Using In-depth Interview to Estimate Non-energy Impacts Resulting from Commercial and Industrial Energy Efficiency Measures
Tin # 1: Consumer Marketing and Intelligence

Noel Stevens, DNV KEMA, Burlington, MA
Lindsay Foley, National Grid, Waltham, MA
Susan Weber, DNV KEMA, Burlington, MA
Pam Rathbun, Tetra Tech, Madison, WI
Miriam Goldberg, DNV KEMA, Madison, WI

ABSTRACT

This paper presents the methods and results of study that yielded statistically reliable estimates of the non-energy impacts (NEI). These were generated by an extensive set of commercial and industrial energy efficiency measures implemented with the support of utility programs in Massachusetts. The study, completed in June of 2011, identified and quantified using the results of in-depth interviews with 505 participants who had implemented 789 measures, with program support. After the interviewers identified categories of cost and revenues impacted and the general direction of those changes, deeper probes were used to determine the nature of those changes and specific metrics for quantifying the impact. This approach improved upon previous NEI survey efforts by having interviewers work with respondents to help them monetize the NEIs and ensure that the respondent thought about the various sub-categories that could apply to an NEI. After completing the interviews, researchers used a multi-step process to translate the qualitative interview responses into a quantitative NEI estimates. We identified a set of standard formulas and metrics for each cost and revenue center (e.g. the cost or revenue items) impacted under each NEI category. Standardizing the formulas across multiple measures allowed analysts to evaluate each in terms of the necessary metrics (i.e. salary, hours, price), and the range of responses to those metrics ($/hour). The evaluation team used ratio estimation to extrapolate results to the population of measures and estimate average NEIs per unit of energy savings. We provided separate average NEI estimates for prescriptive and custom electric and gas measures aggregated into 15 separate reporting categories. In nearly all cases, we found statistically significant average NEIs per unit of energy savings.

Introduction

This paper presents study results of the Massachusetts Cross-Cutting Evaluation Team's analysis of Non-Energy Impacts (NEI) attributable to 2010 commercial and industrial (C&I) retrofit programs administered by the Massachusetts Program Administrators (PAs). The goal of this study was to provide a comprehensive set of statistically reliable NEI estimates across the range of C&I retrofit programs offered by the Massachusetts electric and gas PAs. The evaluation team identified the following objectives for this study:

1. Quantify participant NEIs by gross NEIs per unit of energy savings separately for prescriptive and custom electric and gas measures; and
2. Examine the attribution rates of individuals who did and did not realize NEIs to inform the appropriate free-ridership rate for computing net NEIs.

Non-Energy Impacts (NEIs) include positive or negative effects attributable to energy efficiency programs apart from energy savings. Non-energy benefits (NEB) frequently refer to positive NEIs, while negative NEIs—non-energy costs— reflect ways that energy efficiency measures result in adverse effects. NEIs (or NEBs) can be further distinguished into participant and societal NEIs. This paper focuses on participant non-energy impacts, which Hall et al (2003) define as "monetary and non-monetary benefits (positive or negative) that directly benefit a program partner, stakeholder, trade ally, participant, or the participant's household."

DNV KEMA embarked on this study to fulfill the directive set forth by the State's Department of Public Utilities to update and improve non-energy impact estimates for use in the PA's 2013 to 2015 energy efficiency three-year plan and future annual plans. In addition, the PAs use study results to assist in program marketing, as NEIs increase the value proposition of Energy Efficiency programs for participants.

Methodology

The NEI Study was based on survey data collected from a sample of 2010 C&I program participants for prescriptive and custom as well as electric and gas measures. The primary source for the sample frame was the pool of respondents to the 2011 Massachusetts free-ridership and spillover study, which allowed the evaluation team to examine the relationship between program attribution and NEIs.[1] [2] Drawing on the lessons learned from prior studies (e.g. TecMarket Works and Optimal Energy Research), we conducted a large scale in-depth interview (IDI) effort to provide statistically significant NEI estimates across program type (prescriptive and custom) and fuel types (electric and gas) by measure category.

While there is a wealth of literature surrounding NEIs, there is fairly limited current NEI research specific to Massachusetts-based C&I programs. Our approach builds on the accomplishments of two previous studies that are the most current and directly applicable to the PA's C&I Energy efficiency programs.

