EVALUATION OF MN BOC TRAINING

Prepared for:
Midwest Energy Efficiency Alliance and
Minnesota Office of Energy Security

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1. Executive Summary

The Midwest Energy Efficiency Alliance (MEEA), working with the Minnesota Department of Commerce and Minnesota Power began offering Building Operator Certification Training in 2005 and had held 13 courses by March of 2010 and certified 230 building operators. Two Minnesota utilities included the program in their CIP Triennial filings, with the Office of Energy Security approving the inclusion of one years' savings pending the results of an impact evaluation. Navigant Consulting (Navigant) was hired by MEEA to conduct this evaluation.

Navigant's evaluation of MEEA's Minnesota Building Operator Certification Training program comprehended a number of activities, including a review of program documentation and student evaluations, interviews of the MEEA program manager and five program administrators (PAs), a survey of 50 training participants, interviews of three instructors and modeling of the energy savings. This report summarizes the findings and conclusions from these activities organized into four chapters: Background and Methodology, Process Evaluation, Impact Evaluation, and Conclusions and Recommendations.

In summary, the process evaluation shows that participant satisfaction with the course is quite high, that communication between instructors and MEEA and the instructors and students is excellent, and that change is underway (development of on-line BOC training) that mirrors participants' suggestions for removing a key barrier to course attendance – time. Utility outreach seems to be among the most effective means to attract participants, while many participants realize job-related benefits after completing the BOC training that should be able to be leveraged in program marketing. There are areas for potential BOC training improvement, including some course content and delivery methods such as more hands-on activities in Level I. Overall, however, participants and instructors are largely very satisfied with MEEA's BOC training.

The impact evaluation developed both electric and gas savings from actions attributed by the 50 survey participants to the BOC training program. The savings for the range of retrofit and operations and maintenance (O&M) activities were modeled based on commonly used industry sources for energy consumption data by building type and end use, and provided separately for measures that were rebated by the utility and for purely O&M measures. The program's savings per participant and per square foot range from a low end that reflects savings only from those measures that were not rebated by the utility to all savings influenced by the BOC training program.

Table 1. MEEA MN BOC Training Energy Savings

Metric	kWh	Watts	Therms
Per Participant	42,936-130,746	11,000-30,000	2,276-3,219
Per Square Foot	0.237-0.721	0.0601-0.167	0.013-0.018
O&M only per Square Foot	0.058	0.022	0.00518

There are opportunities to both enhance the BOC training curriculum and better enable future impact evaluations. Both participants and instructors recommend including more "real world," hands on experience, which could include gathering utility cost data and facility square footage data to work with in class or on homework assignments as well as evaluating potential savings from possible future projects. Having improved facility square footage and energy usage data would enhance the ease of conducting future impact assessments and potentially increase their accuracy as well.

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2. Background and Methodology

MEEA holds the license for the BOC training curriculum for six mid-western states: Illinois, Iowa, Kansas, Minnesota, Missouri and Ohio. In 2005 MEEA launched BOC training in Minnesota jointly with Minnesota Department of Commerce (MN DOC) and Minnesota Power. By March of 2010, 11 Level I and two Level II courses had been taught, while two were underway. MEEA certified 230 building operators in Minnesota during this period.

Over this period, MEEA continued to work with Minnesota Power and had also held classes jointly with Southern Minnesota Municipal Power Agency (SMMPA), Otter Tail Power and Minnesota Energy Resources Company (MERC). Both Otter Tail Power and MERC included the BOC program in their CIP Triennial filings, and the Office of Energy Security approved the inclusion of one years' savings pending the results of an impact evaluation. MEEA consequently sought a consultant to perform the impact evaluation that would provide a basis for BOC program savings estimates by any Minnesota gas or electric utility.

Navigant Consulting was chosen to conduct the impact and process evaluation. The objectives of this evaluation are to both quantify the energy savings and other benefits from the program and to identify ways in which MEEA could improve the program as it rolls it out into other mid-western states.

Navigant's approach to the **process** evaluation comprised eight steps:

1. An initial kick-off meeting was held in Chicago with MEEA program staff to review our understanding of the assignment as well as our proposed approach and timeline.
2. Program course listings, training materials and evaluations were reviewed and analyzed.
3. Draft interview guides were developed for both program administrator and instructor interviews for MEEA's review.
4. A draft participant survey instrument was drafted and reviewed by MEEA.
5. MEEA program staff and five PA's were interviewed.
6. Three instructors representing almost 40 sessions were interviewed.
7. Fifty BOC training participants were surveyed, 40 Level I and 10 Level II.
8. Results were analyzed and process evaluation results are summarized in this draft memo.

Navigant used a four-step, quantitative process to estimate the energy savings associated with the BOC program. The first three steps dealt with the evaluation sample of 50 participants who completed phone interviews for the evaluation. The final step quantified the results from the sample on a per-participant and per-square-foot basis to enable extrapolation to overall program participants.

1. Navigant modeled baseline consumption for the sampled participants based on facility type. We used secondary sources to allocate energy use among various end-uses.

2. Navigant Consulting then computed gross kWh and therm savings for each end-use at the 50 sites that participated in the telephone interview (the sample) based on reported measures installed and changed O&M practices.

3. Next, gross savings were converted into net savings by taking into the account the level of influence of the BOC training on the actions taken and whether utility incentives were received for equipment retrofit or replacement measures.

4. Finally, total savings from the sample were calculated on a per-participant and per-square-foot basis to enable extrapolation to all program participants.

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3. Process Evaluation

Navigant's process evaluation findings are presented in this chapter in three subsections: MEEA BOC final course evaluation findings, participant survey process findings and instructor feedback.

MEEA Final Course Evaluation Findings

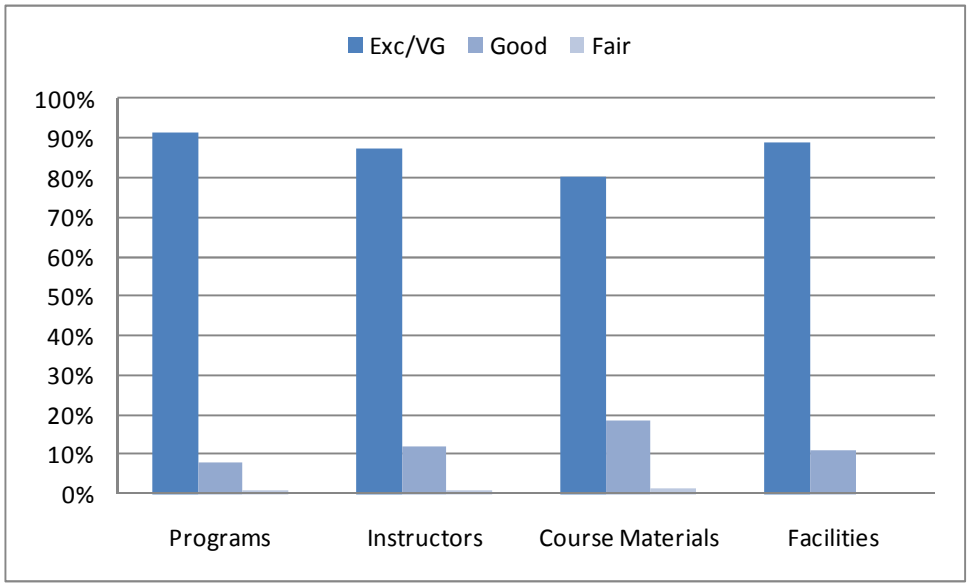
Course evaluations were conducted at the conclusion of each BOC training course. This section summarizes the results of those evaluations, first for the thirteen Level I courses and then for three Level II courses for which data was available at the kick-off meeting.

About 125 Level I students provided feedback on their satisfaction with the training at the conclusion of each course. This feedback reflects participants in nine training sessions since final ratings were not available from students in four Level I sessions.

Level I BOC Training Feedback – Final Course Evaluations

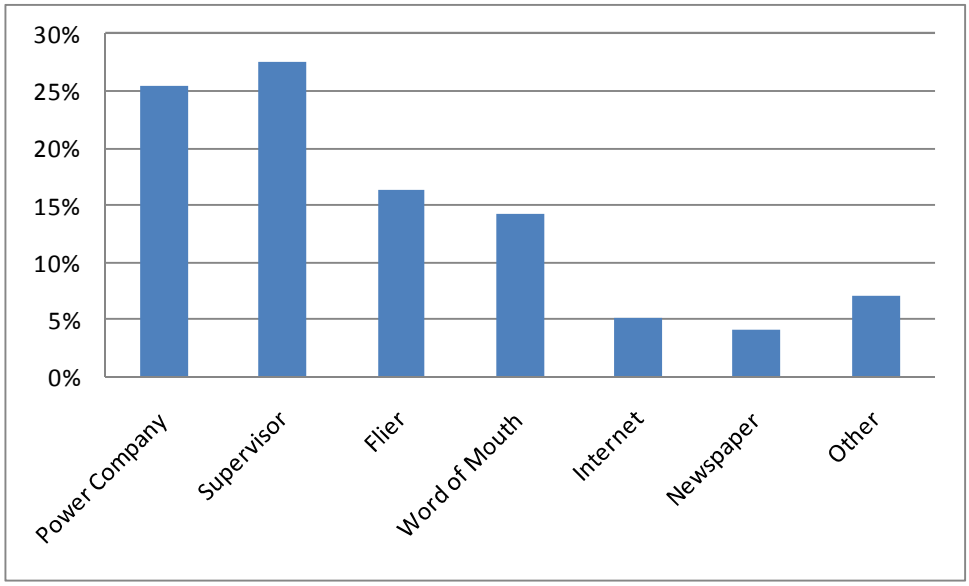
Overall Level I participant satisfaction was high at the immediate conclusion of the training, with 87% either very or moderately satisfied. As shown in Figure 1, Level I students were most satisfied with the programs and least satisfied with the course materials. Nonetheless, 80% of students thought course materials were either excellent or very good.

