SUMMARY OF BUILDING OPERATOR CERTIFICATION PROGRAM EVALUATIONS

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This report is a deliverable submitted to Consumers Energy as part of a multi-year, independent evaluation contract to conduct impact, process, and market assessment studies relating to the nonresidential sector programs administered by Consumers Energy.

The independent evaluation team includes the following firms:

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EXECUTIVE SUMMARY

As part of its Energy Optimization portfolio, Consumers Energy is piloting a Building Operator Certification (BOC) program. The BOC program is a nationally recognized training and certification course offered by 16 energy-efficiency program administrators, many of which offer training in multiple states. The program has an established curriculum and follows a consistent set of implementation processes, although the instructors vary by location. Multiple evaluations of BOC programs have been conducted since the program's inception. To support a decision to expand its BOC pilot program in the future, Consumers Energy sought input from its evaluation team to gain a better understanding of the potential for deeming measurable savings based on the results of prior evaluations of BOC programs.

The following report was prepared by the independent evaluation team led by Energy Market Innovations (EMI) to inform the future implementation and possible expansion of this program. This research focused on a review of *non-measure* savings – that is, savings from changes in operations and maintenance (O&M) practices – associated with BOC training programs operated across the United States. The evaluation team reviewed 16 prior BOC program evaluations and, focusing on the six studies providing information most pertinent to Consumers Energy's interest, produced a summary of O&M and program-level savings attributable to BOC training programs. This research included a desk review of the underlying engineering estimates used by the summarized evaluations and a synopsis of lessons learned from the prior evaluations that provide guidance for the Consumers Energy BOC program.

The six pertinent BOC evaluations reviewed by the research team reported savings associated with the BOC training programs. However, reported program savings varied across the evaluation reports depending on the end-uses included in the study, the underlying engineering estimates assigned to individual O&M actions, the distinction between equipment and O&M savings, as well as the research method used to attribute to the BOC training itself some percentage of savings from all O&M-related actions taken by trained staff. Thus, the evaluation team was unable to conclude that multiple program evaluations or the preponderance of evidence suggests a given savings estimate. Nonetheless, the team is able to recommend that Consumers Energy conduct the BOC program and claim savings based on prior research.

Specifically, the team recommends that Consumers Energy use the program-level per-participant O&M savings estimate of 0.058 kWh and 0.518 MBtu per square foot[1], with an assumed average per-participant square footage of 194,500, as derived by the evaluation of the Minnesota BOC program. The team considers this savings estimate to be conservative from three perspectives, in relation to: (1) the savings estimates reported by the other studies, (2) the findings from our engineering desk review, and (3) the average square footage each building operator is assumed to influence. The team believes it appropriate for Consumers Energy to assume BOC O&M training impacts persist for (at least) five years, based on 2005 research conducted for NEEP.

Consumers Energy should continue to conduct the post-training six-month follow-up survey to provide a measure of trainee's energy efficiency activities subsequent to training. Such a survey effort could be expanded at any time into a full impact analysis of the program, by revising the survey (increasing its complexity and length) to capture the detail necessary to understand the energy-use implications of any equipment and O&M behavior changes and by linking these change data to engineering models or calculations.

[1] The Minnesota evaluation reported savings of 0.00518 therm per square foot, which would be the equivalent of 0.518 MBtus, where 1 MBtu = 1,000 Btus, or 0.000518 MMBtus, where 1 MMBtu = 1,000,000 Btus.

The team recommends that Consumers Energy conduct the research necessary to quantify savings from energy-efficient, yet non-incentivized equipment that trained operators report installing as a result of their training experience. These savings are among the direct impacts of the BOC program, yet these savings initially can be estimated only retrospectively. It may be the case that research spanning multiple groups of trainees suggests that per-participant average savings from non-incentivized equipment installations is rather stable; in such case, a deemed value might be determined from sufficient data. Such research, along with analogous research on the influence of the BOC on rebated equipment installations, could result in a higher, more accurate cost-effectiveness estimate for the BOC program.

1. INTRODUCTION

Consumers Energy contracted with the independent evaluation team led by Energy Market Innovations, Inc. (EMI) to conduct impact and process evaluations of the C&I program portfolio of its Energy Optimization Plan (EO Plan). Consumers Energy is currently piloting the Building Operator Certification (BOC) program and sought input from the evaluation team to support a decision to expand the pilot in the future and to gain a better understanding of the potential for measurable savings. The BOC program is a national program platform that utilities throughout the U.S. have incorporated into their energy efficiency portfolios. Because the program is virtually identical across administrators, training materials have been extensively tested and numerous evaluations have been conducted in recent years. Therefore, the first phase of BOC research for Consumers Energy entailed a thorough review of prior process and impact evaluations of BOC programs implemented throughout the United States.

The evaluation team's scope of work included two main tasks:

- Review program designs and evaluations of BOC programs implemented in other regions and summarize lessons learned and best practices.
- Summarize operations and maintenance (O&M) savings associated with other BOC training programs.

The evaluation team identified 16 BOC-related studies that varied widely in content, some being overviews of previous studies and others only presenting process evaluations. To be as clear as possible regarding the basis for the savings estimates presented in this report, the evaluation team chose to use original works only.[2] Among these studies, the evaluation team identified a handful of reports presenting original results from combined process and impact evaluations of BOC programs. Therefore, this analysis is drawn from the six reports listed in Table 1-1.

2 We found that, in general, these original works referenced and used previous BOC evaluations to inform their research.

Table 1-1: Data Sources

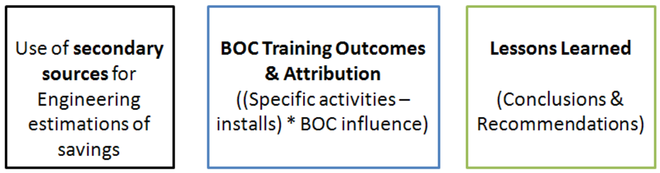
Short Name	Report Title
NEEA_Navigant_2011	Long-Term Monitoring and Tracking Report on 2010 Activities, June 15, 2011. Sponsored by Midwest Energy Efficiency Alliance. Author: Navigant Consulting.
MEEA_MN_Navigant_2011	Evaluation Of MN BOC Training, March 24, 2011. Sponsored by Midwest Energy Efficiency Alliance and Minnesota Office of Energy Security. Author: Navigant Consulting.
KCPL_ODC_2009	Evaluation Of Kansas City Power And Light's Building Operator Certification Program, September, 2009. Sponsored by Kansas City Power and Light. Author: Opinion Dynamics Corporation.
NEEP_RLW_2005	Impact and Process Evaluation Building Operator Training and Certification (BOC) Program, June, 2005. Sponsored by Northeast Energy Efficiency Partnership. Author: RLW Analytics.
NEEP_RIA_2002	Evaluation Of The Building Operator Training And Certification (BOC) Program In The Northeast, September 6, 2002. Sponsored by NEEP and six utility companies: Northeast Utilities, National Grid, NSTAR, KEYSPAN Energy Delivery, Long Island Power Authority, and Unitil Corporation. Author: Research Into Action, Inc. and GDS Associates, Inc.
NEEA_RIA_2001	Regional Building Operator Certification Venture: Final Market Progress Evaluation Report, September 20, 2001. Sponsored by Northwest Energy Efficiency Alliance. Author: Research Into Action, Inc. and Stellar Processes, Inc.

