Innovative Tools for Estimating Robust Non-Energy Impacts that Enhance Cost-Effectiveness Testing and Marketing of Energy Efficiency Programs

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Abstract

While rigorous quantification of non-energy impacts (NEIs) is becoming increasingly necessary to test the cost-effectiveness of particular energy efficiency programs, NEIs can also play an important role in the design and marketing of energy efficiency programs. Participant NEIs provide policy makers and program administrators with substantial near-term benefits that can greatly enhance the cost-benefit justification of energy efficiency programs. This study is the culmination of three separate research efforts that document, quantify, and communicate the NEIs—changes in operational cost and production—that are realized by participants of energy efficiency programs within the commercial and industrial sector. Our research estimated these NEIs from information and data gathered and analyzed from self-reported interviews and an engineering-based approach for a wide range of prescriptive and custom electric and gas measures installed in retrofit and new-construction applications. In addition to quantifying a robust set of NEIs to improve the testing of program cost-effectiveness, we were able to provide implementation staff with key selling points for program marketing by detailing the specific operational cost and production/revenue changes experienced by participant facility managers. Our engineering-based analysis details the life-cycle cost differences between energy efficient and baseline technologies that can assist implementers and participants in overcoming their perceived barriers to implementing program-supported measures. Finally, the ability to readily evaluate and compare quantified NEIs in conjunction with the energy savings at the measure level allows program planners to more comprehensively determine the appropriate mix of measures during program design.

Introduction

Energy efficiency (EE) programs are typically designed to improve the cost effectiveness of and stimulate investment in energy efficient technologies by offering incentives to decrease the capital cost of these investments. Energy-efficient technologies usually consist of higher priced alternatives to standard or baseline-efficiency equipment, and these technologies often result in changes to the costs and/or production capability of facilities. These changes to economic efficiency constitute participant program-attributable non-energy impacts (NEIs) that could factor into the participant's, utility, and policy-maker's overall total resource cost (TRC) of individual measures as well as the portfolio of energy-efficiency programs.

NEIs include positive or negative effects attributable to energy efficiency programs separate from energy savings. "*Participant benefits (or NEIs)* are monetary and non-monetary benefits (positive or negative) that directly benefit a program partner, stakeholder, trade ally, participant, or the participant's household."[2]

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 and 2013 new construction programs administered by the Massachusetts Program Administrators (PAs). This research focuses on participant NEIs that are identifiable, measurable, and quantifiable as changes to their economic efficiency by program participants. The range of programmatic activities considered by this analysis requires both self-reported (survey based) and engineering-based techniques to isolate and quantify NEIs. These techniques are built on the same general approach to quantifying NEIs that identifies specific cost and revenue changes resulting from the energy-efficient (EE) technologies relative to the existing or baseline technology. The estimated NEIs are expressed in terms of costs and revenues directly relevant to the program participant's bottom line. They also serve as powerful marketing tools for program implementers responsible for communicating the investment opportunity to prospective participants.

We identified the following objectives for this study:

1. Quantify gross NEIs per unit of energy savings separately for prescriptive and custom electric and gas measures; and
2. Demonstrate the value proposition of energy efficiency programs beyond energy savings to PA sales and marketing personnel for use in marketing the program.

Methodology

Our approach builds on the accomplishments of two previous studies that are the most current and directly applicable to the PA's C&I EE programs:

- **TecMarket Works (2007),**[2] 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.[1]
- **Optimal Energy (2008)**[3] 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, and clearly defined and documented the specific sources for cost savings resulting from the installed measures.

The present study incorporated elements from each of these studies to further the evolution of NEI research:

[1] These studies included gas savings as a benefit. Therefore, they were referred to as non-electric benefits.