- **TecMarket Works (2007),**[3] used a survey based approach to obtain self-reported non-electric benefits to custom measure programs, separating NEIs into mutually exclusive business impacts that may result from the installation of energy efficiency measures.
- **Optimal Energy (2008)**[4] provided non-electric benefits associated with prescriptive C&I electric programs in Massachusetts using an engineering based approach. This study estimated cost changes resulting from newly installed lighting and energy management system (EMS) equipment, clearly defined and documented the specific sources for cost savings resulting from the installed measures.

[1] 2010 Commercial and Industrial Electric Programs Free-ridership and Spillover Study: Final Report. Prepared for the Massachusetts PAs. Prepared by TETRA TECH. July 26, 2011.

[2] 2010 Commercial and Industrial Gas Programs Free-ridership and Spillover Study: Final Report. Prepared for the Massachusetts PAs. Prepared by TETRA TECH. September 20, 2011.

[3] TecMarket Works. "*Non-Electric Benefits from the Custom Projects Program: A look at the effects of custom projects in Massachusetts*" Prepared for: National Grid. Roth, Johna and Nick Hall. September 25, 2007.

[4] Optimal Energy, Inc. *Non-Electric Benefits Analysis Update. D.P.U. 09-119.* Attachment AG-1-22 (j). . *Mosenthal, Phil and Matt Socks. November 7, 2008.*

The present study incorporated elements from each of these studies in order to further the evolution of NEI research. Our approach used self-reported responses to a series of questions to derive estimates of the same mutually exclusive NEI categories developed by Roth and Hall (2007).5 We then expanded the sample size to nearly 800 measures across prescriptive and custom EE programs. Using energy industry experts to conduct interviews allowed us to probe more deeply to identify the specific relevant business impacts because interviewers were familiar with how the installed measures may impact a facility. Interviewers followed structured probes to extract information to estimate NEIs, similar to the engineering based approach used in the Optimal Energy study. These probes allowed respondents to express the NEIs in terms with which they are familiar (i.e. number of hours saved to change light bulbs and wages) rather than asking respondents to approximate values for abstract concepts such as the impact of EE lighting on operations and maintenance costs.

Interview guide and process

The research instrument provided interviewers with the needed flexibility while maintaining consistency in the data collected.

The NEI question battery focused on 13 categories, as presented in Table 1 below. The questions were structured to prevent possible double counting across categories by presenting related categories sequentially (e.g. three and four) for easier respondent recall. In addition, the interviewer protocols were designed to confirm that costs or savings included in one category were not included in any other categories. When NEI sources were determined, interviewers used additional closed ended questions to assess whether the respondent experienced an increase or decrease in each affected NEI (e.g., an increase or decrease in operations and maintenance costs as a result of the installed measure).

Because many respondents were unable to provide overall NEI estimates outright, the interviewers guided respondents through a series of structured probes to determine whether respondents experienced any changes to various cost or revenue centers associated with each NEI category. For example, internal labor and external labor are separate cost centers associated with Operation and Maintenance (O&M) costs. Once the interviewer identified the impacted cost and revenue centers, deeper probes were used to determine the nature of those changes and specific metrics for quantifying the impact. If a respondent indicated a measure affected their O&M costs, the interviewer asked another series of questions to obtain the necessary information for imputing a value. In this case, if the respondent indicated that the installed measure decreased labor costs, we asked them to estimate the number of hours that labor was reduced and the loaded or un-loaded cost of that labor.

[5] For definitions of the NEI categories see: "Final Report – Commercial and Industrial Non-Energy Impacts Study." Prepared for the Massachusetts Program Administrators by DNV KEMA and TetraTech. June 29, 2012.

Table 1. Non-Energy Impact Categories

NEI Category	Probes						
	Labor [1]	Parts / Materials	Training	Fuel [2]	Water	Fees / Permits	Other
Operations & maintenance	✓	✓	✓	✓			✓
Administration	✓		✓				✓
Materials handling	✓						✓
Materials movement	✓	✓		✓			✓
Other labor	✓		✓				✓
Spoilage/Defects	✓	✓					✓
Water usage					✓		
Waste disposal	✓	✓				✓	✓
Fees						✓	✓
Other costs							✓
Sales							✓
Rent revenues							✓
Other revenues							✓

1. Separated probes were added to change to internal and external labor.
2. Fuel included: natural gas, no. 2 distillate, no. 4 fuel oil, propane, wood, and kerosene.