Figure 1. Level I Course Evaluation – Satisfaction



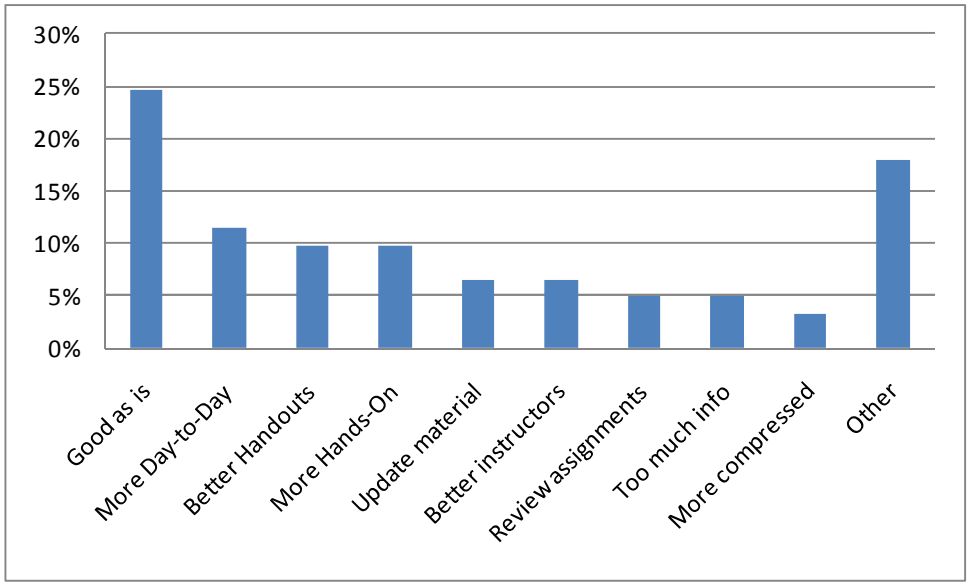
The majority of participants learned about the course either from their power company in an unspecified fashion or from a supervisor at work, as shown in Figure 2. Over fifteen percent learned about it directly through a flier. Ninety-nine participants provided information on how they learned about the program.

Figure 2. Level I Course Evaluation - Program Awareness



Sixty-one participants provided feedback on how the BOC training could be improved. As shown in Figure 3, the highest percentage of respondents, 25%, commented that it was "good as it was". The most common suggestions for improvement included more real day-to-day applications for the working person, 11%, and more hands-on work and facilities visits, 10% each. Ten percent also felt that the textbooks/hand outs needed work – either updating, reduced duplication of information, better printing or more charts and graphs. A few commented that it would be helpful to review assignments and tests, that they would appreciate better instructors or that the slides should better match the text books. Several students had suggestions for additional course material, specifically around controls, Minnesota rules and regulations and plan and contract review. Several others had administrative suggestions, such as not to spread the course out so much, to provide name tags and participant lists, and to develop on-line training and a searchable CD of course material.

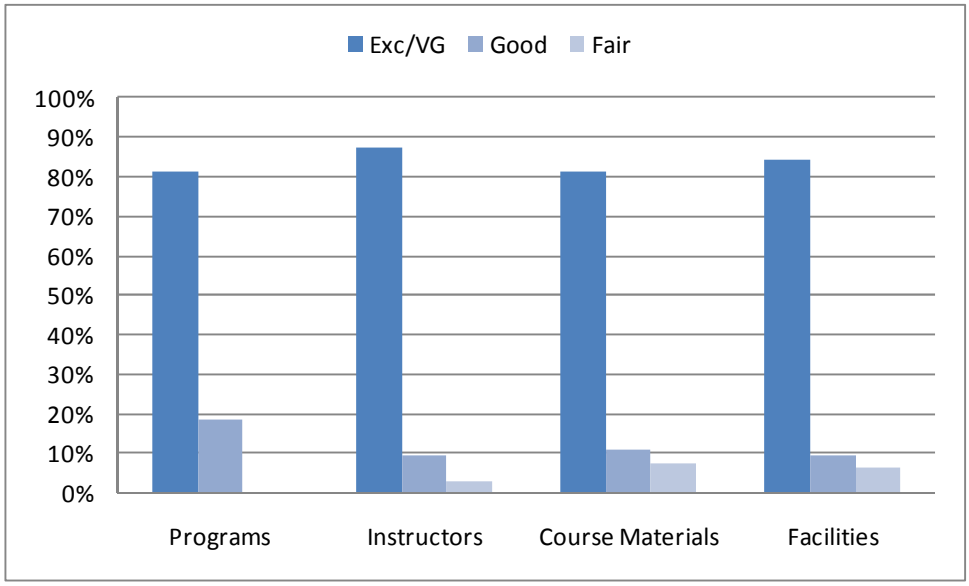
Figure 3. Level I Course Evaluation - Potential Course Improvements



Level II Evaluation BOC Training Feedback

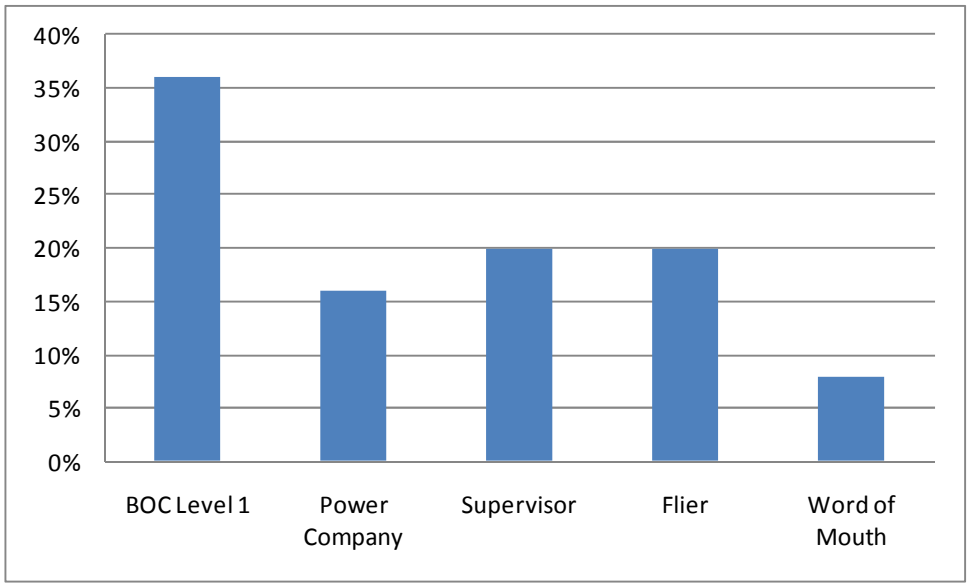
Evaluations were available from three BOC Level II training classes with 38 students, of which 32 students provided satisfaction feedback. The majority of students, over 84% on average, stated the course was excellent or very good overall (Figure 4). Instructors received the highest ratings, while all participants rated the programs good or better. No course element received a poor rating.

Figure 4. Level II Course Evaluation – Satisfaction



25 participants provided feedback on how they learned about the course. Surprisingly only 36% had learned of it in Level I training. The power company (15%), fliers (mostly e-mail) – 20%, and supervisors, also 20%, were also common ways to learn about the Level II course (Figure 5).

Figure 5. Level II Course Evaluation - Program Awareness

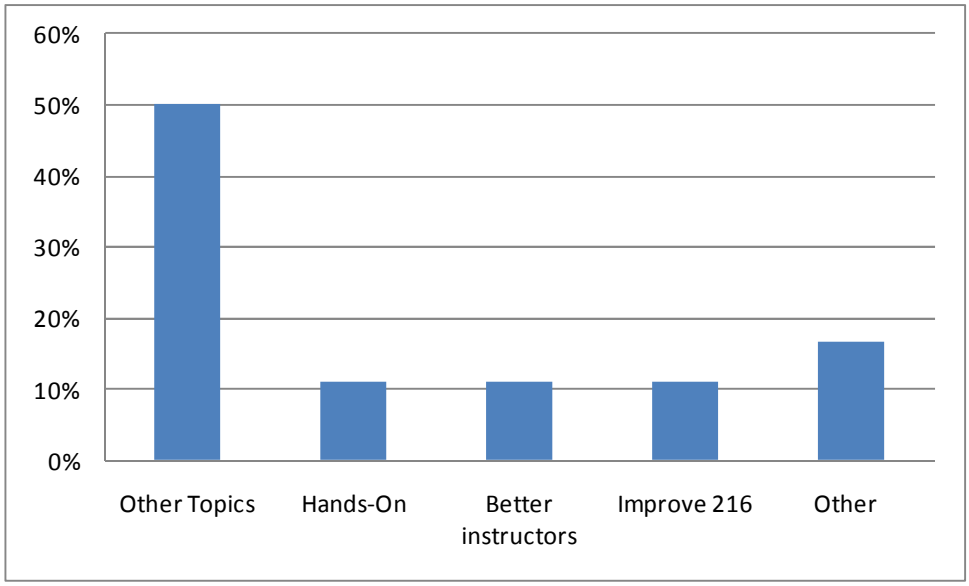


Eighteen participants provided feedback on how the course could be improved. The most common suggestion was to add material in particular areas, including the following:

- Electrical circuits and controls (3 respondents)
- Motors in facilities (2 respondents)
- Pneumatic systems, pipe schematics, and compressors (1)
- Phases of building planning and construction (1)
- Advanced indoor air quality (IAQ) for school members (1)
- Developing a project business case for management to justify investment (1)

At Level II only a couple of participants thought additional hands-on work would be helpful (Figure 6). Two also thought instructors should be more qualified and that course BOC 216 Enhanced Automation and Demand Response needed work.