- **NEI estimation for retrofit measures.** For the study of NEIs associated with retrofit measures,[4] we used self-reported responses to a series of questions to derive estimates of the same mutually exclusive NEI categories developed by TechMarket Works (2007).
- **NEI estimation for new construction measures.** For EI estimation of NEIs associated with new construction measures, we used an engineering cost-estimating approach to determine NEIs for NC projects that were either new buildings or major retrofits (true new construction).[5] We limited this analysis to impacts on operations and maintenance costs. The 2012 Massachusetts C&I retrofit study showed that other sources of NEIs, such as changes in productivity, revenue, and comfort, may also result from energy efficiency measures; however, the 2016 New Construction NEI study was limited to NEIs resulting from life-cycle cost differences due to the use of an engineering-based approach.[4]

NEI information from these two approaches was then also used to provide implementation staff with marketing materials that highlight key selling points (positive NEIs) and potential barriers (negative NEIs).

Non-Energy Impact Estimation Using Self-Reports – Retrofit Measures

Our approach to estimating NEIs for retrofit measures used self-reported responses to in-depth interviews of more than 500 respondents covering 788 installed measures in 2010. These interviews broke impacts into mutually exclusive categories that reflect separate cost and revenue (business impacts) resulting from the PAs' program-sponsored installed measures. We probed respondents for a deeper understanding of the impacts on specific costs and revenues. The key components of the methodology were as follows:

- For prescriptive measures, we successfully completed 302 electric and 99 gas measure NEI interviews. For custom measures, we successfully completed 310 electric and 151 gas measure NEI interviews.
- Designed the research instruments, trained the interview staff, and oversaw quality control.
- Used experienced DNV GL energy analysts to conduct the semi-structured interviews.
- Collected data on NEI types and dollar values, and like and unlike spillover.
- Used ratio-estimation to calculate NEIs by reporting measure category or end-use, as was needed by the Massachusetts PAs for their cost-benefit analysis.[2]

The evaluation team used additional closed-ended and open-ended questions to first assess whether the respondent experienced an increase or decrease in each affected NEI (e.g., an increase or decrease in operations and maintenance costs). If so, we then obtained additional information to construct the NEI's value. Deeper probes were used to determine the nature of

[2] Ratio estimation extrapolates measure level NEIs to the population of measures, allowing for direct computation of the ratio of NEI (in dollars) to reported savings for the sample. The ratio is a combined ratio estimator, calculated as the weighted sum of NEI to the weighted sum of savings, using the same sample points and weights for numerator and denominator.

those changes and provide specific metrics for quantifying the monetary and resource impacts of the installed measures. Table 1 presents the general probes used for each NEI section.

Table 1. Non-Energy Impact Categories

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

[1] Labor included internal and external labor and included probes for assessing fully loaded costs.

[2] Fuel included: natural gas, no. 2 distillate, no. 4 fuel oil, propane, wood, and kerosene.

We used information collected through these interviews to develop standard formulas and metrics for each cost and revenue center (i.e., the cost or revenue items) impacted under each NEI category as seen in Table 2 for the Operation and Maintenance costs category.