The most significant findings from the evaluation team's review of these six reports is that evaluators across the country have relied on relatively old estimates of O&M savings to calculate program savings. In addition, O&M savings also tend to be custom-calculated based on unique O&M actions in unique facilities. These findings are presented in more detail in Section 3.

The next section of this report summarizes reported methods and impact findings across the reviewed studies, and Section 3 summarizes process evaluation findings and lessons learned. Section 4 summarizes the lessons learned from other BOC program evaluations, and Section 5 closes with next steps for the BOC program. Appendix A provides details with respect to savings assumptions related to various BOC program activities of the programs reviewed for this research.

2. OVERVIEW

The evaluation team's in-depth review of the reports listed in Table 1-1 found some similarities across the studies, yet also many differences in approach and metrics reported. The evaluation team used these features to frame this analysis. In all cases, the reports contained three components as illustrated in the following figure; we will summarize each component separately.



Before presenting a summary table of engineering estimates for O&M actions reported, this section describes the common methodologies and constraints found in evaluations estimating impact findings from BOC programs. First, this section gives a brief description of how savings for BOC programs have been estimated. This section then summarizes overall similarities and differences across the six studies with respect to: 1) the use of engineering estimates (units and metric reported) and 2) the methods used to calculate behavioral impacts.

2.1. Overview of BOC program savings estimates

From prior program evaluation methods and from the desk review tables (below), we see that reasonable engineering estimates can be specified for specific O&M actions and end-uses. However, at the core of the BOC program evaluation task is the issue of attribution – identifying whether, and to what extent, the BOC training influences trainees to take (new or more) measurable O&M actions that lead to program-attributable reductions in energy consumption.

It would be relatively easy to attribute O&M savings to the program using engineering estimates by end-use if we could assume that *prior to training* none of the best practices being taught during BOC training were practiced by any of the trainees at any of their facilities. However, prior evaluations have shown that, prior to their training, BOC trainees typically practice at least some of the O&M actions supported by the training program. Therefore, attribution and estimates of savings attributable to the program requires that evaluators know something about O&M actions commonly being practiced both before and after BOC training.

The following is a thumbnail sketch of how program evaluators have calculated savings attributable to BOC training. First, baseline activities for specific O&M actions supported by BOC training were collected from trainees reporting on *pre-training* O&M practices (frequency, end-use, etc.). Alternatively, other studies collected survey data from non-participants to establish current standard practices for comparison to post-trainee practices. Trainees were surveyed after they have completed their BOC training to establish *post-training* activity levels for select O&M practices. Evaluators compared pre- and post- (or participant and non-participant) incidence of the targeted O&M behaviors to establish which, and to what extent, trainees' O&M practices changed. Differences are attributed to the influence of the BOC training. Typically, an engineer then assigned savings estimates based on the relative difference between pre- and post-training O&M practices for specific end-uses to specify O&M energy savings attributable to the BOC training program. Across evaluation reports, savings were estimated for each student, or for each student's facility, or in others ways, as reported below.

2.2. Common Constraints

In all cases, the evaluation of BOC programs had to work within two broad constraints: 1) finite resources for funding the evaluation and 2) practical limitations of survey methodology, such as reasonable survey length, participants' knowledge of their facility, and recall bias. To address the first constraint, evaluators used secondary engineering sources for estimating savings associated with O&M activities. Examples of secondary sources used include:

- Commercial Buildings Energy Consumption Survey (CBECS)
- California Commercial End-Use Survey (CEUS)

In addition to secondary sources, evaluators used sampling methodologies to manage budget constraints. Evaluators used telephone surveys with samples of trainers and participants to establish the influence of BOC training on students' O&M activities. To work within the survey length limitations, these evaluations focused on a relatively small subset of O&M actions (six to 14 specific actions) to track and estimate savings. Interviews with trainers were often used to prioritize the most important actions addressed in student surveys.

2.3. Similarities and Differences

Each of the six reviewed studies included an impact evaluation. However, the evaluation team found limited comparability across these studies due to differences in the level of detail, types of metrics reported, and methods used. Below summarizes the similarities and differences between the reports, in terms of the metrics and methods used to report and develop impact findings.

Metrics

The six studies tended to report savings using different metrics, making it difficult to develop commonalities across program findings. Specifically, we found comparability hampered by these differences:

- Savings reported as total program estimates versus by-measure or by-action savings estimates
- Savings reported in units of energy (kWh, kW, MMBtu) versus a percentage of energy use saved per O&M action
- Differences in how savings were standardized (per student, per facility, per square feet)

Table 2-1 and Table 2-2 summarize the level and types of metrics reported in each of the six studies.

Table 2-1: Program Impacts Reporting, by Energy Units

Report	kWh	kW	MMBtu	% of Energy Use[(a)]
NEEA_Navigant_2011				✓
MEEA_MN_Navigant_2011	✓	✓	✓	
KCPL_ODC_2009	✓	✓	✓	
NEEP_RLW_2005	✓		✓	
NEEP_RIA_2002	✓		✓	
NEEA_RIA_2001				

a. The assumed energy savings realized as a result of BOC certification is 2.5 percent of a facility's energy consumption. Previous long term monitoring and tracking reports have established this value, and Navigant did not change from the 2008 analysis.

Table 2-2: Level of Reporting

Report	by Select O&M Action	by Combined O&M Savings				
		by Student	by Student/ Per SqFt	by Net Savings per Student[(a)]	by Facility	by SqFt
NEEA_Navigant_2011						
MEEA_MN_Navigant_2011	✓	✓		✓		✓
KCPL_ODC_2009	Gross, not net	✓	✓	✓		✓
NEEP_RLW_2005			✓	✓		
NEEP_RIA_2002	✓		✓	✓	✓	
NEEA_RIA_2001	✓			✓		✓

a. Net savings account for O&M actions specifically attributable to BOC training. Note that the KCPL_ODC_2009 only reported gross savings per action, but did not report net savings per action. They did develop net savings per student through site visits.

Research Methods

Each of the six studies included an estimate of the BOC training programs' influence on program graduates. To attribute savings of O&M actions from the BOC training, these studies examined how specific O&M actions undertaken by BOC graduates changed *as a direct result* of the training. In all but one case (NEEA_Navigant_2011), the evaluation of the influence of BOC training on O&M actions was based on surveys with BOC graduates. However, as with the comparison of reported impact metrics, estimates of savings varied across the reports we reviewed. Reporting program impacts varied in the following ways:

- Level of inclusion (O&M with installations, installations only, or O&M actions only)
- Gross savings from student actions versus net savings from BOC-attributable O&M actions

- Methods used to establish BOC training influence (comparison of participants to non-participants versus self comparison of pre-training to post-training)

The overall similarities are displayed in Table 2-3. At first glance, the studies appear to be quite comparable. However, as shown in Table 2-1, the studies often reported gross and net saving estimates using different metrics (units, fuels, etc.). The studies also focused on individual students that performed unique O&M activities at unique facilities, and therefore program-level findings are custom calculated and unique to each program.