Figure 6. Level II Course Evaluation - Potential Course Improvements

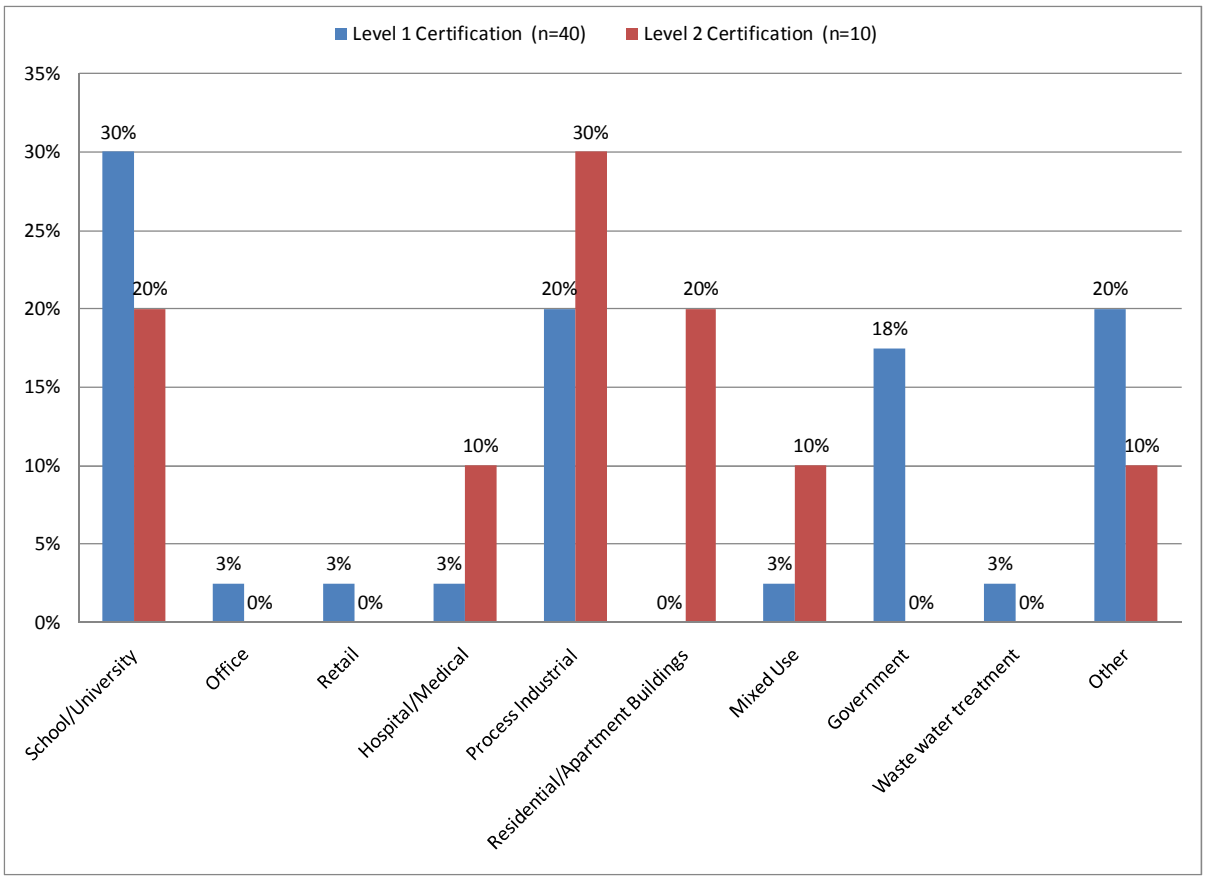


Participant Survey Process Findings

During the months of October and November 2010, 50 BOC training participants were surveyed to both identify opportunities to improve the program and its marketing and to evaluate savings generated as a result of the training. This section discusses program satisfaction and marketing findings. Savings and other impacts are presented in Chapter 4.

Surveys were conducted with 40 Level I and 10 Level II participants. As shown in Figure 7, most Level I respondents manage facilities for school or university buildings, while Level II participants are most likely to manage facilities in a process-based industrial building.

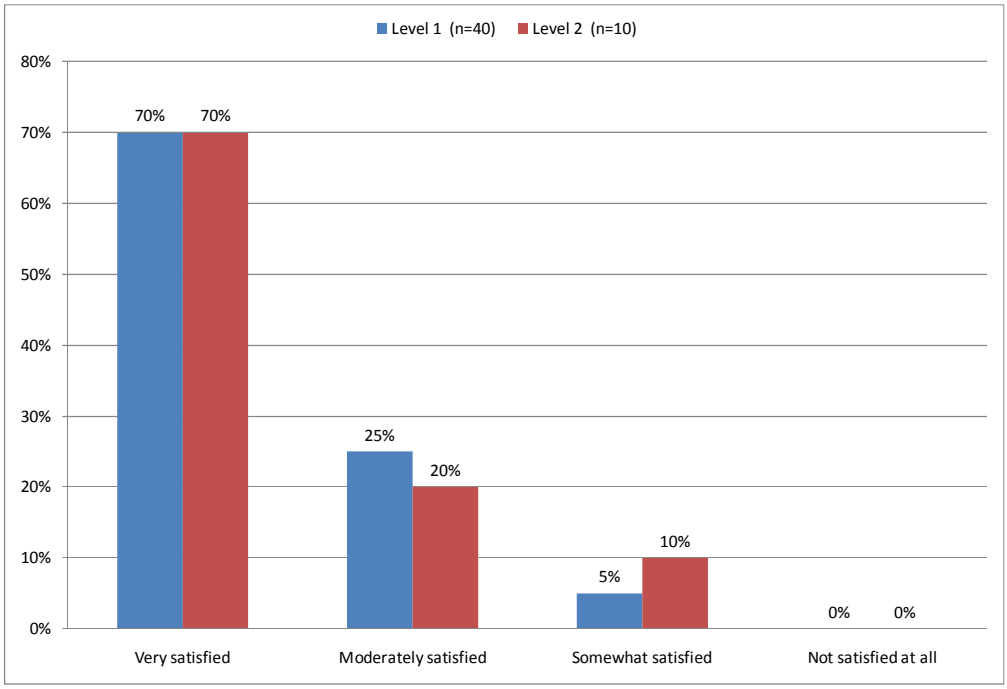
Figure 7. Survey Participation by Facility Type



Participant Satisfaction

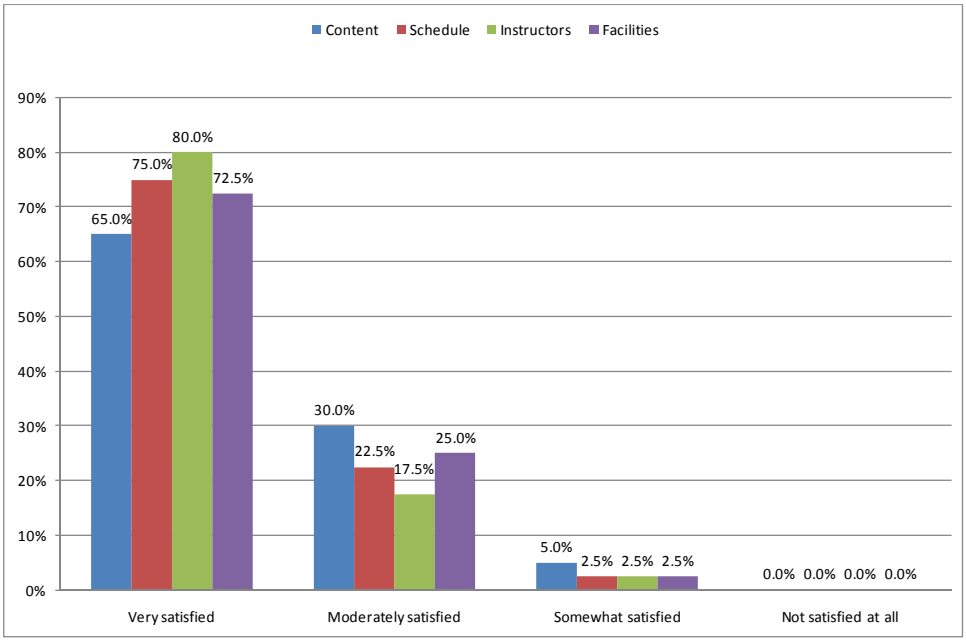
Overall 70% of participants in both Level I and Level II courses were very satisfied with the course, and no participants were not satisfied at all as shown in Figure 8. Twenty percent of Level I participants and 25% of Level II were moderately satisfied, with the balance of participants indicating they were somewhat satisfied with the course overall.

Figure 8. Overall Satisfaction with BOC Training



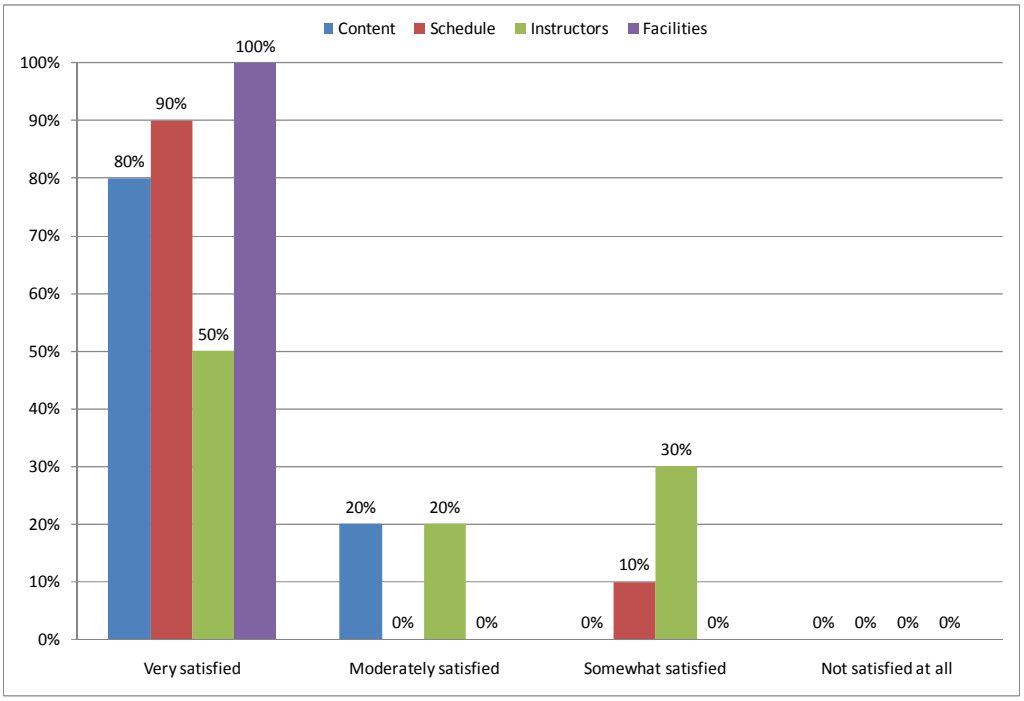
In looking at the four components of the course (Figure 9), Level I participants were most satisfied with the instructors and least satisfied with the content. Overall, between 65% and 80% of course participants were very satisfied with each element of the course – content, schedule, instructors, and facilities.