Table 2. Example of Formulas Used to Calculate NEIs: O&M Cost Changes

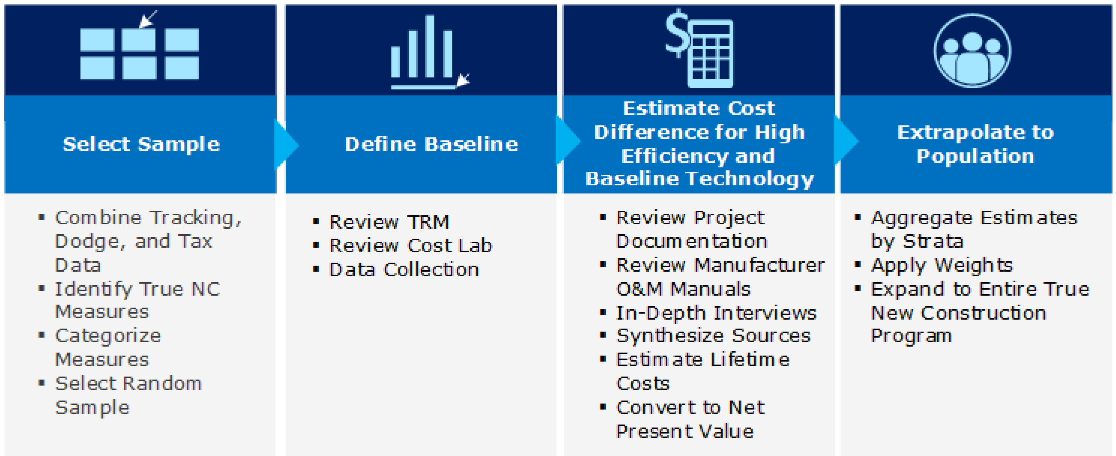
Cost/Revenue Category	Formula	Measures using formula n=x
Internal Labor	(Hours per year due to Old Equipment * Hours per year due to New Equipment)*Loaded wage per hour	145
	(Hours per year due to Old Equipment * Hours per year due to New Equipment)*Unloaded wage per hour	20
	(Hours per year due to Old Equipment * Hours per year due to New Equipment)* Times per year*Loaded wage per hour	10
	(Hours per year due to Old Equipment * Hours per year due to New Equipment)* Times per year*Unloaded wage per hour	1
	Hours per year due to New Equipment*Loaded wage per hour	9
	Hours per year due to New Equipment* Unloaded wage per hour	2
	Hours per year due to Old Equipment*Loaded wage per hour	49
	Hous per year due to Old Equipment * Times per year * Loaded wage per hour	7
	Hous per year due to Old Equipment * Times per year *Unloaded wage per hour	6
	Hours per year due to Old Equipment* Unloaded wage per hour	3
	No Calculation Required- Value stated upfront	38
	Operation and Maintenance Internal Labor Total	**290**
External Labor	(Hours per year due to Old Equipment - Hours per year due to New Equipment)* Cost per h	18
	(Hours per year due to Old Equipment - Hours per year due to New Equipment)* Labor Cos	2
	Cost per hour * Times per year	5
	Hours per year*Times per year* Cost per hour	17
	Hours per year*Cost per hour	19
	Hours per year * Labor Costs	1
	Hours per year due to Old Equipment*Cost per hour	5
	Labor costs*Cost per hour	2
	Labor costs*hours per year	1
	Labor costs * times per year	37
	Times per year* Cost per hour	6
	Times per year*Cost per hour*Labor Costs	1
	No Calculation Required- Value stated upfront	102
	Operation and Maintenance External Labor Total	**216**

Non-Energy Impact Estimation Using Engineering Analysis – New Construction Measures

Figure 1 provides a high-level overview of the four steps in our general approach for estimating NEIs for true new construction projects. First, we combined the PAs' tracking data with the Dodge Players database and tax assessors' data to isolate true NC projects, and then selected a sample of measures by benefit-cost measure category for our analysis. Next, we reviewed the technical resource manual (TRM), data contained in and required by Cost Lab[3], and other sources to construct data collection instruments and define the appropriate baseline for each sampled measure. Third, we estimated the difference in the average annual life-cycle cost between the baseline and EE technologies to reflect the NEI for each sampled measure. Finally, we computed the average NEI per unit of energy savings to identify statistically significant NEIs for each of the measure categories used in the PAs' benefit-cost analysis.

[3] . CostLab is cost-estimation software produced by CBRE Whitestone that provides estimates for building O&M costs that many institutions and large businesses use to set their O&M budgets.

Figure 1. Overview of NEI Estimation Process



Sample Design

Our selection method produced an optimally allocated sample for NEI ratio or factor estimation—in this case, NEI$/unit of energy saved. Our sample consisted of 50 custom electric measures drawn from 9 measure types, 114 prescriptive electric measures drawn from 6 measure types, 30 custom gas measures drawn from 7 measure types, and 60 prescriptive gas projects drawn from 4 measure types. This resulted in an overall sample of 254 true new construction measures out of a population of 956 measures in the 2013 program tracking data.