Table 2-3: Estimating BOC Impact on O&M Actions

	Program Savings Estimated for:				**Savings Estimates for Student Actions**		**Attribution Methods**		
	O&M & Installs	Installs Only	O&M Only	O&M Actions (N)	Gross Savings	Net Savings	Method A:	Method B:	Method C:
NEEA_Navigant_2011	✓								✓
MEEA_MN_Navigant_2011	✓			6	✓	✓		✓	
KCPL_ODC_2009	✓			14	✓	✓		✓	
NEEP_RLW_2005	✓			17	✓	✓		✓	
NEEP_RIA_2002			✓	11	✓	✓	✓		
NEEA_RIA_2001			✓	5	✓	✓	✓		

For reference, the savings estimates and attribution methods are defined below:

- **Gross Savings:** Estimates for post-training O&M actions reported irrespective of BOC influence.
- **Net Savings**: Estimates of post-training O&M actions attributed to BOC training.
- **Method A:** Incremental impact established by comparing participant O&M activities to non-participant activities.
- **Method B:** Participant self reports of program influence (e.g., pre/post surveys or ranking of BOC influence on O&M actions taken).
- **Method C:** Program-level modeled savings using ACE inputs and assumed 2.5% BOC attributable savings levels per certified building operator.

3. SUMMARY OF ESTIMATED PROGRAM IMPACTS

Despite differences across reports noted in Section 2, the evaluation team summarized BOC-attributable savings by various O&M actions. The evaluation team found that reported impacts were based on a variety of activities: O&M actions only, installs only, or some combination of the two. Authors of the reports generally estimated gross and net impacts for the program overall, but based their estimates on different combinations of O&M actions and/or installs. The evaluation team examined the sources used to generate impact findings and found that the initial work in BOC evaluation served as a foundation for much of the subsequent research in this area. (The sources for engineering estimates reported in this section are included in Appendix A.)

The evaluation team found that a comprehensive summary of comparable cross-program impacts was not possible because each report estimated and summarized findings differently. Overall, this review of six BOC program evaluations completed between 2001 and 2011 revealed that O&M impacts generally were based on energy savings estimates derived from secondary engineering sources; however, not all original sources were available. Overall, differences in evaluation approaches and reporting metrics have produced little comparable BOC attributable impact data related to O&M actions.

Where possible, this section summarizes comparable impact data (see Appendix A for source data). The remainder of this section reports on the O&M savings found in the six reports. Findings are broken down between operational-related impacts and maintenance-related impacts.

3.1. Estimated Impacts from Operational Changes

First, the evaluation team examined the operational-related impacts from the BOC programs (see Table 3-1). These types of activities included actual changes to building operations, rather than more routine maintenance activities. It also included some measures, such as VFDs.[3] Table 3-1 provides the reported impacts associated with specific operational-related actions across each of the reports. The underlying assumptions behind these values are presented in Appendix A.

As shown in Table 3-1, impacts from specific operational changes were largely identical in the NEEP_RIA and NEEP_RLW reports because both studies used the same engineering estimates to estimate impacts per operation. The operational impacts reported in the MEEA_MN_Navigant and KPCL_ODC studies are not directly comparable because they used different methods for assigning gross and net impacts to each operation studied. The MEEA_MN_Navigant study developed maximum savings ratios to calculate gross and net impacts for select actions. The KPCL_ODC study used engineering estimates and on-site information, where applicable, to estimate gross savings for O&M actions. For example, KPCL_ODC's assumptions related to adjusting HVAC or EMS controls were based on two student reports on actions taken related to set point adjustments.

The KPCL_ODC estimate assumed savings of 5% over baseline cooling and ventilation loads (CBECS intensities used). ODC further noted *"For avoiding simultaneous heating and cooling, an annual savings of 1.5% over baseline loads (from CBECS) was assumed. This percentage savings is approximately equal*

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[3] While the evaluation team reported measure-related findings in Table 3-1, the evaluation team is aware that Consumers Energy is accounting for measure-related savings through the Business Solutions Program.

to the savings seen from similar measures in the DEER database." In the KPCL_ODC study, net impacts for BOC influenced actions taken at the specific sites visited were combined to estimate net program impacts at "the student" and "square foot" levels. These examples illustrate two take-aways: 1) the importance of knowing the underlying savings assumptions used by individual program evaluators to estimate both gross and net impacts, and 2) savings impacts are not often comparable across evaluation studies. Refer to Appendix A for more information on savings assumptions used to calculate energy impacts.

Care must be taken when interpreting the savings values presented in Table 3-1, as these savings values are highly dependent on the mix of customers and weather conditions for the evaluated BOC programs. For each of the below values, a desk review was completed to determine the reasonableness of the values suggested. The results of this desk review are presented in Table 3-2.

Table 3-1: Summary of Estimated Impacts from Operational Activities

Operations Activity	NEEP_RIA_2002		NEEP_RLW_2005			MEEA_MN_Navigant_2011	KCPL_ODC_2009
	Net Savings	% of Consumption Reduction	Assumed Savings	Net Savings	% of Consumption Reduction	% of Consumption Reduction	% of Consumption Reduction
Air Handler Door Gaskets	0.01 kWh/sf		0.01 kWh/sf				2%
HVAC Controls (EMS, thermostats in kWh)	0.53 kWh/sf	10%	0.41 kWh/sf		10%	5%	
HVAC Controls (EMS, thermostats in MMBtu)	0.005 MMBtu/sf	10%	0.005 MMBtu/sf		10%	5%	
Replacement (new) Motors	52.9 kWh/hp		191 kWh/hp				
VFDs	937.2 kWh/hp		937.2 kWh/hp				
Lighting Controls			1.219 kWh/sf				2.50%
Efficient Lighting			4.209 kWh/sf				
Unitary Equipment			50.5 kWh/ton				
Pipe Insulation (Gas/Oil)			1.48 MMBtu/lf				
Pipe Insulation (Electric)				433.8 kWh/lf			
Drive Power						1%	
Panel Management						1%	
Outside air pre-cooling							5%
Avoiding simultaneous heating and cooling							2%