Figure 9. Level I Participant Satisfaction with Course Components



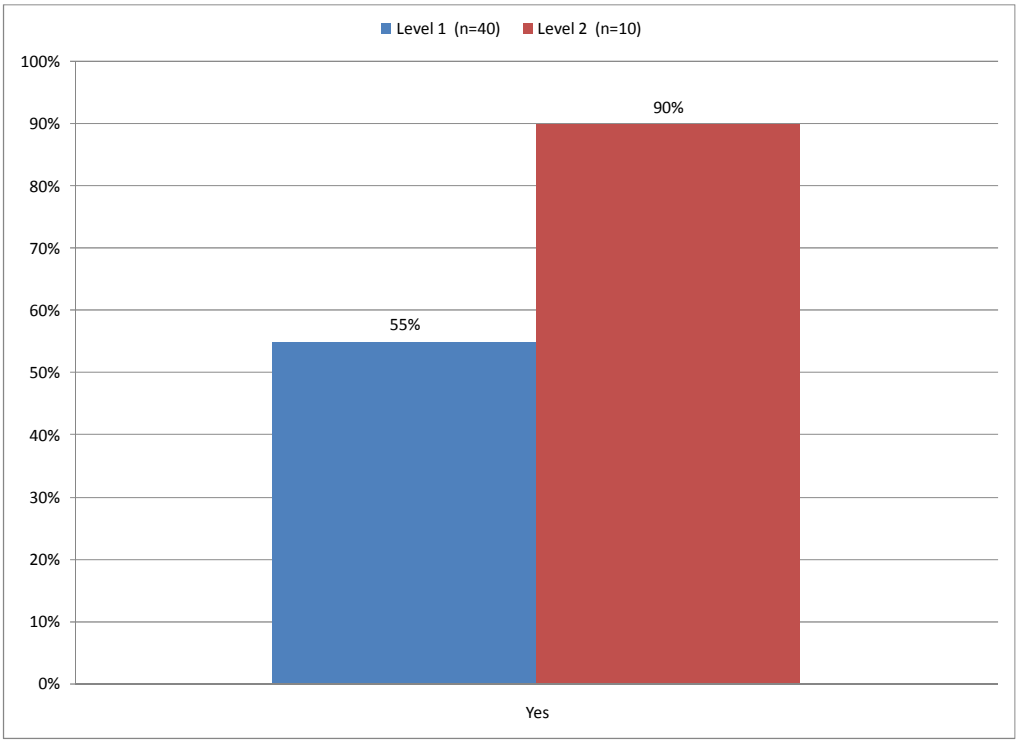
As shown in Figure 10, Level II participants were extremely satisfied with the facilities and very satisfied with the schedule. Thirty percent were only somewhat satisfied with the instructors.

Figure 10. Level II Participant Satisfaction with Course Components



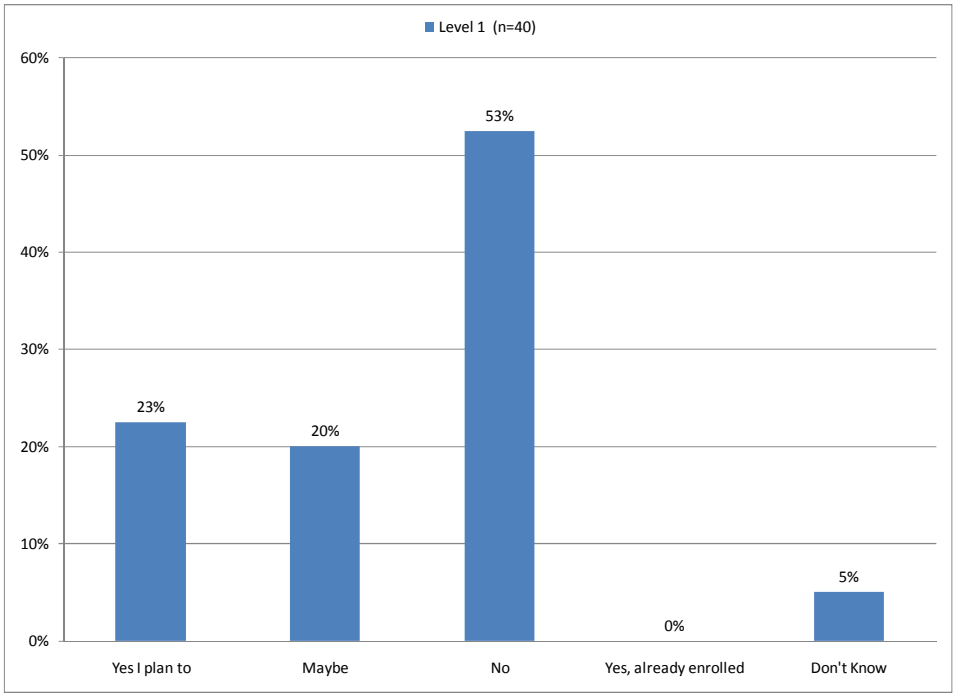
However, the overall level of Level II participant satisfaction is clear in their stated intention to recommend the course to colleagues – 90% indicated they would do so, while 55% of Level I participants indicated that they would do so, as shown in Figure 11.

Figure 11. Participant Plans to Recommend Training to Colleagues



The lower level of overall satisfaction among Level I participants is also evident in the percentage of students indicating that they do not plan to enroll in Level II BOC training – 53% as shown in Figure 12. Twenty three percent of Level I participants indicated that they plan to enroll in Level II, while another 20% stated that they may enroll.

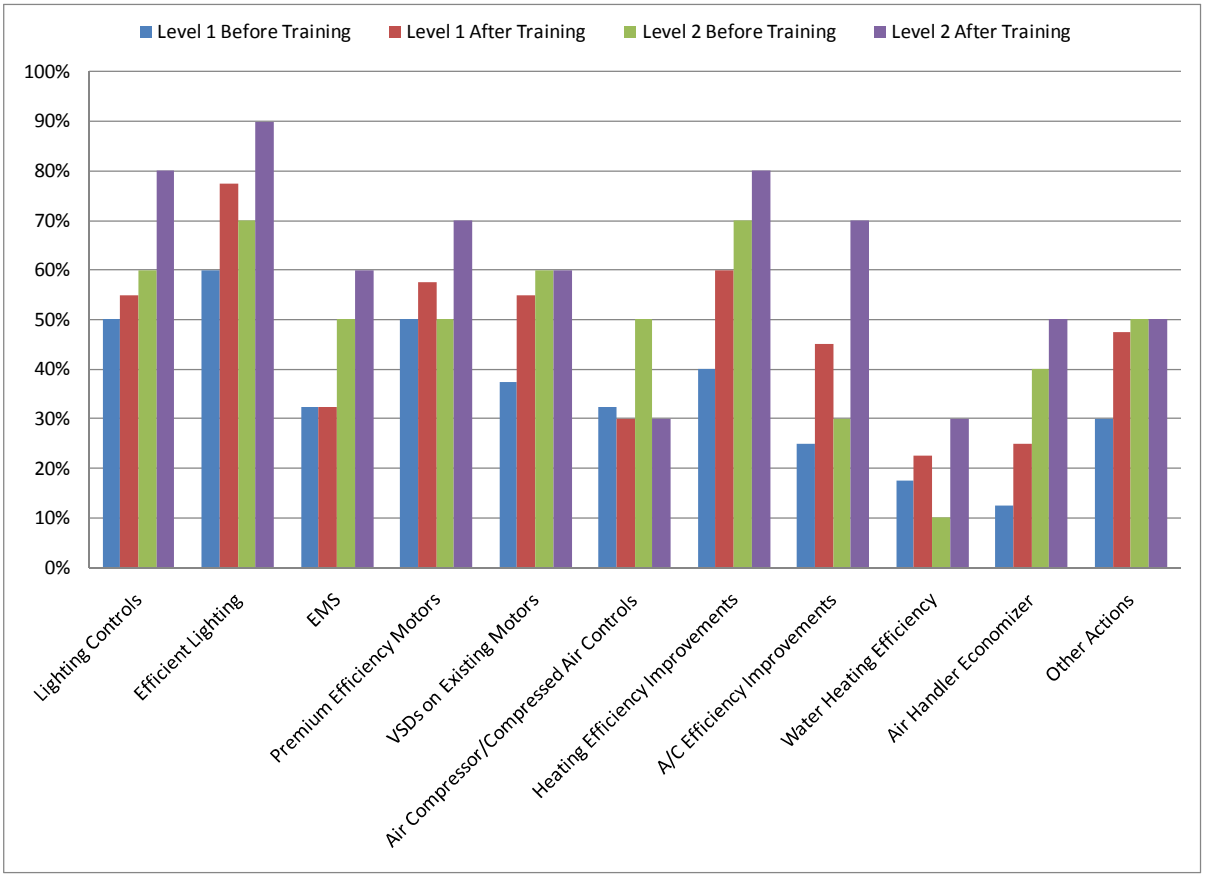
Figure 12. Level I Participants' Intent to Enroll in Level II