Selecting Baselines

The next step in estimating NEIs for new construction measures was to define the baseline technology from which we could measure facility cost changes relative to the installed energy efficient technology. For prescriptive measures included in the TRM), we used the associated baselines defined in the MA TRM. In instances where the TRM did not specify the baseline technology, we selected the most commonly installed code-compliant equipment type using our own expertise and experience, as well as the results from our in-depth interviews with equipment manufacturers, facility managers, and engineering firms.

Estimating the Cost Differences between Baseline and Energy Efficient Technologies

To estimate the cost differential between the baseline and EE technologies, we constructed detailed cost schedules for these technologies, which formed the basis for the NEI estimates. We used published data, our technical knowledge, and reported maintenance and replacement schedules outlined in the manufacturer O&M manuals, supplemented with information obtained from the in-depth interviews with equipment manufacturers and engineering firms to develop or corroborate these costs. We classified costs into the following three types for further analysis:

- *Annual maintenance* – Routine maintenance recommended by manufacturers, such as annual oil changes for reciprocating air compressors.

- *Periodic repair* – Many types of equipment require repairs during their lifetimes, while other types are not repaired but simply replaced. For example, a reciprocating air compressor will require a rebuild every three years, while a screw compressor does not.
- *Replacement* – For equipment for which the baseline option is likely to fail before the end of the useful life of the equipment, we included and amortized the cost of replacement of the option with a shorter lifetime. We considered the type of equipment that would be installed as a replacement to represent the baseline condition. Through the in-depth interviews, we found that owners replace equipment in-kind with similar equipment in most cases, except for lighting. Given the rapid adoption of more energy efficient LED lighting, we assumed that baseline lighting equipment would be replaced in-kind with a similar type of lighting for the first replacement cycle, but with LED lighting for subsequent replacement cycles.

Once we developed the NEI cost schedules and cost breakdowns, the life-cycle costs were amortized to provide the average annual cost of maintaining the baseline and energy-efficient equipment. We assumed the following in computing the net present value (NPV) of life-cycle costs:

- *Planning horizon* – For each line item, we defined the measure life of the longer-lasting piece of equipment (installed or baseline) to contrast the life-cycle costs.
- *Discount rate* – We applied a discount rate of 0.44%, as reported in the 2016–2018 Three-Year Plan.[i]
- *Capital replacement* – Equipment replaced prior to the end of the planning horizon was assumed to be replaced in-kind and amortized over its useful life. The annual payment of that equipment appeared as a liability starting in the year the equipment was replaced until the end of the planning horizon.

For example, in the table below a T8 fixture is presumed to be replaced with an LED fixture in year 10. LED fixtures last ten years, but there are only five years remaining in the analysis period. Therefore, we amortized the cost of the LED fixture over ten years to get $14 per year. Applying this $14 for each of the remaining five years accounts for the fact that the LED fixture will continue to be in-place and in operation after our analysis period (for five more years), and so much of its value remains.

We estimate NPV costs of $209 and $81 for a T8 and LED fixture, respectively, over an analysis period of 15 years. As a result, the estimated NEI for an efficient LED fixture is $129 relative to the baseline T8 fixture.

Table 3. Example of NPV of Cost Differences for a Sampled Lighting Fixture Measure (Assuming 3 Lamps per Fixture) *

Type	Cost Category	Costs by Year (values measured in dollars)															Net Present Value		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Measure	Totals	NEI
Baseline T8	Bulb Change	0.0	0.0	9.9	0.0	9.9	0.0	0.0	9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.7	132	132
	Recycle	0.0	0.0	3.2	0.0	3.2	0.0	0.0	3.2	0.0	3.2	0.0	0.0	0.0	0.0	0.0	12.7		
	Fixture Replacement	0	0	0	0	89	0	0	0	0	0	0	0	0	0	0	89.2		
Efficient LED	Bulb Change	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	
	Recycle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	Fixture Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0		

*Items shown in bold/red indicate capital costs incurred at some future year. Since the expected life for those costs extends beyond the analysis period, we limited the portion of costs used in the NEI computation to the annual costs incurred during the analysis period.