Table 3-2: Desk Review of Estimated Impacts from Operational Activities

Operations Activity	Net Savings	% of Usage Reduction	Estimate Assessed as…	Comments
Air Handler Door Gaskets	0.01 kWh/sf	2%	Reasonable	Insufficient information is available to justify an alternative savings value.
HVAC Controls	0.41-0.53 kWh/sf	5%-10%	Reasonable	Many studies of HVAC controls suggest typical savings of around 10%, and based on as review of CBECs data for the East North Central census region, the values listed are approximately 10% of the HVAC energy usage.
	0.005 MMBtu/ sf	5%-10%		
Replacement (new) Motors	52.9-191 kWh/hp	N/A	High	Per a review of the documentation, BOC impacts have typically been from specifying NEMA premium motors for a replace on burnout condition. Due to NEMA premium being the current standard, no savings are expected.
VFDs	937.2 kWh/hp	N/A	Reasonable	Insufficient information is available to justify an alternative savings value. An alternative approach would be to use the MEMD value.
Lighting Controls	1.219 kWh/sf	2.5%	Reasonable	Many studies suggest lighting controls will save 20%-50% of lighting energy. Based on a review of CBECS data for the East North Central census region, the kWh/sf value is reasonable. The 2.5% value appears low.
Efficient Lighting	4.209 kWh/sf	N/A	High	Based on a review of CBECS data for the East North Central census region, an unweighted mean lighting power density is approximately 5.7W/sf.
Unitary Equipment	50.5 kWh/ton	N/A	Reasonable	Insufficient information is available to justify an alternative savings value.
Pipe Insulation (Gas/Oil)	1.48 MMBtu/ lf	N/A	High	The savings for this measure are based on insulating 6" pipe at a temperature of 180°F that operates approximately 3500 hours per year, with none of the heat providing useful heat to conditioned space. The use of 6" diameter pipe and no useful heat gain appear to be higher than anticipated for the typical case.
Pipe Insulation (Electric)	433.8 kWh/lf	N/A		
Drive Power	N/A	1%	Reasonable	Insufficient information is available to justify an alternative savings value.
Panel Management	N/A	1%	Reasonable	Insufficient information is available to justify an alternative savings value.
Outside air pre-cooling	N/A	5%	Possibly high	Based on a review of the literature, the savings for this measure may be high for Michigan climate, however, insufficient information was found to suggest an alternate value.
Avoiding simultaneous heating and cooling	N/A	2%	Reasonable	Insufficient information is available to justify an alternative savings value.

3.2. Estimated Impacts from Maintenance Changes

Next, the evaluation team analyzed savings impacts from maintenance-related changes. Findings for specific maintenance actions are presented in Table 3-3 and associated underlying assumptions are presented in Appendix A. As stated above, the NEEP_RIA and NEEP_RLW evaluations used similar engineering estimates to estimate maintenance-related savings. Even with additional information collected from on-site surveys, ODC assumed savings rates (see "SavingsPercent" below) to calculate gross savings. For example, ODC used the following algorithm to estimate energy savings related to improved motor maintenance:

$$kWh = HP * EFLH * (\text{kW/HP}) * (1/\eta) * \text{SavingsPercent}$$

Where

- *kWh* is the annual kWh savings
- *HP* is the total HP of affected motors
- *EFLH* is the equivalent full load hours (4000 hours, based on respondent application and U.S. DOE guidelines)
- *kW/HP* is the conversion factor from HP to kW (0.745)
- η is the motor efficiency of a typical motors (0.88, estimate)
- *SavingsPercent* is the assumed percentage savings over baseline consumption from improved motor maintenance practices (1%)

Table 3-3: Estimated Impacts from Maintenance Activities

Maintenance Activity	NEEP_RIA_ 2002		NEEP_RLW_2005			MEEA_MN _Navigant_ 2011	KCPL_ ODC_2009
	Net Savings	% Consumption Reduction	Assumed Savings	Net Savings	% Consumption Reduction	% Consumption Reduction	% Consumption Reduction
Boiler Maintenance (Gas/Oil)	0.003 MMBtu/ sf	5%	0.003 MMBtu/ sf		5%		
Damper Seal Maintenance	0.06 kWh/sf		0.06 kWh/sf				
Chiller system/Cooling Tower maintenance	80 kWh/ton	5%	85.6 kWh/ton				
Economizer Maintenance	0.62 kWh/sf		0.62 kWh/sf	0.78 kWh/sf		5%	
Motor Maintenance	24.52 kWh/hp		24.52 kWh/hp				34 kwh/hp
Air Compressor Maintenance	68,000 kWh/ facility		22,440 kWh/ Facility			10%	
Air Compressor Leak Repair	-		45,560 kWh/ facility				5%
HVAC improved cooling maintenance							2.50%
HVAC improved heating maintenance							2.50%

Similar to the operation savings value, care must be taken when using the above savings values. These savings values result from evaluations of specific programs, and the specific customer mix and weather characteristics of each program can significantly affect savings. Table 3-4 presents a desk review of the reasonableness of these savings values.

Table 3-4: Desk Review of Impacts from Maintenance Activities

Maintenance Activity	Net Savings	% Consumption Reduction	Estimate Assessed as…	Comments
Boiler Maintenance (Gas/Oil)	0.003 MMBtu/sf	5%	Reasonable	The savings value appears reasonable. Insufficient information is available to justify an alternative savings value.
Damper Seal Maintenance	0.06 kWh/sf	N/A	Reasonable	The savings value appears reasonable. Insufficient information is available to justify an alternative savings value.
Chiller system/Cooling Tower maintenance	80-85.6 kWh/ton	5%	Reasonable percentage; High kWh	The 5% savings value appears reasonable. However, based on this, the 80-85.6 kWh may be excessive. Based on 1 kW/ton and 1000 EFLH, 5% savings is 50 kWh.
Economizer Maintenance	0.62-0.78 kWh/sf	5%	High	Based on the MEMD, the installation of an economizer is expected to save approximately 0.5 kWh/sf. Based on this, the expected savings of 0.62-0.78 kWh/sf for economizer maintenance appears excessive.
Motor Maintenance	24.52-34 kWh/hp		Reasonable	The savings value appears reasonable. Insufficient information is available to justify an alternative savings value.
Air Compressor Maintenance	68,000 kWh/ facility -	10%	High variance across facilities suggested deemed savings estimate not appropriate	The savings of this measure will vary greatly based on the level of leaks, maintenance completed, and the size of the compressed air plant. Insufficient information is available to justify any savings value for this measure.
Air Compressor Leak Repair		5%		
HVAC improved cooling maintenance		2.5%	Reasonable	Insufficient information is available to justify an alternative savings value.
HVAC improved heating maintenance		2.5%	Reasonable	Insufficient information is available to justify an alternative savings value.

3.3. Overall Program Impacts

All of the BOC program evaluations reviewed here reported savings attributable to the training program. However, as we have seen none of the evaluations reviewed used exactly the same method to assess program impacts - the O&M actions studied varied, and in some cases the engineering estimates for O&M actions varied. The following is a summary of average net program-level savings reported in the reviewed evaluation literature, to the extent the original studies provided this information.

Table 3-5: Summary of BOC Program Level Savings Reported

Study	Net kWH Savings	Net MBtu Savings	Metric
NEEP_RLW_2005 – Non-schools	0.404	0.294	Per graduate per SqFt
NEEP_RLW_2005 – Schools	0.263	0.407	Per graduate per SqFt
KCPL_ODC_2009	0.02	0.0107	Per graduate per SqFt
NEEA_Navigant_2011	0.42		Per graduate per SqFt (a)
MEEA_MN_Navigant_2011	0.058	0.518	Per graduate per SqFt (and specified as O&M only)

a. Program savings of 2.5 % of facility energy consumption, assuming an energy intensity of 16.7 kWh/ft2, yielding an estimate of 0.42 kWh of savings per graduate per square foot. Study cites NEEA's analogous 2008 long-term market transformation study (conducted by Summit Blue, which was subsequently bought by Navigant) as supporting an estimate of 2.5% energy savings realized as a result of BOC certification.

