greater than 81.6°F for Hartford (Brainerd) for the TMY3 file utilized.

A similar approach was taken to correlate to WHI; however, the WHI correlation did not affect the hours selected, and therefore was not included.

Winter Seasonal Peak

To determine the winter seasonal peak demand reductions, a similar approach was taken as given above. However, several changes were made to the analysis. First, based on the 2011-2020 Forecast Report of Capacity, Energy, Loads, and Transmission report, the expected 50/50 system peak load for the winter condition was expected to be 22,085 kW.[4] Therefore, 90% of the 50/50 system peak load for the winter load condition is met when the system load was 19,877 kW or greater. Second, for the winter condition, humidity is not expected to significantly affect the system load; therefore, the system load is correlated to dry bulb temperature. Finally, based

[3] ISO New England. (2011). 2011-2020 Forecast Report of Capacity, Energy, Loads, and Transmission. Retrieved from: http://www.iso-ne.com/trans/celt/report/2011/2011_celt_rprt.pdf
[4] ibid

on a review of the data, the system load varied significantly based on the time of day. Therefore, the decision was made to produce separate correlations for each hour considered.

Figure 3 System Load as a function of Dry Bulb Temperature for Hour 18

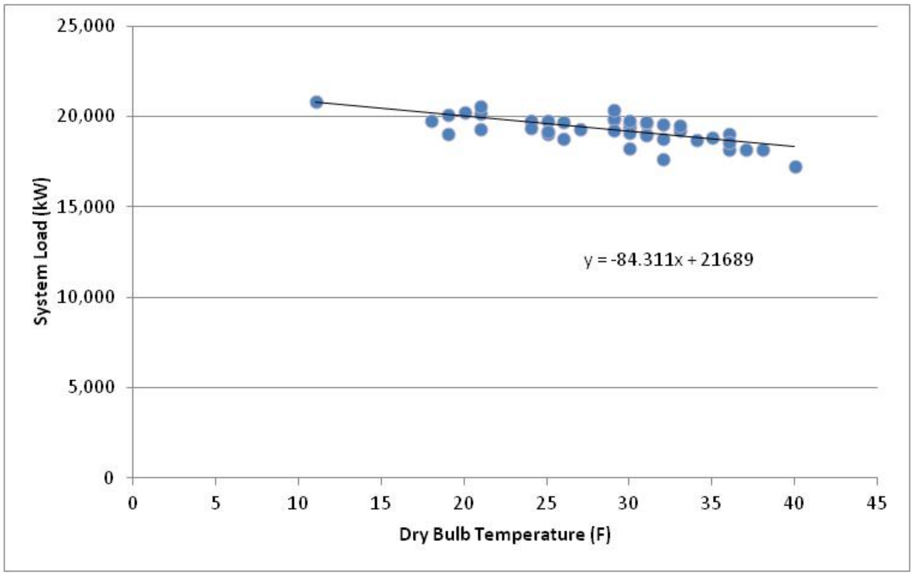


Figure 4 System Load as a function of Dry Bulb Temperature for Hour 19

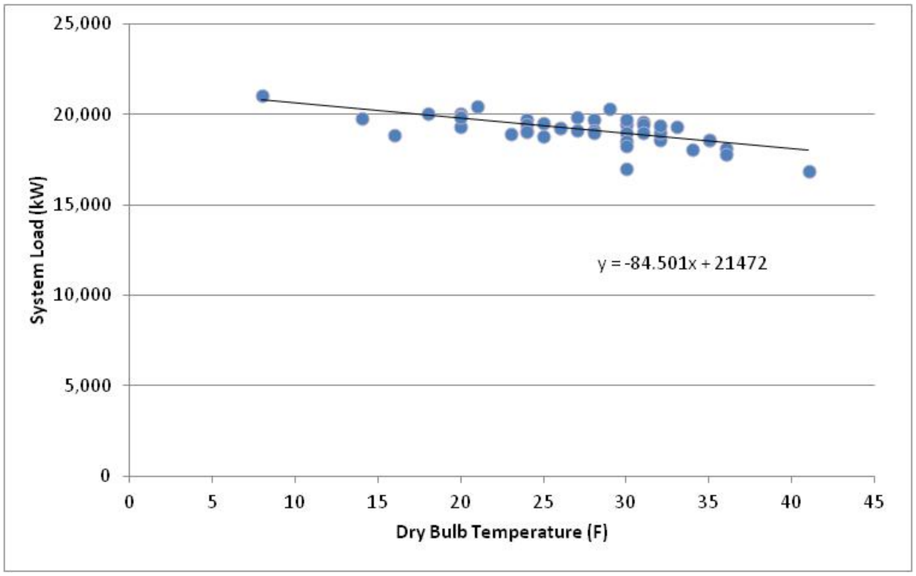
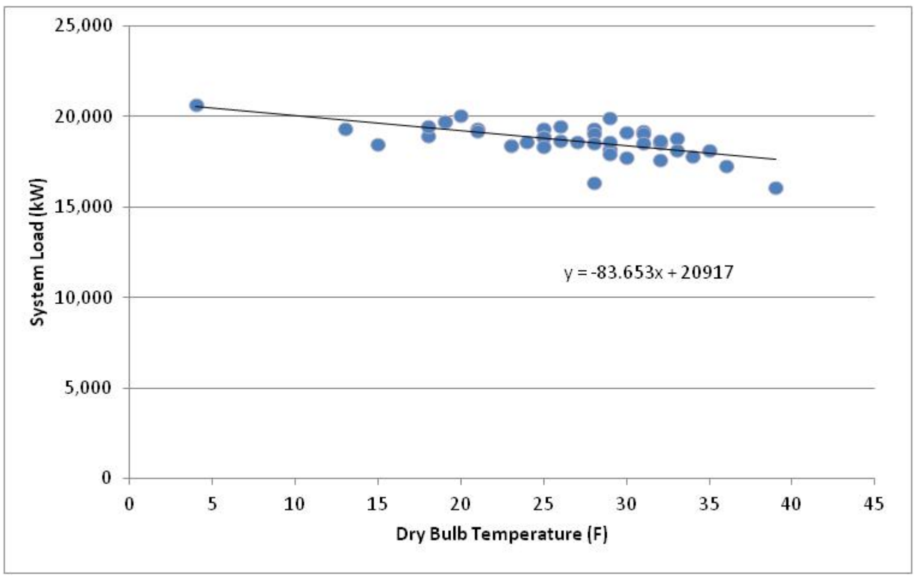


Figure 5 System Load as a function of Dry Bulb Temperature for Hour 20



Based on this analysis, the peak load condition is expected to be met when the temperature is at or below the temperatures given for each hour listed in the table below.

Table 1 Winter Peak Temperature Conditions

Hour	Starting Time	Ending Time	Dry Bulb Temperature (F)
Hour 16	5:00	6:00	20.4°F
Hour 17	6:00	7:00	17.7°F
Hour 18	7:00	8:00	5.0°F