Once we estimated NEIs per unit of energy savings ($ per kWh or therm) for each sampled measure, we applied sample weights to calculate the estimated NEI per unit of energy savings for the group of measures represented by our sample.

NEI Marketing Methodology

Once we identified sources of NEIs and quantified their impact, we were able to repurpose the data used to construct NEI estimates to provide implementation staff with the most valuable information for their marketing efforts. This analysis focused on statistically significant NEI sub-categories (e.g. internal labor, external labor, parts and supplies) within each industry. For the NEI marketing analysis we summarized both quantitative and qualitative NEI results.

Results

Retrofit Measure Self-Reported NEI Results

The results of the retrofit and new construction NEI studies are presented in Table 4 below. Our analysis of NEIs associated with retrofit measures are as follows:

Prescriptive electric. HVAC showed the highest estimated NEI ($0.097kWh), which were largely driven by decreases in annual maintenance costs. Lighting showed the second highest NEI, both in terms of NEI / kWh ($0.027/kWh) and average NEI ($1,636 per measure), which was driven by the increased life of energy efficient lighting leading to fewer bulb changes.

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). 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.

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 increased administrative costs.

Custom Gas. HVAC showed the highest estimated average annual NEI ($2,798 per measure). Building Envelope had the second highest estimated average NEI ($922 per measure) and the highest NEI/Therm ($0.4774/Therm), largely due to a reduction in annual maintenance costs.

Table 4. NEI results for retrofit measures

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)

New Construction Measure Engineering Analysis NEI Results

The results of the new construction NEI studies are presented in Table 5 below. For new construction measures, we provide NEI estimates for several measure categories even though they are not statistically significant at the 10% significance level or better. Examples of the level of detail concerning the operational cost savings provided by this analysis include:

- *Lighting* –The only savings from the T5 versus the baseline (T8s) is the reduction in number of fixtures, resulting in a 10% increase in lumens that translates into fewer lamps used at the site. LEDs, however, last significantly longer and only need to be replaced every ten years, whereas the T8 and T5 technologies require bulb replacement every three years, and ballast or fixture replacement every five years.

- *HVAC* – In a new construction setting, NEIs for HVAC measures often have offsetting positive and negative NEIs. For example, centrifugal compressors require more maintenance than a screw, and a screw requires more than a scroll compressor. However, a magnetic bearing centrifugal compressor does not require oil and therefore offers a unique and valuable NEI by reducing oil changes, oil analysis, oil pump rebuilding, and oil heater/cooler maintenance.