High Level Course Impacts and Barriers to Implementing Training

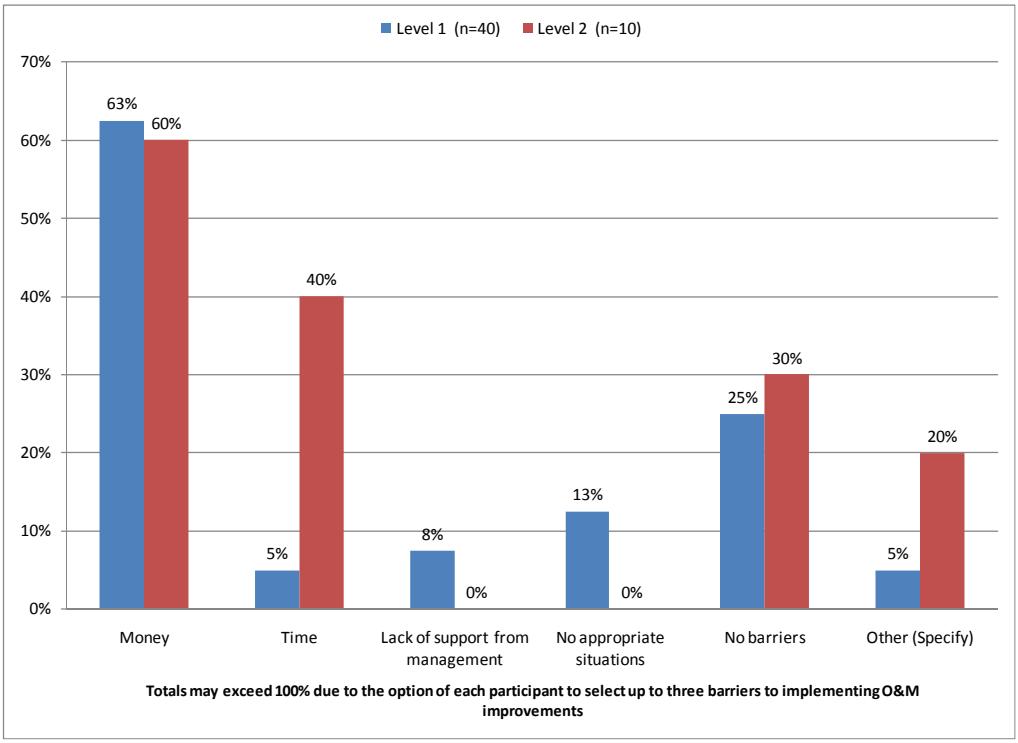
Survey responses indicate that the BOC training was quite effective at increasing the participant's ability and willingness to undertake energy efficiency measures. As shown in Figure 13, the percentage of participants undertaking EE actions of virtually all types increased after either Level I or Level II training.

Figure 13. Participant EE Actions Before and After BOC Training



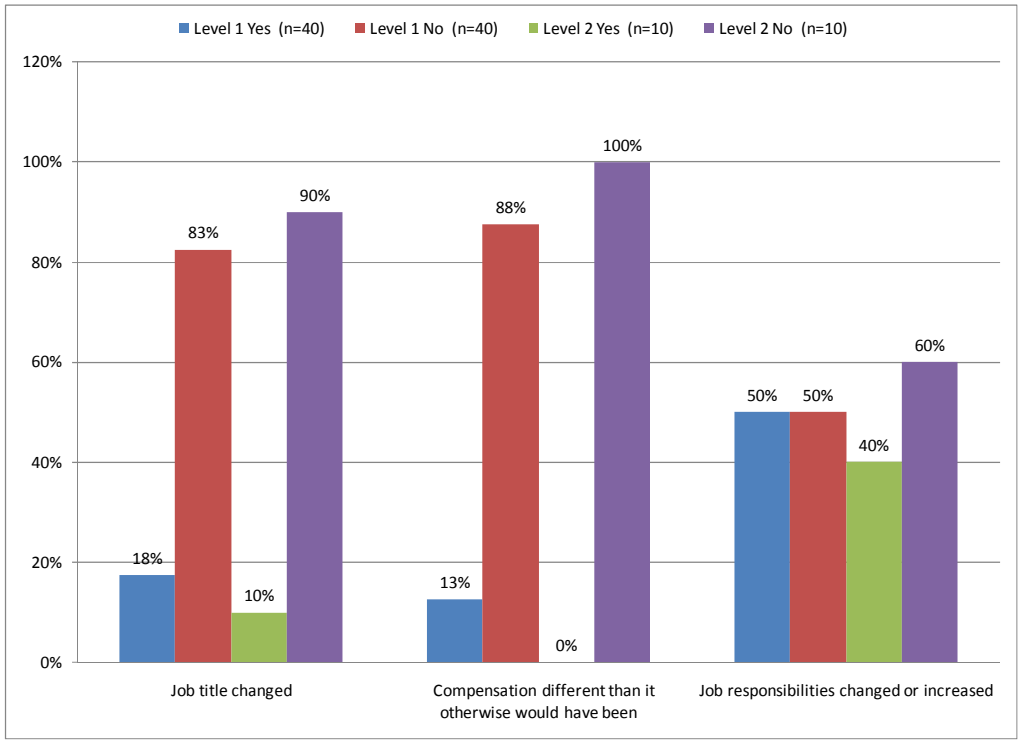
Only about one-quarter (25% of Level I and 30% of Level II) of all participants indicated there were no barriers to implementing the training (Figure 14). Many participants cited money as a barrier (63% of Level I and 60% of Level II). The next most commonly cited barrier by Level II participants was time, while Level I participants cited "no appropriate situation," which future surveys may wish to delve into further. Only 8% of Level I participants cited lack of support from management as an issue.

Figure 14. Barriers to Implementation of O&M Improvements



Other impacts of the BOC training included title changes, responsibility changes or changes in compensation (Figure 14). Eighteen percent of Level I and 10% of Level II participants indicated that their job titles changed after the training, though only 12% of Level I participants indicated that their compensation changed as a result of the training. Fifty percent of Level I and 40% of Level II participants had changed job responsibilities subsequent to the BOC training. Future surveys should obtain more detail on these changes so that related potential marketing benefits can be more clearly identified.

Figure 15. Changes in Job Title or Scope since Completing BOC Training

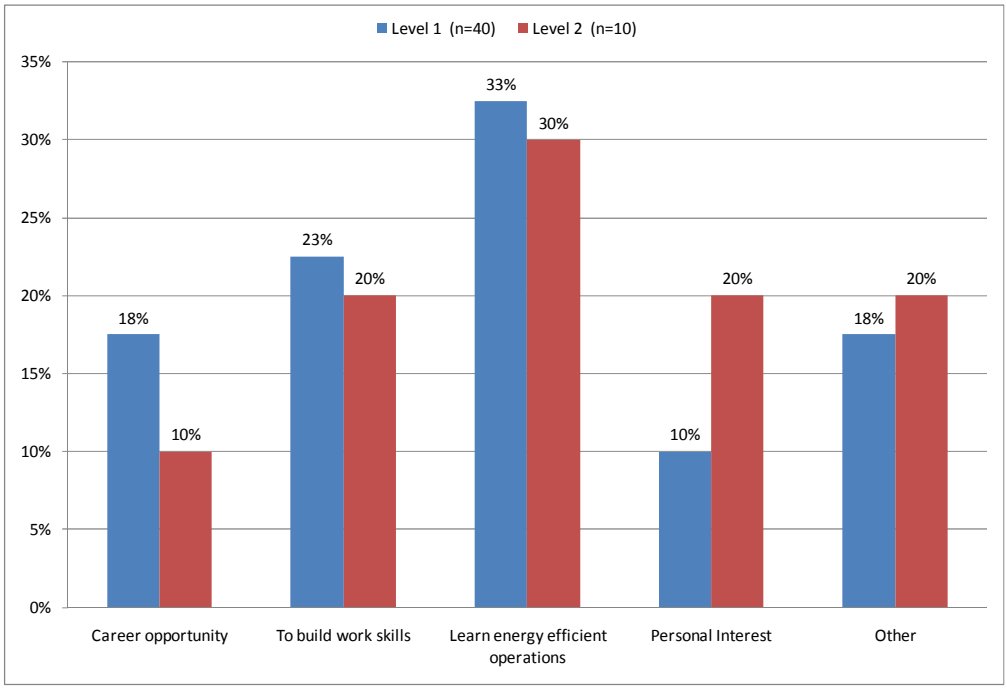


Input to Program Marketing

Participant survey questions also addressed such questions as why they enrolled, how they heard about the program, barriers to participating in the program, recommended changes to course formats and the importance of the tuition rebate in their enrollment. This section provides feedback from participants on these matters.

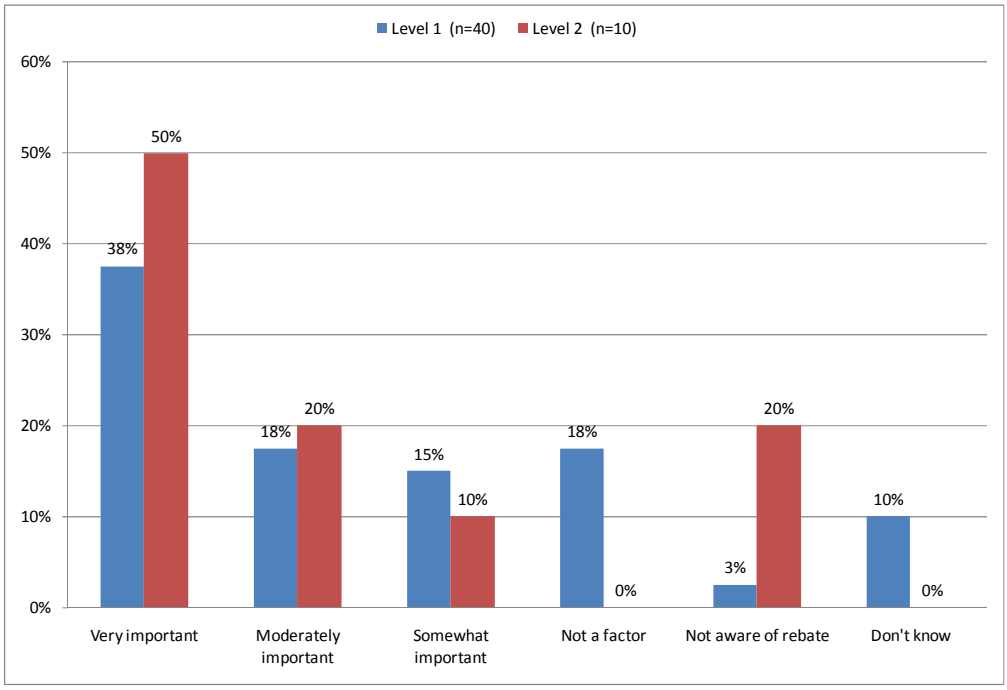
The most common reason participants enrolled in either Level I or II training was a desire to learn about energy efficient operations, at 33% and 30% respectively (Figure 16). More Level II participants than Level I indicated that it was a personal interest. A higher percentage of Level I (41%) than II participants (30%) indicated that career opportunity or added work skills were the motivating factors.