Computing NEIs

DNV KEMA used a multi-step process to compute NEIs associated with each measure. This process began with the in-depth interview, and flowed into the data analysis process. The data analysis process and final estimation process were interrelated, as estimating average NEIs across all measures helped identify extreme values.

During the interview process, interviewers used their knowledge of the intersection of energy efficiency measures and business functions to identify an appropriate formula for estimating cost and benefit impacts resulting from the installed measures in relation to each specific facility. This was the first step in estimating NEIs for each measure. In order to complete this step, the interviewer captured the following information during the interview:

- Discern the relevant cost and revenue items impacted;
- Identify the nature of those impacts; and
- Capture estimates for each parameter necessary to monetize NEIs.

Interviewers used the following basic formula to capture the necessary information for computing most NEIs:

NEI cost change = (old equipment) – (new equipment)

Where

Cost change = increase or decrease in NEI category/activity
Old equipment = NEI activity prior to measure installation in 2010
New equipment = NEI activity after measure installation in 2010

Interviewers probed to ensure that the pre and post measure installation time periods were typical, and adjusted if necessary. For example, if a respondent said they repaired the boiler four times per year, interviewers asked further questions to verify the frequency of the equipment maintenance. On occasion the additional questions revealed that the repairs happened four times in 2009, but occurred only two times per year in previous years. This information was used to revise the initial response. This formula compared the typical year prior to and after the measure installation, typically 2009 to 2011.

Data analysis and Calculation of Participant NEIs

Translating the qualitative interview into NEI estimates required the following multi-step process:

1. Identifying and coding cost and revenue centers impacted for each NEI category – Responses to the detailed probes for each were re-coded to delineate the specific cost and revenue changes that resulted from the installation of the energy efficient measures, as well as the specific metrics used to quantify those impacts. For example, the evaluation team first determined that internal or external O&M labor was impacted. Then they identified the direction of that impact, as well as the hours impacted and fully loaded wage associated with that change.
2. Ensure consistency across interviewers and data analysts – Responses to open ended in-depth interviews often varied across respondents and had the benefit of eliciting information that may not be uncovered through traditional pre-determined close-ended responses. The evaluation team ensured consistency by having a second analyst responsible for reviewing all data entered, as well as verifying and standardizing data coding.
3. Construct standard set of formulas for computing NEIs –The evaluation team identified a set of standard formulas and metrics for each cost and revenue center (i.e., the cost or revenue items) impacted under each NEI category. Standardizing the formulas across multiple measures allowed analysts to evaluate each in terms of the necessary metrics (i.e. salary, hours, price), and the range of responses to those metrics ($/hour).

Table 2. Formulas used to Calculate Overall NEIs for Operations and Maintenance NEIs

NEI Category	Cost/Revenue Center	Formula	Measures using formula	Percent
Operation and Maintenance	Internal Labor	(Hours per year due to Old Equipment - Hours per year due to New Equipment)*Unloaded wage per hour*Loaded factor	21	6%
		(Hours per year due to Old Equipment - Hours per year due to New Equipment)*Loaded wage per hour	153	44%
		(Hours per year due to Old Equipment - Hours per year due to New Equipment)* Times per year*Loaded wage per hour	11	3%
		(Hours per year due to Old Equipment - Hours per year due to New Equipment)* Times per year*Unloaded wage per hour*Loaded factor	1	0%
		Hours per year due to New Equipment*Loaded wage per hour	13	4%
		Hours per year due to New Equipment* Unloaded wage per hour*Loaded Factor	2	1%
		Hours per year due to Old Equipment*Loaded wage per hour	50	14%
		Hours per year due to Old Equipment * Times per year * Loaded wage per hour	7	2%
		Hours per year due to Old Equipment * Times per year * Unloaded wage per hour*Loaded Factor	6	2%
		Hours per year due to Old Equipment * Unloaded wage per hour*Loaded Factor	3	1%
		Don't Know	1	0%
		No Calculation Required- Value stated upfront	79	23%
		Operation and Maintenance Internal Labor Total	**347**	**100%**
	External Labor	(Hours per year due to Old Equipment - Hours per year due to New Equipment)* Cost per hour	24	4%
		Cost per hour * Hours per year	26	4%
		Cost per hour * Times per year	11	2%
		Hours per year * Labor Costs	1	0%
		Hours per year*Cost per hour * Times per year	17	3%
		Labor costs * Times per year	38	6%
		Times per year * Cost per hour * Labor costs	1	0%
		No Calculation Required- Value stated upfront	550	82%
		Operation and Maintenance External Labor Total	**668**	**100%**
	Parts and Supplies	Number of parts * Cost of Parts	89	81%
		Cost of parts * Number of parts * Times per year	1	1%
		Hours * Costs of Parts	1	1%
		Times per year * Cost of parts	19	17%
		Operation and Maintenance Parts and Supplies Total	**110**	**100%**
	Training	Hours * Labor Costs	20	91%
		hours * Times per year	1	5%
		No Calculation Required- Value stated upfront	1	5%
		Operation and Maintenance Training Total	**22**	**100%**
	Other	No Calculation Required- Value stated upfront	6	100%
		Operation and Maintenance Other Total	**6**	**100%**