Appendix E: Forward Looking *Ex ante* Values

Project ID	Measure Description	Summer Seasonal Peak Demand (kW)	Winter Seasonal Peak Demand (kW)	Yearly Savings (kWh)	Notes
CE10L258	Interior Lighting Retrofit	2.52	1.60	9,035.14	COP from 2.4 to 3.5
CE11L580	LIGHTING	0.39	0.26	1,172.03	COP from 2.4 to 3.5
EA10L396	LED Retrofit	0.00	0.00	4,612.61	COP from 2.4 to 3.5
EA10L397	LED Retrofit	0.00	0.00	1,153.15	COP from 2.4 to 3.5
EA11C018	Lighting	2.12	1.91	9,401.73	None - Does not use IE
EA11L014	Exterior LEDs	0.00	0.32	999.00	None - Exterior
EA11L032	Lighting	3.23	2.05	7,786.82	COP from 2.4 to 3.5
EA11L441	LIGHTING	1.30	0.90	3,827.82	COP from 2.4 to 3.5
EA11L452	LIGHTING	2.15	1.45	6,406.40	COP from 2.4 to 3.5
EA11L480	LIGHTSandOCC SENSORS	1.09	0.71	8,217.86	COP from 2.4 to 3.5
EA11L490	Outdoor Lighting	0.00	0.90	6,037.20	None - Exterior
EA11L575	OCC SENSORS	0.23	0.21	770.00	COP from 2.4 to 3.5
EA11L584	Lighting	0.25	0.16	321.20	COP from 2.4 to 3.5
EA10L408	Install Retrofit ligjhting	1.09	0.81	6,188.24	COP from 2.4 to 3.5
CE11L432	Lighting Retrofit	8.24	4.44	35,145.18	COP from 2.4 to 3.6 Cs from 0.600 to 0.599 and Cw from 0.380 to 0.388
CE11L592	OCC SENSORS	7.08	6.33	23,529.00	COP from 2.4 to 3.5
CE11L643	Lighting	10.55	7.13	40,309.28	COP from 2.4 to 3.5
EA10L198	Lighting replacement w/ hi eff	3.51	2.36	21,950.40	COP from 2.4 to 3.5
EA10L219	LIGHTING	0.00	0.00	23,747.30	None - Exterior
EA11L521	LIGHTING	5.37	3.99	21,513.36	COP from 2.4 to 3.5
WE11C004	LIGHTING	8.79	10.01	49,275.83	None - Does not use IE
WE11L221	High Effic Ltg and Controls	4.11	2.84	18,560.26	Cs from 0.600 to 0.599 and Cw from 0.380 to 0.388
WE11L351	Install retrofit Lighting	2.71	2.31	24,181.69	Cs from 0.900 to 0.904
WE11L425	Interior and Exterior Lighting Upgrade	12.09	10.03	46,622.07	None - Does not use IE
WE11L475	Outdoor LED lighting	0.00	1.16	11,882.94	None - Does not use IE
WE11L604	Lighting	2.25	1.55	15,873.00	COP from 2.4 to 3.5
WE11L606	Lighting	1.70	1.17	12,012.00	COP from 2.4 to 3.5
CE11L155	Interior Lighting	11.87	7.54	40,235.91	COP from 2.4 to 3.5
CAjn	EOP-LIGHTING, CUSTOM, INTERIOR, LED/INDU	4.74	3.12	28,776.03	COP from 2.4 to 3.5

CE10L309	Exterior Lighting	0.00	0.00	94,142.49	None - Does not use IE
CE11L010	Lighting	14.38	11.21	86,907.44	COP from 2.4 to 3.5
CE11L423	Freezer cooler Lighting	8.96	8.96	78,524.64	None - Does not use IE
CE11L585	INTERIOR LIGHTING	9.90	9.90	86,724.00	None - Does not use IE
CE11L601	LIGHTING	9.11	5.79	75,984.68	COP from 2.4 to 3.5
CE11L651	Install LED freezer lighting	7.64	7.71	69,351.24	COP from 2.4 to 3.5
EA09L441	retrofit lighting and controls	10.76	7.21	56,872.10	COP from 2.4 to 3.5
EA10L274	Install Retrofit Lighting	9.62	6.47	49,959.54	COP from 2.4 to 3.5
EA11L433	Exterior Lighting	0.00	5.65	63,963.00	None - Does not use IE
WE11L039	Interior Lighting Upgrades	10.25	7.00	59,741.37	COP from 2.4 to 3.5
WE11L433	Lighting retrofit	7.57	4.45	27,274.50	COP from 2.4 to 3.5
WE11L504	Lamp and Ballast Retrofit	12.11	8.21	77,327.76	COP from 2.4 to 3.5
WE11L544	Lighting and Occ. Sensors	22.10	12.41	69,632.51	COP from 2.4 to 3.5
WE10L183	Lighting upgrades	9.32	6.27	62,287.10	COP from 2.4 to 3.5
AX26	EOP-LIGHTING, STANDARD	17.15	11.85	60,757.13	COP from 2.4 to 3.5
CE09C019	Lighting	82.39	46.54	247,604.70	COP from 2.4 to 3.5
CE09L381	retrofit lighting	30.49	16.24	258,100.13	COP from 2.4 to 3.5
CE10L248	Interior Lighting	13.22	8.91	67,725.78	COP from 2.4 to 3.5
CE10L248	Exterior Bonus Lighting	0.00	0.00	75,580.51	COP from 2.4 to 3.5
CE10L248	Interior Bonus Lighting	28.93	19.46	167,277.46	COP from 2.4 to 3.5
CE10L248	Exterior Non Bonus Lighting	0.00	0.00	13,315.53	COP from 2.4 to 3.5
CE10L318	LIGHTING	23.24	23.24	203,539.00	None - Does not use IE
CE11L446	Lighting Retrofit	11.28	11.28	98,786.52	None - Not conditioned
CE11L555	LIGHTINGandOC C SENSORS	30.80	20.74	125,427.06	COP from 2.4 to 3.5
EA10C027	Occupancy Sensors	30.27	19.08	65,464.01	COP from 2.4 to 3.5
EA10C027	LED Lights Exterior	0.00	0.00	99,480.66	COP from 2.4 to 3.5
EA10C027	Exterior Lighting EMS	0.00	0.00	17,426.36	COP from 2.4 to 3.5
EA10C055	Lighting and Controls	7.11	4.80	23,481.24	COP from 2.4 to 3.5
EA10C055	Lighting and Controls	14.59	9.12	82,176.05	COP from 2.4 to 3.5
EA10C055	Lighting and	7.45	5.03	39,156.89	COP from 2.4 to 3.5