Figure 16. Motivations to Enroll in BOC Training



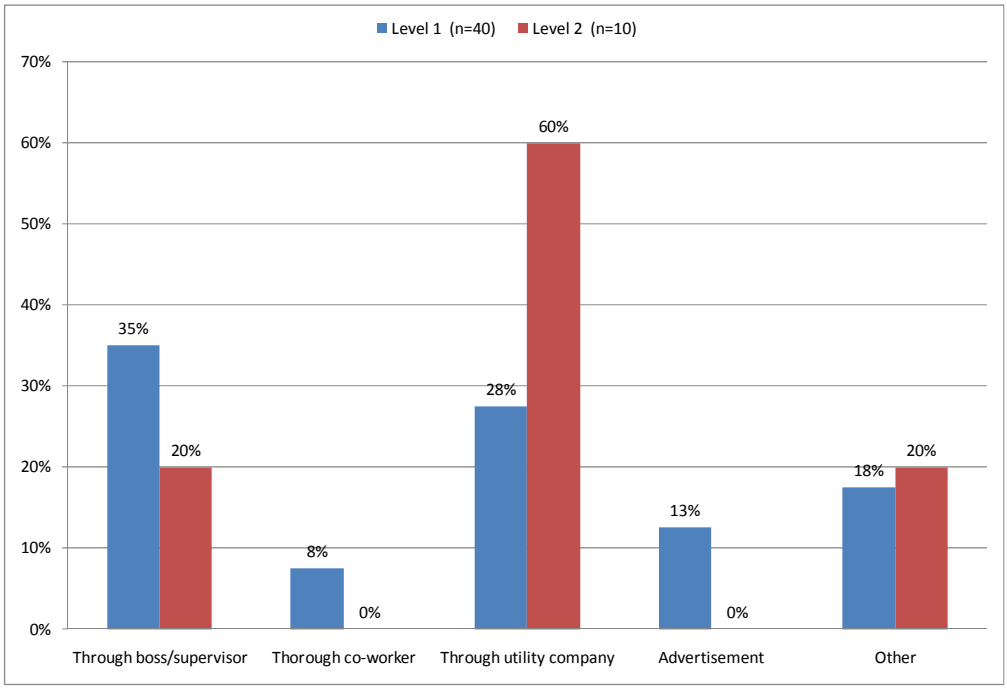
For the majority of both Level I and Level II participants the tuition rebate was either very or moderately important – 56% of Level I and 70% of Level II as shown in Figure 17. Eighteen percent of Level I participants indicated it was not a factor while 20% of Level II participants were not aware of the rebate. This lack of awareness may in part reflect the fact that rebates were not available to all participants.

Figure 17. Tuition Rebate Importance



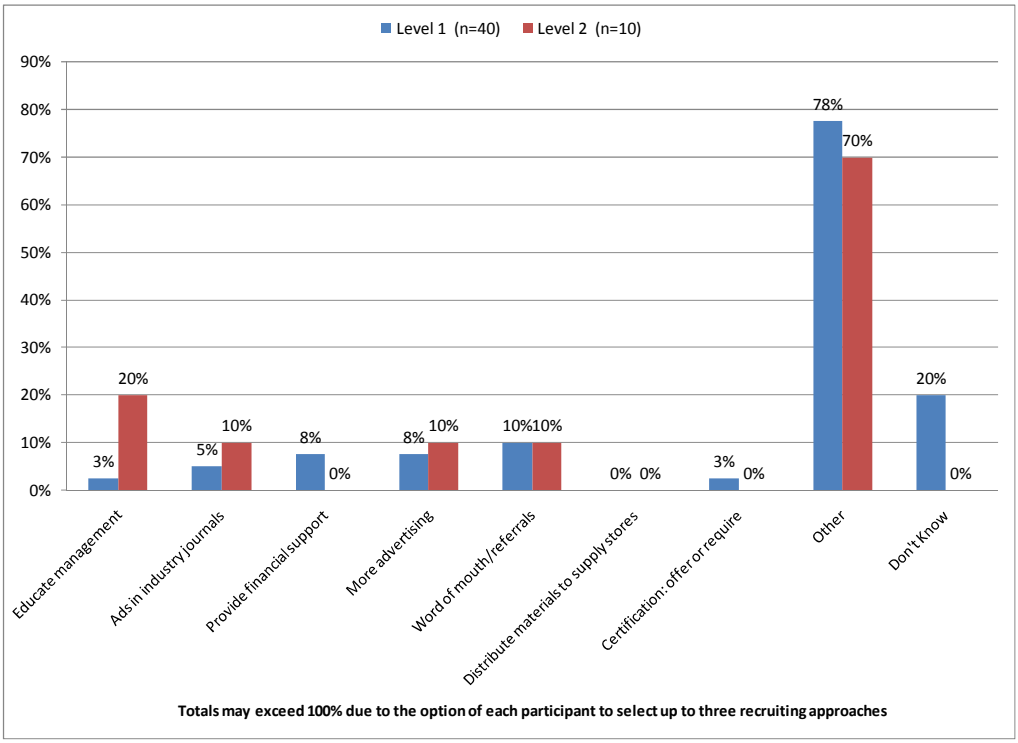
The most common means for participants to hear about the BOC program was through their supervisors in the case of Level I participants (35%), and through the utility company in the case of Level II (60%) participants (Figure 18). Many Level I participants also learned about the course from their utility (28%). Advertisements were more likely to attract Level I participants (13%) than Level II (none) and appeared to be among the least effective means overall.

Figure 18. How Participants Heard About the BOC Course



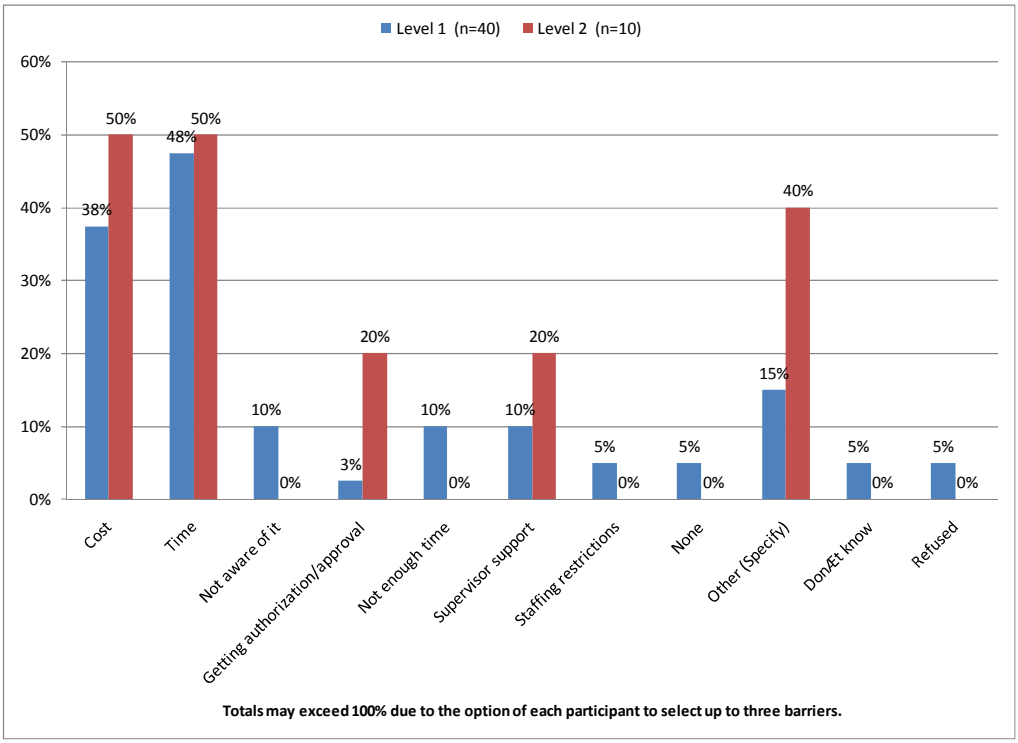
Most participants did not consider the proposed recruiting methods to be most effective, with 78% of Level I and 70% of Level II participants identifying methods they considered to be more effective than those spelled out in the survey as shown in Figure 19. Most respondents specifying other methods indicated e-mails, fliers and rebates as the most effective recruitment methods. Twenty percent of Level II participants thought educating management would be a good recruitment approach, compared to 3% of Level I participants. Ten percent of both Level 1 and Level II participants thought word of mouth was a good recruitment tool. Ads in industry journals were considered effective by only 5% of Level I respondents and 10% of Level II respondents.