Table 3. Formulas used to Calculate Overall NEIs for All Other NEIs

NEI Category	Cost/Revenue Center	Formula	Measures using formula	Percent
Administration	Internal Labor	(Hours per year due to Old Equipment - Hours per year due to New Equipment)*Loaded wage per hour	49	44%
		(Hours per year due to Old Equipment - Hours per year due to New Equipment)*Unloaded wage per hour*Loaded factor	10	9%
		No Calculation Required- Value stated upfront	53	47%
		Administration Internal Labor Total	112	100%
	External Labor	Hours*Labor Costs	2	100%
		Administration External Labor Total	**2**	**100%**
Material Handling	Internal Labor	Number of hours* Loaded wage per hour	4	9%
		Number of hours*Unloaded wage per hour* Loaded factor	1	2%
		No Calculation Required- Value stated upfront	38	88%
		Material Handling Internal Labor Total	**43**	**100%**
	External Labor	No Calculation Required- Value stated upfront	4	100%
		Material Handling External Labor Total	**4**	**100%**
Other Labor	Internal Labor	(Hours per year Old Equipment- Hours per year New Equipment)*Loaded wage per hour	7	70%
		(Hours per year due to Old Equipment - Hours per year due to New Equipment)*Unloaded wage per hour*Loaded factor	1	10%
		Times per year*Unloaded wage per hour* Loaded factor	1	10%
		No Calculation Required- Value stated upfront	1	10%
		Other Labor Internal Labor Total	**10**	**100%**

1. Identify incomplete and incorrectly calculated NEIs – Assigning interview responses to the standard formulas enabled data analysts to identify incomplete, incorrect, and illogical responses.
2. Adjusting NEI estimates for replace on failure measures – During the QC process, the evaluation team realized that a number of NEIs resulted from measures that were either replaced on failure of the existing measure or replacing a functioning measure that was scheduled to be replaced immediately. The Team determined that the portion of the NEI associated with these measures' "newness" was not applicable to the program because the participant would have incurred that benefit or cost without the program.
3. Identify double counting of NEIs – By reviewing the sources of each reported NEI, their descriptions, and metrics, the evaluation team ensured that a single NEI was not reported for multiple NEI categories.
4. Eliminate invalid NEIs - Occasionally, respondents reported NEIs that should not be included in the analysis. For example, one respondent reported high "other revenue" resulting from clean energy credits which was separately accounted for in the PAs benefit-cost models.
5. Impute missing values – Approximately 40 respondents provided incomplete information for one or more of the NEIs for a measure. Imputing values for partial responses provided for reduced standard errors without biasing the results.
6. Compute total NEIs - The last step in the data coding and quality control phase was to calculate total NEIs for the measure by summing across the different NEI categories at the individual measure level. DNV KEMA used the statistical procedure of ratio estimation to develop estimates of NEI per kWh or per therm, for electric and gas measures, respectively.

Analysis of attribution

The analysis followed the same group of respondents through from the 2010 participant FR/SO study to this NEI study, allowing the evaluation team to track the attribution rates of people who did and did not report NEIs. This enabled us to examine potential differences in attribution rates for participants who realize NEIs and those who do not. Specifically, we explore whether it is appropriate to apply the same attribution rate used to estimate net savings, when estimating net NEIs. Currently, the PAs compute NEIs attributable to program activities by multiplying an estimate of NEI per unit of gross savings (e.g. per kWh) by gross savings for a measure or measure group. They multiply the resulting measure NEIs by the measure's attribution rate to calculate net NEI for the measure. This approach assumes that participants who experience NEIs have the same free ridership rate as those who do not. If free ridership rates are higher among participants who experience non-energy benefits, then the overall free ridership rate is not the appropriate value to use for non-energy impacts.