Table 5. NEI results for New Construction measures

	Sample Category	Average Annual NEI per Measure	Average Annual NEI per Measure	Lifetime Replacement NEI/ kWh or NEI/ Therm	Operations and Maintenance NEI/ kWh or NEI/ Therm	Overall NEI/kWh or NEI/ Therm	p-value, ratio ≠ 0	90% CI Low	90% CI High	Statistically Significant?
Electric - Custom										
	CHP	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Not Studied
	Comprehe	$ 11,605	$ 207	$ 0.002	$ (0.001)	$ 0.001	0.84	$(0.007)	$ 0.009	Not Recommended
	Compress	$ 1,872	$ 1,155	$ 0	$ 0.026	$ 0.026	0.08	$ 0.002	$ 0.050	b
	Commerc	$ 660	$ 0	$ 0	$ 0	$ 0	0.00	$ 0	$ 0	0
	HVAC	$ 331	$ 330	$ 0.001	$ 0.001	$ 0.001	0.44	$(0.002)	$ 0.005	a
	Lighting	$ 3,044	$ 84	$ 0.002	$ (0.001)	$ 0.001	0.55	$(0.001)	$ 0.003	Not Recommended
	Motors	$ (1,034)	$ 0	$ 0	$ 0	$ 0	0.00	$ 0	$ 0	0
	Other	$ -	$ 0	$ 0	$ 0	$ 0	0.00	$ 0	$ 0	0
	Industrial	$ 4,008	$ 3,990	$ 0.000	$ 0.013	$ 0.013	0.02	$ 0.004	$ 0.022	b
	Refrigerat	$ 293	$ (436)	$ 0.005	$ 0.002	$(0.001)	0.90	$(0.020)	$ 0.017	Not Recommended
	Overall	$ 3,113	$ 362	$ 0.002	$ 0.002	$ 0.002	0.57	$(0.004)	$ 0.007	Not Recommended
Electric - Prescriptive										
	Compress	$ 1,872	$ 1,717	$ 0	$ 0.038	$ 0.038	0.00	$ 0.033	$ 0.042	c
	Commerc	$ 660	$ 0	$ 0	$ 0	$ 0	0.00	$ 0	$ 0	0
	HVAC	$ 1	$ 0	$ 0	$ 0	$ 0	0.00	$ 0	$ 0	0
	Lighting	$ 1,344	$ 744	$ 0.014	$ 0.006	$ 0.020	0.00	$ 0.013	$ 0.027	c
	Motors	$ 0	$ 0	$ 0	$ 0	$ 0	0.00	$ 0	$ 0	0
	Overall	$ 887	$ 514	$ 0.009	$ 0.006	$ 0.015	0.00	$ 0.010	$ 0.021	c
Gas - Custom										
	Building S	$ -	$ 0	$ 0	$ 0	$ 0	0.00	$ 0	$ 0	0
	Comprehe	$ (878)	$ (121)	$ 0	$ (0.004)	$(0.004)	0.13	$(0.008)	$ 0.000	a
	Boilers		$ (76)	$ 0	$ (0.006)	$(0.006)	0.19	$(0.013)	$ 0.002	a
	Commerc	$ 515	$ 2,732	$ 0	$ 3.399	$ 3.399	0.02	$ 0.961	$ 5.836	b
	HVAC/ H	$ (45)	$ 4	$ 0	$ 0.000	$ 0.000	0.41	$(0.000)	$ 0.001	a
	Other Gas	$ -	$ 0	$ 0	$ 0	$ 0	0.00	$ 0	$ 0	0
	Other	$ (2,875)	$ (241)	$ 0	$ (0.027)	$(0.027)	0.37	$(0.078)	$ 0.023	a
	Industrial	$ 77	$ 72	$ 0	$ 0.007	$ 0.007	0.51	$(0.011)	$ 0.025	Not Recommended
	Overall	$ (696)	$ (79)	$ 0	$ (0.004)	$(0.004)	0.02	$(0.008)	$(0.001)	b
Gas - Prescriptive										
	Boilers		$ (139)	$ 0	$ (0.085)	$(0.085)	0.00	$(0.112)	$(0.059)	c
	Commerc	$ 515	$ 2,732	$ 0	$ 3.399	$ 3.399	0.02	$ 0.961	$ 5.836	b
	HVAC/ H	$ 176	$ 17	$ 0.200	$ (0.094)	$ 0.106	0.65	$(0.278)	$ 0.491	Not Recommended
	Other Gas	$ 15	$ 17	$ 0	$ 0.053	$ 0.053	0.00	$ 0.043	$ 0.063	c
	Overall	$ 51	$ 253	$ 0.007	$ 0.222	$ 0.229	0.12	$(0.013)	$ 0.471	a