Figure 19. Effective Recruiting Approaches



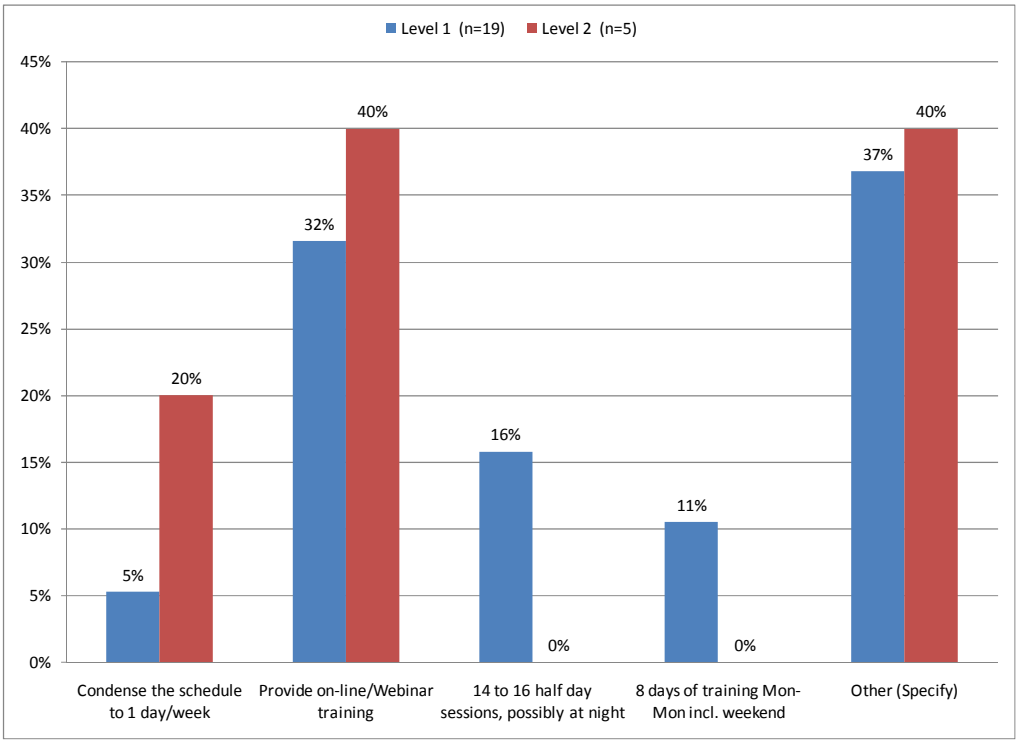
Participants were in general agreement about the two primary barriers to participation in the BOC course: time and money (Figure 20). Twenty percent of Level II participants also cited getting supervisor support and approval. Other barriers identified were the travel distance to the class location and a lack of understanding of the value of the course.

Figure 20. Barriers to BOC Training Participation



The 48% of Level I and 50% of Level II participants that indicated that time was a key barrier to participating in the program were asked for suggestions as to how the format could be changed to best address this issue. Most responded – 38% of Level I and 40% of Level II – that offering the course on-line would be the best solution (Figure 21). Relatively few were interested in having it condensed or in spreading it out. Many of the others recommended sticking to the existing schedule, though one suggested offering it during his downtime – in the summer – and another suggested offering it two nights per week from 6 to 10 pm.

Figure 21. Alternative Course Formats to Address Time Barrier



Instructor Feedback

To obtain the instructors' perspective on the course content, student preparedness and course administration, NCI interviewed three instructors who in combination had run almost 40 Level I and II courses in Minnesota. This section summarizes their feedback.

Course Content and Materials

All interviewed instructors were generally positive about the course materials and contents. All appeared to agree with the comments of one who said that the basic platform is there in the materials provided and offers a good core for consistency. All three indicated that they added material of their own to the presentation material because their personal stories helped the material come alive for the students and at the same time helped the instructors teach the material. They commented that this would be a necessary step no matter what the presentation content.

Some suggestions for course improvements centered on the content of particular classes, though the instructors also indicated that they had previously suggested improvements to either MEEA or the national BOC organization.

One instructor mentioned that his favorite part of the course was the handbook as its detailed information was very valuable as a takeaway for the student. This same instructor felt that the presentation content for some courses was antiquated. He was particularly concerned about courses 101

Building Systems Overview, 102 Energy Conservation Techniques and 105 Environmental Health & Safety Regulations. Another instructor commented that a number of the courses run for shorter periods of time than those allotted and the content could be enhanced. He suggested, for example, that BOC 101 could be expanded further into commercial operations, including renewables, control schemes and smart buildings. Another instructor's suggestion to add meat and real life experience to the course was to suggest that participants bring in a sample of their utility bills for BOC 102 - energy conservation techniques - since participants could be served by different utilities.

Test structure was an area that one instructor felt the course could improve, specifically by keeping the number of test questions more constant across tests – like all having twenty on each instead of ranging from ten to thirty. He also felt that some of the questions had no clear right answer and that this should be addressed to avoid the waste of time involved in arguing the correct answer.

Course Administration and Marketing

All instructors were very positive about how the course was administered. They were universally positive about the feedback opportunities and mechanisms in both directions and did not feel anything additional was required. The feedback form and evaluation from every session was deemed very useful in obtaining early feedback, and the instructor conference calls for sharing ideas were also considered very helpful. They commented that the utility program coordinator was a major help in keeping them focused on teaching the course and that they felt very positively about the opportunity to communicate with MEEA.

Instructors responded that MEEA was very accessible and responsive and ran very well organized events. One instructor had an unfortunate experience of being asked late in the game to teach a course which he had not taught before and he felt he had not done it justice because of the late notice. However, he believed that MEEA had probably needed to substitute him at the last minute due to the unexpected absence of the planned instructor.

Several utility PAs commented that they felt having regular communication would be helpful, though in contrast this was not a need of the instructors. Benefits to the PAs of even infrequent conference calls would include knowing what was coming up and being able to coordinate and inform customers of opportunities to participate in the other utilities' classes.

Regarding marketing of the course, instructors variously suggested the following: advertise through the Association of Energy Engineers, the Association of Facility Engineers and through some of the technical colleges. Several instructors commented that *running* BOC through the technical colleges was not a good approach because the technical colleges do not have the on-site coordinators that handle all the homework and test corrections and do not have one individual consistently there for each class. This latter is necessary because the instructors can vary from one class to the next in the same series.

Several utility PAs also commented on the value of reaching the target market through the Minnesota branches of industry associations and their publications. Suggestions included magazines for commercial building custodial staff, masms.org for K to 12 school facilities, Association of Counties for public buildings, Clean Energy Resource Teams (.org), The Association of Private Colleges and

Universities, and the League of Cities for city managers. One commented that BOC is getting to be better known, but it would be good if BOC had a stronger brand.

Student Preparedness

Again there was general agreement among the instructors about the preparedness of students: they all felt that the students had the necessary background and were capable of learning. However, they also agreed that there was a certain percentage – up to 10% - that were there because they had to be and that they were less likely to take the learnings back and apply them on the job. They universally felt that there was little that could be done either in the course content or instructional approach that would change this.

One instructor commented that he really appreciates having a mix of new and very experienced employees in the class and that he would like the screening process to make sure there is that mix. His concern appeared to be that classes could be too heavy on new entrants in the field.

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4. Impact Evaluation

As stated in the methodology chapter, building on the participant survey responses Navigant undertook a four-step process to estimate energy savings impact from BOC training: (1) Modeling baseline consumption based on facility type of individual survey respondents; (2) Computing gross energy savings for each end use at the sampled participant sites; (3) Converting gross savings into net savings based on reported BOC training and rebate influence on the actions taken and (4) Results standardization for extrapolation across all participants.

This section describes the impact estimate approach and summarizes the results of the analysis.

Data Resources

The impact evaluation, like the process evaluation, was based 50 interviews conducted in November 2010 for a sample of BOC training participants who took either Level 1 or Level 2 training in the period April 2005 – March 2010. During these interviews a series of questions assessed whether the participants had undertaken any energy efficiency activities after the training that could be attributed to the BOC course content. The questions asked about both equipment retrofit or replacement measures and operational changes that were a result of the BOC Training. Furthermore, the participants were asked to rate the influence of the training on their energy efficiency activities and whether utility incentive programs were used. These factors are used to attribute net savings to the BOC program.

Calculations used to assess energy impacts were based on both the survey answers and the following secondary sources:

- The 2003 Commercial Building Energy Consumption Survey[1] (CBECS), which provided a breakdown of energy use by end use for types of commercial building represented by program participants.
- The Minnesota Deemed Savings Database, which was used to estimate savings from retrofit and equipment replacement measures.
- Program materials for the BOC courses, including secondary sources used during courses such as Motor Master and Compressed Air Master.

Participant Survey Summary

According to the participant surveys, each participant is responsible for the operations of and average 194,500 square feet. This average reflects 40 of the 50 telephone interviews. For ten (10) of the surveyed sites, building operators were unable to provide gross floor area. For these 10 sites the analysis assumes that the affected floor area is equal to the average of the other 40 sites. The BOC participants who were unable to provide floor area represent university campuses, municipal school districts or casinos – all

[1] US Department of Energy - Energy Information Agency 2003 Commercial Building Energy Consumption Survey http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html

site types that frequently have multiple buildings and/or with large operator staffs with shared and overlapping responsibilities. The full distribution of survey participant building types is presented in Figure 7 in the Process Evaluation chapter.

Gross Savings for Sample

Navigant Consulting undertook a multi-step process to derive gross savings estimates. In the first step, savings were calibrated to typical energy use. To do this Navigant created a Baseline Consumption Model. Gross savings are then based on the actions taken and amount of the facility (or pieces of equipment) affected by those actions. The following two subsections present these processes.

Baseline consumption model

Previous analyses of BOC program savings have been conducted by assuming a universal energy intensity that applies to all building types and is independent of energy end use. One such resource for this approach is the 2009 Northwest Commercial Building Stock Assessment (CBSA)[2], which provides a universal building energy usage intensity of 16.7 kWh/ft^2. This energy intensity was generated by combining utility billing information with respective building square footages, and categorizing the results by building types. Results are presented in categories ranging from building square footage, year of building construction, monthly energy use patterns, and others.

In order to more accurately determine energy savings from the MN BOC program, it was necessary to analyze building energy consumption by end use for various building types. This would allow the savings from BOC-influenced procedures, upgrades, and behaviors pertaining to individual end use categories to be targeted and quantified. Data for this analysis were obtained from the 2003 Commercial Buildings Energy Consumption Survey (CBECS), which is published by the U.S. Energy Information Administration[3].