3.4. Persistence

The BOC Administrator, located in Seattle, Washington certifies building operators meeting the BOC requirements (completion by qualified applicants of BOC classes, exams, and on-the-job projects) and requires the certified operators to take steps annually to maintain their certification. The BOC Administrator has identified courses for which it accepts continuing education credits; 5 credit hours per year are required to maintain Level I certification and 10 hours per year for Level II. Continuing education credits are given for attending BOC technical webinars, and trainings offered by The Association of Physical Plant Administrators (APPA), Building Owners & Managers Association (BOMA), Building Owners & Managers Institute (BOMI), ENERGYSTAR®, Federal Energy Management Program (FEMP), US Green Building Council, and International Facility Management Association (IFMA), among other resources.

NEEP_RLW_2005 conducted an assessment of the persistence of program-induced activities. In a BOC persistence survey conducted in 2005, the researchers interviewed 17 building operators who completed the BOC in 2000 or 2001 and had been interviewed for the NEEP_RIA_2002 study. The operators were asked whether they had performed any of the same set of O&M activities used to assess program influence in 2002. The researchers then calculated for these operators the 2005 incremental savings for program influence using the 2002 study method, and expressed persistence as the ratio of the 2005 to 2002 savings estimates by fuel/resource type. The resulting ratios were slightly greater than 100% for electric, oil and gas, and water savings. The researchers confirmed as reasonable NEEP's planning assumption that training effects persisted for five years. The researchers noted that the persistence value was partially due to the fact that most operators had been in their positions for over 10 years.

NEEA_Navigant_2011 supports NEEA's use of a five-year persistence of BOC savings, although the researchers cite no supporting research.

3.5. Implications for Consumers Energy

We initiated this review of BOC impact studies assuming we would find comparability among the study's evaluation metric definitions and metric estimates (for example, lighting O&M savings); we would then triangulate the metric estimates to develop a range of reasonable BOC savings estimates and offer a recommendation to Consumers Energy as to what point estimate to use (such as the mid-point of the range). Had the different methodologies used by the reviewed studies produced similar impact estimates, then these different analytical approaches would have provided further assurance of the validity of the savings estimates. However, this was not the case, as savings estimates varied considerably. In sum, none of our assumptions about comparable metric definitions, methodologies, or estimated metric values (savings estimates) held true.

Unable to triangulate among the study findings, we instead separately considered each study to determine if one of them provides a defensible savings estimate for Consumers Energy. We believe the program-level per-participant O&M savings estimate of 0.058 kWh and 0.518 MBtu per square foot derived for the Minnesota BOC program (MEEA_MN_Navigant_2011) provides such an estimate. The team considers this savings estimate to be conservative from three perspectives, in relation to: (1) the savings estimates reported by the other studies, (2) the findings from our engineering desk review, and (3) the average square footage each building operator is assumed to influence.

As Consumers Energy has experienced, the reviewed studies suggest it is common for BOC trainees to come from large facilities, especially in the early years of the program, which is the period most of the evaluations studied. Based on responses to survey questions seeking facility size and percentage of space for which the trainee is responsible for operations, the MEEA_MN_Navigant_2011 study estimated the average square footage to which estimated savings impacts should be applied to be 194,500 square feet. This area is about one-fourth the average total facility size of the surveyed trainees.

The team believes it appropriate for Consumers Energy to assume BOC O&M training impacts persist for (at least) five years, based on 2005 research conducted for NEEP, described previously in Section 3.4.

As described, the reviewed studies varied in the definition of appropriate program impact metrics. Considering the studies collectively, it is clear that BOC evaluators have considered three types of savings to *directly* result from the BOC training, potentially. These are: (1) savings from the installation of energy-efficient equipment for which the facility received an incentive from the utility; (2) savings from the installation of energy-efficient equipment for which the facility *did not* receive an incentive from the utility; and (3) savings from O&M actions. A BOC trainee might attribute any or all of these savings to information learned through the training. The concept of indirect energy savings is not relevant to an energy efficiency education and training program, as the broader awareness stimulated by the program that cost-effective energy savings abound might lead to energy savings in any arena.

Consumers Energy structured the current review of past studies to focus on the third savings type – savings from O&M actions that the studies have attributed to the training, and Sections 3.1 and 3.2 provide our findings. The MEEA_MN_Navigant_2011 study also estimated the first two savings types – from rebated and non-rebated equipment installations – and assessed the program net savings from these installations ("net" meaning the savings attributable to the BOC). For rebated equipment, the analysis included distinguishing between the influence of the equipment rebate and the BOC training. As a point of contrast, the NEEP_RLW_2005 study estimated net O&M savings as well rebated-equipment savings, yet the methodology for the latter did not distinguish between the influences of rebates and training.

While Consumers Energy might use the per-participant O&M savings estimate of 0.058 kWh and 0.518 MBtu per square foot, with an assumed average per-participant square footage of 194,500, additional research would be needed to estimate the savings attributable to the BOC from non-rebated efficient equipment installations and, if desired, to assess the role of the BOC in inducing rebated equipment installations. Estimates of the latter would not increase the estimate of total savings garnered by Consumers Energy's programs, but would result in higher cost-effectiveness estimates for the BOC program.[4]

[4] In turn, the cost-effectiveness of the incentive program would be slightly reduced, yet the effect is anticipated to be negligible as the measures installed by BOC participants comprise a very small proportion of total rebated measures.

4. LESSONS LEARNED

As noted in the introduction, the evaluation team reviewed the findings, conclusions, and recommendations from the six evaluation studies of other BOC programs, which spanned both process and impact analyses. For this section, the evaluation team focused primarily on three of these studies and a summary of the three California statewide BOC program evaluations because they provided the most pertinent information.

- NEEA_Navigant_2011
- MEEA_MN_Navigant_2011
- NEEP_RLW_2005
- CA_RIA_2004-2005 (also summarizes the 2002 and 2003 evaluations)

In addition, the evaluation team reviewed the websites for the BOC maintained by NEEC, which owns the copyright for the program materials, and for MEEA, which offers the program in Midwestern states under license to NEEC. The urls for the two sites are: *http://www.theboc.info/index.html (National)* and *http://www.boccentral.org/ (Midwestern States)*.

This review of BOC studies and related websites produced a comprehensive overview of lessons learned throughout the past 10-years of BOC program implementation. This final section of this report, begins with an overview of key lessons learned, and concludes with a summary of recommendations from past studies related to curriculum and delivery, marketing, and program monitoring.

4.1. Lessons Learned

The following is a summary of program processes and practices that reflect consistent findings across the sources and conform to best practices in training and education:[5]

- Program viability depends on the value placed on it by supervisors and operators.
- Although each of the evaluation studies has a slightly different focus and approach, they all use satisfaction levels as the primary indicator of value of the BOC program to participants. Across the evaluations, all parties surveyed express high levels of satisfaction with the curriculum and delivery of the professional certification program, which consists of two series of courses (Level I and Level II).

[5] Itron 2008. *National Energy Efficiency Best Practices Study – Volume 02 – Nonresidential Education and Training*, prepared by Itron and Research Into Action for Pacific Gas & Electric Company under the auspices of the California Public Utility Commission, San Diego Gas and Electric, Southern California Edison, and Southern California Gas Company. *www.eebestpractices.com*.