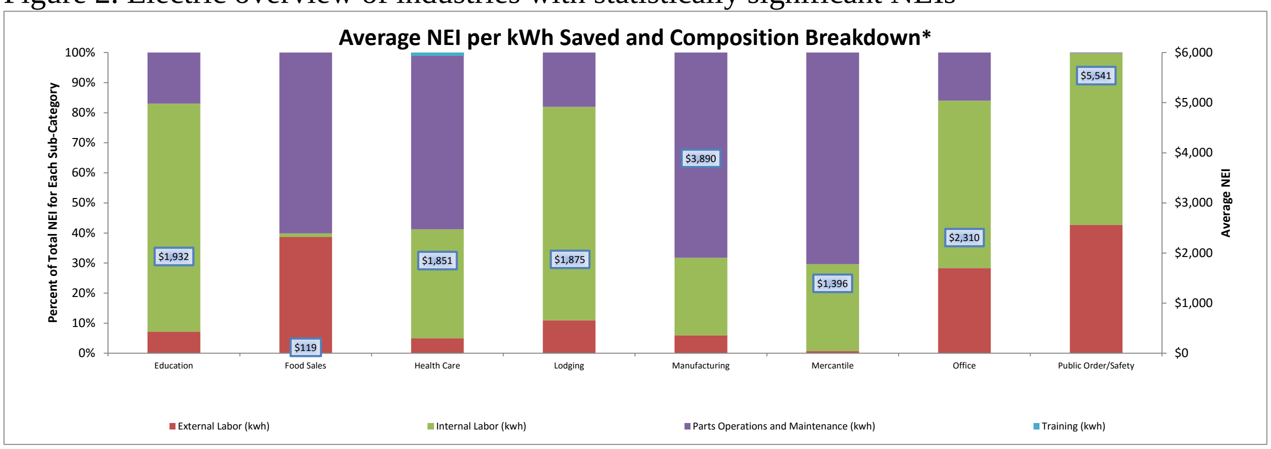
a: Recommended, but not well determined (.10 < p ⩽ .50);b: Recommended, statistically significant at 90% confidence (p ⩽ .10); c: Recommended, statistically significant at 99% confidence (p ⩽ .01) 0: NEIs are determined to be negligibleNot Recommended: p >.5

NEI Marketing Analysis Results

DNV GL re-examined the data used to compute NEIs by measure type for retrofit projects to provide program implementers with key selling points that call out sources of cost savings for customers within various industries. The highest median NEIs are reported by the public order/public safety, manufacturing and office segments. While sources for those NEIs vary considerably across these three segments, parts and supplies make up the largest share of the average. Figure **2** below presents the median NEI for electric measures by industry. The figure also shows the percent of each industry's NEIs that are derived from internal labor, external labor, parts and supplies, and training. Combining the quantified NEIs with their qualitative explanations provide powerful marketing messages for EE programs. For example:

- **Healthcare –**The most prevalent NEIs resulted from parts and supplies, as thermostats did not need to be replaced due to electronic sensors and fewer lighting components needed to be on hand. EMS and control systems led to decreased maintenance and repair costs as staff were notified of the need for servicing prior to equipment failure. Further, staff were reported to spend less time coordinating with vendors, changing out lighting ballasts, and had fewer bills to pay, which saves time invoicing and receiving and stocking equipment.
- **Manufacturing –** Within the manufacturing sector**,** the most prevalent NEIs resulted from internal labor as electricians spent less time maintaining lighting because there were fewer internal repairs with high-end equipment. Respondents reported production gains as plants experienced less downtime and an overall increase in worker activity.

Figure 2. Electric overview of industries with statistically significant NEIs*



***** Median NEI presented for each industry = NEI/kWh savings X Median Savings for the industry

Conclusions

Our analysis demonstrates that participant NEIs provide important indicators of the overall value proposition of EE programs and the measures they support. Positive NEIs can provide substantial benefits to program participants, thereby helping to justify the capital investment in EE technologies. Negative NEIs identify areas where program support may be required to offset annual maintenance charges, or suggest that program planners reallocate resources to measures with lower life-cycle costs to eliminate barriers to implementation. Finally, program evaluators and regulatory agencies should seek to include NEIs in benefit cost tests used to assess the cost-effectiveness of EE programs as they provide a clearer indication of the overall changes to economic efficiency resulting from EE programs.

Limitations

Our research approach focused primarily on identifying annual NEIs. Consequently, the results may underestimate NEIs associated with one-time costs or benefits. 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 Massachusetts may be higher than that in a Midwestern state.
- The new construction NEI study was focused on operational cost changes only. Because the measures installed were new construction, we could not justify including productivity or revenue increases, as our analysis did not find such changes would occur from an engineering perspective. Further research is required to explore whether there are additional sources of NEIs.

For the C&I retrofit study, 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.

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