	Controls				
EA10C055	Lighting and Controls	1.19	0.80	12,307.02	COP from 2.4 to 3.5
EA10C055	Lighting and Controls	0.64	0.43	6,636.83	COP from 2.4 to 3.5
EA10C055	Lighting and Controls	1.40	0.94	13,132.43	COP from 2.4 to 3.5
EA10C055	Lighting and Controls	8.12	5.49	30,780.99	COP from 2.4 to 3.5
EA10C055	Lighting and Controls	1.19	0.80	9,875.09	COP from 2.4 to 3.5
EA10C055	Lighting and Controls	1.19	0.80	9,747.94	COP from 2.4 to 3.5
EA10C055	Lighting and Controls	3.22	2.18	19,502.34	COP from 2.4 to 3.5
EA11L021	Lighting	25.68	14.32	217,824.92	COP from 2.4 to 3.5
EA11L563	Lighting	21.52	13.67	145,104.96	COP from 2.4 to 3.5
WE09L265	Lighting Retrofit	53.12	27.99	177,486.69	COP from 2.4 to 3.5
WE10C166	Retrofit Existing Outdoor Lights to Induct	0.00	0.00	108,768.23	COP from 2.4 to 3.5
WE11L443	Lighting	14.72	7.88	115,075.00	COP from 2.4 to 3.5
EA09L423	RETROFIT LIGHTING	20.60	13.87	108,486.40	COP from 2.4 to 3.5
C11M	EOP-LIGHTING, STANDARD	14.14	11.28	103,827.94	COP from 2.4 to 3.5
CGGP	EOP-LIGHTING, CUSTOM, INTERIOR	35.22	23.71	192,400.41	COP from 2.4 to 3.5
CPvP	EOP-LIGHTING, EXPRESS SERVICE	34.36	19.55	268,944.09	COP from 2.4 to 3.5
CE10C048	Interior Lighting and lighting Controls	145.40	104.31	536,479.17	COP from 2.4 to 3.5
CE10C048	Exterior Lighitng	0.00	0.00	41,302.06	COP from 2.4 to 3.5
CE10L242	New and Retrofit Lighting With Lighting Controls	130.84	106.50	1,089,958.80	COP from 2.4 to 3.5
EA10C028	New Lighting and controls	193.96	152.72	1,062,121.76	COP from 2.4 to 3.5
EA10C028	Interior LED Lifghitng	21.93	15.99	127,167.00	None - No Calcs
EA10C028	Exterior Retrofit lighting	0.00	0.00	20,417.00	None - No Calcs
EA10C028	Exterior LED lighting	0.00	0.00	132,984.00	None - No Calcs
EA11S434	Lighting Retrofit LED case lights	58.05	58.05	717,354.47	None - Refrigerated Cases
WE09L258	Lighting Retrofits	161.47	85.11	545,728.85	COP from 2.4 to 3.5
WE10C163	Lighting Retrofit	93.77	50.40	693,706.80	None - No Calcs

	and Controls				
WE10L061	New interior fluorescent and inductive lighting	236.29	184.24	1,822,696.13	COP from 2.4 to 3.5
WE10L061	New exterior inductive lighting	22.53	13.18	147,045.36	COP from 2.4 to 3.5
C5nb	EOP-LIGHTING, CUSTOM, INTERIOR	133.73	92.71	891,164.19	None - No Calcs