- Factors that contribute to high satisfaction with the BOC training include quality instruction, convenient locations, appropriate price, as well as positive outcomes such as improved job performance, increased confidence, and rewards such as increases in pay or job status. These outcomes are achieved by:
    - Following best practices in training and education, e.g., incorporating adult learning principles and providing offerings for different skills levels
    - Providing participants with a framework for being proactive and employing systems thinking in their ongoing O&M practice
    - Being responsive to participant feedback regarding barriers to participation and suggestions for course content
    - Allying with professional organizations to provide continuing education credits and recognition of the credential
    - Raising awareness among employers of the value of the credential

Evaluators found utility involvement important in terms of providing incentives and credibility to the programs in all the states, thereby increasing value. For example, the evaluation of the Level II series in California found that utility involvement increased credibility for non-participants as well, and that some participants were more satisfied with their utility as a result of its program sponsorship.

Curriculum that targets a specific occupation group with offerings for different skills levels leads to better outcomes than more generalized instruction

One of the success factors attributed to the BOC is that it targets a particular occupational group: building operators. Within that, the targeted curriculum for different experience and skills levels has also been important. For example, early evaluations such as the first evaluation of the Level I series in California (2002) found that the most experienced operators, particularly supervisors, did not find the BOC courses as valuable as did operators with less than 10 years of experience. These findings resulted in marketing efforts that made it clear the Level I course was targeted at line staff. The introduction of Level II offerings created an option for more experienced staff and a pipeline for graduates of the first level series. Although the BOC curriculum is mature and stable, best practices dictate continued updating to changing demand and technology change. For example, NEEC has been updating the curriculum materials through a DOE grant and piloting them in the Northwest during 2011. These curriculum enhancements cover building tune-ups, advanced technologies for high performance buildings, and other training modules targeted primarily at property management and health care sectors.

Targeted outreach and marketing to different facilities and sectors are also critical

Awareness of the training program is a critical first step to adoption and long-term viability. However, effective outreach relies on knowledge of the market. Market assessments are useful for assessing the general awareness of the program across program territories. In addition, assessing participation in particular types of facilities or sectors relative to a program's regional market allows targeted marketing in underrepresented sectors or facilities of specific sizes.[6]

[6] In some states, the program targets a particular facility size and/or sector. For example, the Minnesota program targets operators for buildings > 50,000 square feet. It is not clear what other programs do.

NEEA has led the way in tracking participation and the long-term market performance of the BOC. This effort was taken in response to early evaluations that recommended robust data collection and monitoring to assess the viability of the program (e.g., NEEA_RIA_2001). While the statewide program in California is taking action on similar recommendations from evaluators, other program sites have been weaker in this area, as noted by their evaluations.

Most evaluations look at participation and make inferences about program awareness. Several studies have measured awareness directly and made recommendations about target markets (notably NEEA_RIA_2001 and the California studies). For example, the most recent California evaluation (2002-2004) found that institutional customers were underrepresented and had less awareness of the program. NEEA has provided scholarships to health care and property management operators to increase participation from these sectors. The program and scholarships have been marketed through NEEA's BetterBricks commercial-sector program.

In the process evaluations, the lack of information about the potential market is generally found to be a weakness in program implementation, leading to recommendations about establishing performance indicators and data collection and tracking, as discussed in the following section.

Training and certification adds value and creates a demand pipeline

Evaluators have consistently found that the combination of training and certification is a sound approach, being valued by participants and leading to demand for further training and recertification. Participants express high levels of interest in taking more advanced training. Affiliating with professional organizations reinforces the value of the professional development opportunities. For example, the U.S. Green Building Council approved Level I BOC courses as qualifying continuing education for its LEED certification. A review of the BOC and MEEA websites indicated a variety of options for recertification and CEUs sponsored by the BOC national program. It should be noted that the BOC has competition from programs offered by community colleges, unions, and independent organizations such as Building Owners Management Institute (NEEA_Navigant_20111).

Program participation fluctuates but generally increases over time for robust programs

It takes time to establish the infrastructure to deliver a BOC program. Overall, upgrades, outreach, the number of classes, certifications, and renewals has increased for those programs tracked by NEEA.[7] Fluctuations in new certifications from year to year may be related to the availability of rebates, when courses start and stop, or to timing of graduation – it can take up to two years to complete the program. Performing market assessments helps fine tune programs in line with all the best practices addressed above.

Energy savings calculations appear to be more accurate when appropriate measures and actions are selected

Most impact evaluations consulted with the BOC instructors to identify the measures and actions that should be included in surveying participants. This check increases the accuracy of the savings estimates. In order to use individual measures or actions to estimate program level savings, it helps to have as large a

7 The persistence of the behavioral changes is assumed to be 5 years for each sequence of courses, i.e., 5 years for Level I, another 5 years for Level II. That period is extended for another 5 years with recertification.

number of measures or actions as possible to best capture the range of possible program effects.[8] The measures need to be sufficiently defined so that one can assess from survey responses (self-reported behaviors) the extent to which the operator engages in the behavior with the frequency, tools, and skill set needed to yield energy savings. The measures need to have savings estimates available from the engineering literature.

Impact evaluations should use a method enabling the derivation of net impacts.

The evaluation studies that produced net impacts (estimates of the effect of BOC training, not simply estimates of energy savings through O&M at participants' sites) either asked students to identify behavior changes they attribute to their training or compared the O&M behaviors of students with those of untrained building operators. Ideally, an impact evaluation would use a combined test/control, pre/post methodology to compare students and nonstudents in O&M behavior change over time. This method would eliminate concerns that students describing their own behavior changes have faulty recall of the past and concerns that the comparison of students and nonstudents does not account for the possibility that students attended the training because they were already concerned about (and taking actions to) save energy.

4.2. Recommendations from Past Studies

The types of recommendations that are most common across evaluations have to do with: 1) tweaking the curriculum and overcoming local barriers to participation, 2) improving marketing activities, and 3) collecting data and tracking program progress over time. Although the first two categories of recommendations build on what works well in programs, data collection and tracking remain a weakness for most programs. The following recommendations illustrate each of these categories:

Curriculum and Delivery

Incorporate hands on activities and real world application, especially in Level 1, addressing issues of relevance and transfer and motivation

The curriculum owners and developers (NEEC) have generally been responsive to participants' feedback and recommendations made by evaluators. However, individual instructors have considerable leeway in how they use these materials. The quality of instructors is an important success factor for program implementation. What constitutes quality instruction is beyond the scope of this evaluation and is not addressed specifically in most of the existing process evaluations.[9] The evaluations assess the instructional quality based on student feedback on each BOC module or course. Yet best practices in adult education and training include engaging students in problem-solving and offering multi-sensory training, such as through reading, talking, seeing equipment, taking measurements, and so on.

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[8] Several studies, including NEEP_RLW_2005, noted that they were constrained by the length of the interview and lack of engineering values for savings for other measures. These studies have concluded that the savings were underestimated. NEAA estimates a current savings of 119,000 kWh per operator (excluding IBOA data, which was not available at the time of the study). This might be a useful benchmark for programs as they mature.

[9] The most comprehensive evaluations of curriculum and delivery were the early studies conducted for NEEA and NEEP (NEEA_RIA_2001 and NEEP_RIA_2002) and for the first year of implementation in California (CA_RIA_2002). The other evaluations focus on new issues raised in surveys with participants and whether or not recommendations from prior evaluations were implemented or not.