DNV KEMA's analysis applied the attribution rate from the 2010 participant FR/SO study for each respondent to the gross NEIs estimated in the present study. This provided a revised estimate of net NEIs specific to each respondent. We then calculated the average net NEI by reporting category, and compared it to the net NEIs using the traditional approach, and compared the two approaches. The evaluation team further explored differences in attribution rates and net NEIs for individuals who did and did not expect to receive NEIs prior to participation. Finally, we examined the impact of program marketing on NEI expectations and program attribution.

DNV KEMA used four separate analyses to explore the relationship between program the NEIs and the program attribution:

- A high level comparison of overall NEI values by attribution scores

- A visual inspection of plots of NEI to energy savings ratios and attribution scores
- An examination of the correlation statistics for NEI to energy savings ratios and attribution scores
- A comparison of approaches to estimate net NEIs

Results

Our analysis identified the presence of NEIs resulting from energy efficiency programs, providing statistically significant NEI estimates and also identified that there was a significant correlation between program savings and the level of NEIs reported. The evaluation team found a strong and statistically significant correlation between NEIs and savings for the following measures: prescriptive electric, custom electric and custom gas. We also found a statistically significant correlation between NEIs and savings for prescriptive gas, but this result was not as strong, largely resulting from the low sample size. These results are summarized in Table 4 below.

Prescriptive electric. HVAC measures, which included measures such as air conditioning, air handling units, and chillers, showed the highest estimated NEI ($0.097kWh), as well as the largest average NEI ($7,687 per measure). Lighting showed the second highest NEI, both in terms of NEI / kWh ($0.027/kWh) and average NEI ($1,636 per measure). Estimating NEIs associated with lighting measures are simpler than for other types of measures, because NEIs largely consisted of reduced time replacing bulbs and decreased disposal costs.

Prescriptive gas. Building envelope measures resulted in the highest NEI both in terms of NEI/therm ($3.62/therm) and average NEI ($1,551 per measure). This category included measures such as insulation and energy efficient windows and doors. Many of the NEIs for building envelope measures resulted from savings in operations and maintenance due to reduced labor in repairs and equipment replacement. HVAC measures, which include measures such as gas boilers, furnaces, and chillers, resulted in the second largest average NEI ($755 per measure) and second highest estimated NEI per therm ($1.346/therm). Most HVAC NEIs were reported as operation and maintenance savings. Through the use of energy efficient HVAC equipment, respondents stated that there was a decrease in time spent on labor and cost incurred for parts and supplies. There were fewer NEIs reported for water heater savings. Respondents noted that after the water heater was installed, there was virtually no maintenance required.

Table 4. Summary of Average Annual NEI Estimates

Electric measures	n	Average Annual NEI per Measure*	NEI/kWh	90% CI Low	90% CI High	Stat Sig
Precriptive						
HVAC	27	$ 7,687	$ 0.0966	$ 0.0544	$ 0.1389	Yes
Lighting	163	$ 1,636	$ 0.0274	$ 0.0176	$ 0.0372	Yes
Motors and Drives	50	$ 541	$ 0.0043	$ (0.0005)	$ 0.0091	No
Refrigeration	30	$ 5	$ 0.0013	$ (0.0002)	$ 0.0028	No
Other	32	$ 28	$ 0.0039	$ (0.0002)	$ 0.0079	No
Total	*302*	*$ 1,439*	*$ 0.0274*	*$ 0.0188*	*$ 0.0360*	*Yes*
Custom						
CHP/Cogen	6	$ (12,949)	$ (0.0147)	$ (0.0247)	$ (0.0047)	Yes
HVAC	20	$ 5,584	$ 0.0240	$ 0.0003	$ 0.0477	Yes
Lighting	89	$ 5,686	$ 0.0594	$ 0.0318	$ 0.0871	Yes
Motors and Drives	42	$ 1,433	$ 0.0152	$ (0.0005)	$ 0.0309	No
Refrigeration	90	$ 1,611	$ 0.0474	$ 0.0244	$ 0.0705	Yes
Other	29	$ 15,937	$ 0.0562	$ 0.0038	$ 0.1087	Yes
Total	*276*	*$ 4,454*	*$ 0.0368*	*$ 0.0231*	*$ 0.0506*	*Yes*