Be responsive to feedback from participants regarding specific barriers to participation as well as suggested improvements

Programs use a variety of outreach channels and locations from which to offer their programs. However, long-term viability of a BOC program requires being responsive to the particular needs and preferences of participants in particular locations. For example, the most frequently cited barriers to participation are time and money. Recommendations for responding to these barriers include offering multiple training formats: e.g., classroom, online, and onsite (for large customers). Another example is the recommendation to provide a Spanish language version of the courses in California.

Marketing

Increase utility involvement in marketing

Because utility involvement has proved to add value to participants and results in better marketing efforts, many evaluations recommend increasing utility involvement in BOC activities when a non-utility contractor is responsible for course delivery. Specific recommendations include:

- Increase the presence of utility staff at trainings
- Provide utility program materials at training sites other than utilities' energy resource centers (which have program brochures prominently displayed)
- Encourage program administrators to actively communicate the need for recertification for credentialing and value in marketplace
- Involve trade allies in outreach and recruitment

Assess potential markets for targeted outreach and marketing

The following issues were raised in individual evaluations but there was no agreement on how to best address them: the role of incentives, participants' willingness to pay, overall cost-effectiveness, as well as the issue of market potential addressed in the previous section. Further research is needed in these areas. Implementing this recommendation requires that good data collection and tracking systems, as discussed in the next recommendation.

Program Monitoring

Establish and track program metrics

Virtually all evaluations have identified a need for more and ongoing program monitoring. There is not a standard set of performance indicators or metrics for BOC programs. A minimum set of metrics would support programs and process evaluations. For example, the NEEA_Navigant_2011 study recommends the following metrics:

- Number graduates as percent of enrollees
- Average savings undertaken by participants that qualified for rebates
- Percent of Level I graduates who go on to Level II
- Number of participants relative to total market

The first three should be relatively straightforward to collect but the fourth would be more difficult. Other studies recommend tracking additional indicators such as:

- Number of dropouts and re-certifications

In addition, several studies urge program staff to collect data about facilities and equipment, most importantly:

- Square footage controlled by participants
- Specific systems participants are responsible for

Being able to track these metrics assumes that the program has adequate resources, e.g., staff and databases, to do so.

5. SUMMARY AND RECOMMENDATIONS

The six pertinent BOC evaluations reviewed by the research team reported savings associated with the BOC training programs. However, reported program savings varied across the evaluation reports depending on the end-uses included in the study, the underlying engineering estimates assigned to individual O&M actions, the distinction between equipment and O&M savings, as well as the research method used to attribute to the BOC training itself some percentage of savings from all O&M-related actions taken by trained staff. Thus, the evaluation team was unable to conclude that multiple program evaluations or the preponderance of evidence suggests a given savings estimate. Nonetheless, the team is able to recommend that Consumers Energy conduct the BOC program and claim savings based on prior research.

Specifically, the team recommends that Consumers Energy use the program-level per-participant O&M savings estimate of 0.058 kWh and 0.518 MBtu per square foot, with an assumed average per-participant square footage of 194,500, as derived by the evaluation of the Minnesota BOC program. The team considers this savings estimate to be conservative from three perspectives, in relation to: (1) the savings estimates reported by the other studies, (2) the findings from our engineering desk review, and (3) the average square footage each building operator is assumed to influence. The team believes it appropriate for Consumers Energy to assume BOC O&M training impacts persist for (at least) five years, based on 2005 research conducted for NEEP.

Consumers Energy should continue to conduct the post-training six-month follow-up survey to provide a measure of trainee's energy efficiency activities subsequent to training. Such a survey effort could be expanded at any time into a full impact analysis of the program, by revising the survey (increasing its complexity and length) to capture the detail necessary to understand the energy-use implications of any equipment and O&M behavior changes and by linking these change data to engineering models or calculations.

The team recommends that Consumers Energy conduct the research necessary to quantify savings from energy-efficient, yet non-incentivized equipment that trained operators report installing as a result of their training experience. These savings are among the direct impacts of the BOC program, yet these savings initially can be estimated only retrospectively. It may be the case that research spanning multiple groups of trainees suggests that per-participant average savings from non-incentivized equipment installations is rather stable; in such case, a deemed value might be determined from sufficient data. Such research, along with analogous research on the influence of the BOC on rebated equipment installations, could result in a higher, more accurate cost-effectiveness estimate for the BOC program.

Appendix A: BOC SAVINGS ASSUMPTIONS

The below table summarizes reported savings from each identified report. It also includes information on the savings assumptions used to generate impact findings.

BOC Activity	NEEP_RIA_2002		NEEP_RLW_2005			MEEA_MN_ Navigant_ 2011	KCPL_ ODC_2009	Savings Assumptions
	Net Savings	% of Consumption Reduction	Assumed Savings	Net Savings	% of Consumption Reduction	% of Consumption Reduction	% of Consumption Reduction	
Boiler Maintenance (Gas/Oil)	0.003 MMBtu/ sf	5%	0.003 MMBtu/sf		5%			RIA and RLW values are based upon an estimate of 50,000 Btu/sqft/yr and an assumed savings of 5%. As of 2005, RLW could not find information to provide a more refined estimate.
Air Handler Door Gaskets	0.01 kWh/sf		0.01 kWh/sf				2%	RIA taken from Jane Peters, et al., Regional Building Operator Certification Venture: Final Market Progress Evaluation Report, September 20, 2001, prepared for the Northwest Energy Efficiency Alliance. RLW studied the repair of air handler dampers and seals in a previous O&M study, and agreed with the savings estimates used in the 2002 study. ODC estimated 2% savings from HVAC base load based on CBECS and DEER data.
Damper Seal Maintenance	0.06 kWh/sf		0.06 kWh/sf					RIA taken from Jane Peters, et al., Regional Building Operator Certification Venture: Final Market Progress Evaluation Report, September 20, 2001, prepared for

BOC Activity	NEEP_RIA_2002		NEEP_RLW_2005			MEEA_MN_ Navigant_ 2011	KCPL_ ODC_2009	Savings Assumptions
	Net Savings	% of Consumption Reduction	Assumed Savings	Net Savings	% of Consumption Reduction	% of Consumption Reduction	% of Consumption Reduction	
								the Northwest Energy Efficiency Alliance.
HVAC Controls (EMS, thermostats in kWh)	0.53 kWh/sf	10%	0.41 kWh/sf		10%	5%		RIA estimate based on 300 square foot per ton of cooling, 0.8 kW/ton and 2,000 equivalent full load hours (MA): cooling savings due to EMS are estimated to be 0.53 kW.RLW evaluated three sites with HVAC controls in previous O&M impact work and believes 0.41 kWh/sf is a more accurate impact estimate. Navigant estimate based on survey responses and conservative estimates based on Piper, J., "HVAC Maintenance and Energy Savings", Building Operating Management, March 2009,
HVAC Controls (EMS, thermostats in MMBtu)	0.005 MMBtu/ sf	10%	0.005 MMBtu/sf		10%	5%		RIA and RLW estimate based on 300 square foot per ton of cooling, 0.8 kW/ton and 2,000 equivalent full load hours (MA): heating assumed to be 50,000 Btu/sf/yr, resulting in 5,000 Btu/sf/yr for controls savings at 10%. Navigant Estimate based on survey responses and conservative estimates based on Piper, J., "HVAC Maintenance and Energy Savings", Building Operating Management, March 2009,