Gas measures	n	Average Annual NEI per Measure**	NEI/Therm	90% CI Low	90% CI High	Stat Sig
Prescriptive						
Building Envelope	2	$ 1,551	$ 3.6151	$ 2.6418	$ 4.5885	Yes
HVAC	50	$ 755	$ 1.3464	$ 0.5433	$ 2.1496	Yes
Water Heater	47	$ 129	$ 0.2604	$ (0.0012)	$ 0.5221	No
Total	*99*	*$ 439*	*$ 0.8344*	*$ 0.3634*	*$ 1.3053*	*Yes*
Custom						
Building Envelope	46	$ 922	$ 0.4774	$ 0.1258	$ 0.8290	Yes
HVAC	41	$ 2,798	$ 0.2291	$ 0.1522	$ 0.3060	Yes
Water Heater	23	$ 803	$ 0.1824	$ (0.4953)	$ 0.8601	No
Other	2	$ 1,905	$ 0.5253	$ (5.6577)	$ 6.7083	No
Total	*112*	*$ 1,940*	*$ 0.2473*	*$ 0.1490*	*$ 0.3455*	*Yes*

*Equals (NEI/kWh) x (Average annual kWh); *Equals (NEI/therm) x (Average annual therms)

Custom Electric. CHP/Cogeneration measures showed the highest negative estimated NEIs (-$12,949 per measure). NEIs for cogeneration showed negative results because the energy efficient equipment required increased preventative maintenance and increase administrative costs. The Other category showed the highest average NEI ($15,937 per measure). Lighting showed the highest NEI in term of NEI/kWh ($0.056/kWh) and the second highest in average NEI ($5,686 per measure).

Custom Gas. HVAC, which includes measures such as boilers, furnaces, and gas chillers, showed the highest estimated average annual NEI ($2,798 per measure). Building Envelope, which included measure such as insulation, windows, and doors, had the second highest estimated average NEI ($922 per measure) and the highest NEI/Therm ($0.4774/Therm).

Analysis of attribution

Of our four analysis methods, two, the correlation analysis and the comparison of net NEI estimation methods, found some evidence of a relationship between NEIs and attribution. In both cases the strongest evidence for a relationship came for the motors and drives reporting category, which plays a small role in the program's overall NEI estimates. The high attributions from the FR/SO study may be preventing us from seeing more evidence. Eighty-five percent of the intersection sample for electric and 61% of the intersection sample for gas had attributions above 75%.

When we held the samples constant and compared the PA's current estimation method for net NEIs to an alternative approach that should result in more accurate NEIs, we found only small differences in the ratios. Our analysis of the relationship between attribution and NEIs supports continuing the PA's existing estimation method for net NEIs. Further analysis of the correlation between NEIs and attribution using different attribution scores may help shed more light on their relationship.

Conclusions

Our analysis clearly identified the presence of NEIs resulting from energy efficiency programs, which provided statistically significant NEI estimates, and significant correlations between the program savings and the level of NEIs reported. However, it is important to identify study limitations as well as listed below:

Limitations

- Our research approach focused primarily on identifying annual NEIs. Consequently, the results may under estimate NEIs associated with one-time costs or benefits.
- The NEI estimates provided by this study were largely influenced by O&M cost reductions. In a number of instances this change in O&M costs resulted from decreased repair costs associated with the new, high efficiency (high quality) equipment. Due to number of assumptions required to depreciate the installed equipment and amortize the cost differential, our estimates assumed that this cost differential occurs annually, over the life of the equipment. This may over estimate NEIs associated with older measures. Further research is required to examine the appropriate treatment of NEIs associated with maintenance over time.
- NEIs may be underestimated simply due to the nature of self report surveys. Survey respondents were frequently able to identify NEIs, but we found that, for the same measure type, some did and some did not see the same NEIs across multiple respondents.
- There was an increased chance of self-selection bias because much of the sample consisted of people who agreed to be interviewed twice. This was true for all of the prescriptive measures and many of the custom measures.
- The following factors may limit the applicability of NEI estimates in other jurisdictions:
  - ✓ Values were specific to Massachusetts customers. For example the general cost of labor in MA may be higher than that in a Midwestern state.
  - ✓ The mix of measures assumes C&I programs that are retrofits, which consisted of a mix of early replacement and replace on failure measures. Additional steps should be taken to address new construction.
- The following limitations apply to the applicability of this research to future years:
  - ✓ The confidence intervals reported do not correct for the 2010 population size.
  - ✓ Significant program changes in terms of mix of measures, or favoring early replacement over replace on failure could make the NEI values from this study less applicable.