BOC Activity	NEEP_RIA_2002		NEEP_RLW_2005			MEEA_MN_ Navigant_ 2011	KCPL_ ODC_2009	Savings Assumptions
	Net Savings	% of Consumption Reduction	Assumed Savings	Net Savings	% of Consumption Reduction	% of Consumption Reduction	% of Consumption Reduction	
Chiller system/Cooling Tower maintenance	80 kWh/ton	5%	85.6 kWh/ton					RIA based on 5% savings, 0.8 kW/ton and 2,000 equivalent full load hours (MA). RLW evaluated six sites with various chiller maintenance and cooling tower maintenance in previous O&M impact work and believes 85.6 kWh/ton is a more accurate impact estimate.
Economizer Maintenance	0.62 kWh/sf		0.62 kWh/sf	0.78 kWh/sf		5%		RIA taken from Jane Peters, et al., Regional Building Operator Certification Venture: Final Market Progress Evaluation Report, September 20, 2001, prepared for the Northwest Energy Efficiency Alliance.. RLW has performed limited evaluations of sites with economizer maintenance savings and the 0.62 value appears larger than we might expect. However, this value will be used in this study in the absence of a more definitive estimate. Navigant estimate based on survey responses and conservative estimates based on Piper, J., "HVAC Maintenance and Energy Savings", Building Operating Management, March 2009,

BOC Activity	NEEP_RIA_2002		NEEP_RLW_2005			MEEA_MN_ Navigant_ 2011	KCPL_ ODC_2009	Savings Assumptions
	Net Savings	% of Consumption Reduction	Assumed Savings	Net Savings	% of Consumption Reduction	% of Consumption Reduction	% of Consumption Reduction	
Motor Maintenance	24.52 kWh/hp		24.52 kWh/hp				34 kwh/hp	RIA and RLW Suozzo, Margaret and Steve Nadel. August 1998. "Selecting Targets for Market Transformation Programs: A National Analysis. American Council for an Energy Efficient Economy, Washington, D.C., page 140. RLW was unable to acquire a more refined estimate for the 2005 study. ODC used equation kWh/HP = EFLH*(kW/HP) *(1/n) *SavingsPercent where EFLH = 4000 hours from respondents and US DOE guidelines, kW/HP = 0.745, n = 0.88 motor efficiency & SavingsPercent = 1* from Drivepower Technology Atlas (Volume IV), eSOURCE.
Replacement (new) Motors	52.9 kWh/hp		191 kWh/hp					RIA based on Suozzo and Nadel, op. cit., page 137. RLW reviewed 21 previous motor replacement projects in previous impact work and believes 191 kWh/hp is a more accurate impact estimate.
VFDs	937.2 kWh/hp		937.2 kWh/hp					RIA and RLW based on National Grid 2000 DSM Performance Measurement Report, December 2001, page 26. RLW has studied the installation of VFDs in previous retrofit studies which confirm RIA numbers as reasonable

BOC Activity	NEEP_RIA_2002		NEEP_RLW_2005			MEEA_MN_ Navigant_ 2011	KCPL_ ODC_2009	Savings Assumptions
	Net Savings	% of Consumption Reduction	Assumed Savings	Net Savings	% of Consumption Reduction	% of Consumption Reduction	% of Consumption Reduction	
Air Compressor Maintenance	68,000 kWh/ facility		22,440 kWh/ facility			10%		RIA and RLW based on US DOE Industrial Assessment Database, Version 8.1, January 2001, Office of Industrial Technologies. Based on 4,847 projects involving air compressor maintenance. RLW has performed multiple evaluations of sites with compressed air maintenance, and leak repair typically returns twice as much savings as maintenance. Although the 68,000 value appears smaller than we might expect, it is derived from national IAC data that is believed to be a reasonable estimate. Therefore, we estimate that leak repair generates two-thirds of the savings estimated from the 2002 study and maintenance the other third. Navigant and ODC based on EnergyStar, U.S. Department of Energy and U.S. EPA.
Air Compressor Leak Repr	-		45,560 kWh/ facility				5%	
Water Savings measures	1,551,20 7 Gallons/ facility		1,551,207 Gals/ facility				1%	RIA based on BOC survey. RLW asked a battery of questions probing typical water savings activities in the current study but participants were not able to provide estimates of gallons saved due to their actions. ODC- as percent of baseline hot water load from multiplying the respondent's estimate of annual natural gas consumption by the ratio of hot

BOC Activity	NEEP_RIA_2002		NEEP_RLW_2005			MEEA_MN_ Navigant_ 2011	KCPL_ ODC_2009	Savings Assumptions
	Net Savings	% of Consumption Reduction	Assumed Savings	Net Savings	% of Consumption Reduction	% of Consumption Reduction	% of Consumption Reduction	
								water to total natural gas consumption for similar buildings from California Commercial End-Use Survey (CEUS), sponsored by the California Energy Commission.
Waste Water Savings measures	-		-					RLW finds this estimate is not able to be quantified as although some participants indicated performing activities to reduce wastewater, none were able to provide estimates of wastewater gallons saved due to their actions.
Lighting Controls	-		1.219 kWh/sf				2.5%	RLW based upon data from 17 efficient lighting projects, using W/Sf savings and logger hours of use. ODC based on two site audits.
Efficient Lighting	-		4.209 kWh/sf					RLW based upon data from 31 lighting control projects, using W/Sf savings and logger hours of use.
Unitary Equipment	-		50.5 kWh/sf					RLW based on an average of 5 studies, assuming an average of 3 years operation between tune-ups.
Pipe Insulation (Gas/Oil)	-		1.48 MMBtu/lf					RLWased on 6" pipe with 2 inches of insulation added for 180oF hot water system in a large building.

BOC Activity	NEEP_RIA_2002		NEEP_RLW_2005			MEEA_MN_ Navigant_ 2011	KCPL_ ODC_2009	Savings Assumptions
	Net Savings	% of Consumption Reduction	Assumed Savings	Net Savings	% of Consumption Reduction	% of Consumption Reduction	% of Consumption Reduction	
Pipe Insulation (Electric)	-			433.8 kWh/lf				-
Drive Power						1%		Navigant based on Drivepower Technology Atlas (Volume IV), eSOURCE.
Panel Management						1%		Navigant estimate based on survey responses and conservative estimates based on Piper, J., "HVAC Maintenance and Energy Savings", Building Operating Management, March 2009,
Outside air pre-cooling							5%	ODC used CBECS intensities and “Using Off-Peak Precooling”, Kurth Roth, John Dieckmann, and Jamred Brodrick. ASHRAE Journal, March 2009.
Avoiding simultaneous heating and cooling							2%	ODC as percentage of baseline heating and cooling loads from CBECS, comparable to DEER database measures.
HVAC improved cooling maintenance							2.5%	ODC estimated 2% savings from HVAC baseline cooling load based on CBECS and DEER data.
HVAC improved heating maintenance							2.5%	ODC estimated 2% savings from HVAC baseline heating load based on CBECS and DEER data.