The 2003 CBECS data for energy intensity by end use are based on monthly consumption data and climate degree-day data. The results for electrical use were determined by data from 1,500 buildings, and the results for gas were based on data from 1,000 buildings.

The energy usage numbers were developed using a series of modeling techniques. The models incorporated data regarding the building sizes and equipment types (HVAC, water heating, lighting, office equipment, cooking, refrigeration, other) along with engineering equations from the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), the Illuminating Society of North America (IESNA), and others. The energy usage model estimates were based on a number of technical parameters, including the system efficiencies of building equipment, heat losses and gains, ventilation volumes, lighting power densities, and many others.

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[2] *Northwest Commercial Building Stock Assessment, Final Report*, December 21, 2009, report by The Cadmus Group, accessed December 2010 at http://neea.org/research/reports/10-211CBSA.pdf

[3] *2003 Commercial Buildings Energy Consumption Survey*, U.S. Energy Information Administration, accessed December 2010 at http://www.eia.doe.gov/emeu/cbecs/contents.html. The 2007 CBECS report was scheduled for release at the end of 2010; however, at the time of this report it was not available and a release date was not specified.

To determine the MN BOC program savings, CBECS data were used to tabulate average energy intensities by end use for various building types. A total of 18 different building types were specified. The energy intensities were reported for both electric (in units of kWh/ft²) and gas (in units of thousand Btu/ft²) end use categories. The CBECS data contained ten categories for electric end use and four categories for gas end use.

In order to link the MN BOC survey results with the CBECS data, it was first necessary to place the results for each survey participant building type into one of the CBECS building type categories. The MN BOC survey contained 16 options for building types, plus an additional option to specify any unlisted building type. Several of the types directly corresponded to CBECS categories, whereas some did not. Facilities without direct matching to CBECS were mapped to CBECS categories based on CBECS' description of which types of buildings were included in each of the 18 categories (see Table 2). The industrial properties listed in Table implemented mainly lighting and drive-power measures; therefore, the CBECS baselines of "Other" commercial buildings are adequate.

End-Use Savings Calculations

Navigant used a variety of resources, combined with engineering analyses, to estimate energy and demand impacts for the various actions taken by the sample sites. Both electric and natural gas savings were included in the analyses, as appropriate.

- Baseline lighting and HVAC load intensities (kWh and Therms/ft²) were primarily based on the Commercial Buildings Energy Consumption Survey (CBECS)[4] and adjusted to match the specifications of individual sites as noted above.
- The ratio of energy savings to demand savings (kWh/kW) for specific end-uses and other savings calculation factors such as hours of operation were estimated based on a review of ratios of energy savings to demand savings from the Minnesota Deemed Savings Database;[5].
- Engineering analysis was used directly to estimate energy savings from motor and compressed air measures.

[4] Commercial Buildings Energy Consumption Survey 2003, Public Use Microdata, U.S. Department of Energy, Energy Information Administration. http://www.eia.doe.gov/emeu/cbecs/contents.html

[5] Minnesota Deemed Savings Database, MN Department of Commerce. Results from the Zone 3 region were used (primarily for kWh/kW ratios). Zone 3 was chosen since a majority of commercial building stock is in this zone. http://www.state.mn.us/portal/mn/jsp/content.do?subchannel=-536895041&programid=536919090&id=-536893853&agency=Energy&sp2=y

Table 2. Mapping Survey Participants to CBECS Facility Types

Building Type Specified by Survey Participants	Corresponding CBECS Building Type
School/University	Education
Hospital/Medical	Health Care
Casino/Hotel	Lodging
Retail	Retail (non-mall)
Office Government Electric Utility Power Plant (support)	Office
Conference Center	Public Assembly
Corrections/Jail	Public Order and Safety
Computer Communications	Service
Process Industrial Waste Water Treatment Mixed Use	Other

The following subsections describe the savings estimate approach for each of the ten retrofit/replacement and six operational system improvement categories identified in the follow-up interviews.

Installed Lighting Controls

Lighting controls reduce the hours of operation of a lighting system. The MN Deemed Savings Database estimates that controls reduce hours of operation for the lighting end-use by approximately 30%.

Energy Savings = End-Use Intensity (kWh/ft²) x Savings ratio x affected area (ft²).

Where:

Energy Use Intensity: based on CBECS
Savings ratio: Navigant estimate based on survey responses
Affected Area: survey response

Installed Energy Efficient Lighting

Lighting technology upgrades are typified by T8 or T5 replacements for T12 systems, CFL replacement of incandescent lights or Fluorescent high-bay replacement of HID lighting. Navigant estimates lighting equipment saves about 28% of the lighting end-use.

Energy Savings = End-Use Intensity (kWh/ft²) x Savings ratio x affected area (ft²).

Where:

Energy Use Intensity: based on CBECS
Savings ratio: Navigant estimate based on survey responses and MN deemed savings database
Affected Area: survey response

Installed High Efficiency Motors
Premium efficiency motors have superior efficiency compared to like-style standard motors by 1% to 2.7% depending on the size of the motor.

Energy Savings = Nameplate HP x Conversion Factor x hours of operation x loading x savings ratio.

Where:

Nameplate HP: Survey data
Conversion factor: 0.746 kW/HP
Hours of operation: Navigant estimate 3500 hours
Loading: Navigant estimate 70%
Savings ratio: Navigant estimate 1.5%

Installed Variable Frequency Drives (VFDs)
VFDs drive motors serve centrifugal loads with far less power at lower loads and speeds. Various load profiles estimate power energy reduction between 10% and 60% depending on use.

Energy Savings = Nameplate HP x Conversion Factor x hours of operation x loading x savings ratio.

Where:

Nameplate HP: Survey data
Conversion factor: 0.746 kW/HP
Hours of operation: Navigant estimate 3500 hours
Loading: Navigant estimate 70%
Savings ratio: Navigant estimate 30%

Installed Compressed Air Upgrades
This end-use category includes measures for a range of capital upgrades with different savings profiles. Typical measures include new compressors with variable speed drives, new single speed compressors with or without improved loading controls, efficient air dryers, sequencing controls, distribution upgrades, *etc*.

Energy Savings = Nameplate HP x Conversion Factor x hours of operation x loading x savings ratio.

Where:

Nameplate HP: Survey data
Conversion factor: 0.746 kW/HP
Hours of operation: Navigant estimate 3500 hours
Loading: Navigant estimate 90%
Savings ratio: Navigant estimate 15% based on survey responses

Installed Energy Efficient Heating
The heating end-use measures include condensing boilers and furnaces, retrofit heat recovery and retrofit combustion controls.

Energy Savings = End-Use Intensity (Therms/ft²) x Savings ratio x affected area (ft²).

Where:

Energy Use Intensity: based on CBECS
Savings ratio: Navigant estimate based on survey responses and MN deemed savings database, 4%.
Affected Area: survey response

Installed Energy Efficient Cooling
The cooling end-use measures include new chillers or high-efficiency direct expansion cooling, cooling towers and cooling coils.

Energy Savings = End-Use Intensity (kWh/ft²) x Savings ratio x affected area (ft²).

Where:

Energy Use Intensity: based on CBECS
Savings ratio: Navigant estimate based on survey responses and MN deemed savings database, 12%.
Affected Area: survey response

Installed Energy Efficient Domestic Hot Water
Condensing and instant water heaters, insulation and heat recovery are measures for the hot water end-use category.

Energy Savings = End-Use Intensity (Therms/ft²) x Savings ratio x affected area (ft²).

Where:

Energy Use Intensity: based on CBECS
Savings ratio: Navigant estimate based on survey responses and MN deemed savings database, 5%
Affected Area: survey response

Installed Energy Management System
This end-use is an overlay to heating cooling and ventilation end-uses and includes basic stop-start control all the way up to optimization of heating, cooling and ventilation systems.

Energy Savings = End-Use Intensity (kWh/ft²) x Savings ratio x affected area (ft²).

Where:

Energy Use Intensity: based on CBECS heating (Therms/ft²), cooling and ventilation energy use.
Savings ratio: Navigant estimate based on survey responses, 10%

Affected Area: survey response

Installed Economizer

This end-use is a subset of the cooling end-use and it reflects installation of new equipment to reduce hours of mechanical cooling operation.

Energy Savings = End-Use Intensity (kWh/ft²) x Savings ratio x affected area (ft²).

Where:

Energy Use Intensity: based on CBECS
Savings ratio: Navigant estimate based on survey responses, 5%
Affected Area: survey response

The participant survey also asked about operations and maintenance improvements. Navigant Consulting grouped O&M activities by end-use. Savings calculations are similar to those for equipment installation measures except for two universal differences – O&M savings ratios are generally lower than those for equipment upgrade measures, and the thoroughness and frequency of O&M activities are key to realizing savings. Table 3 shows the estimated maximum savings ratio from rigorous O&M practices for end-uses investigated in this study.

Table 3. O&M Savings Ratios by End-Use

End-Use	Maximum O&M Savings Ratio
Compressed air[6]	10%
Cooling[7]	5%
Economizer/Ventilation[7]	5%
Electrical PM[7]	0.5%
Heating[7]	5%
Drive Power[8]	1%

The savings ratios above are modified by Navigant's estimate of the rigor with which they were applied. Rigor has two elements – content and frequency. The more additional O&M tasks that are applied, the

[6] EnergyStar, U.S. Department of Energy and U.S. Environmental Protection Agency. This reference indicates that 20 to 30% of a compressor's output may be wasted by leaks and other operational inefficiencies http://www.energystar.gov/ia/business/industry/compressed_air3.pdf

[7] Navigant Consulting Estimate based on survey responses and conservative estimates based on Piper, J., "HVAC Maintenance and Energy Savings", Building Operating Management, March 2009, http://www.facilitiesnet.com/hvac/article/HVAC-Maintenance-and-Energy-Savings--10680 . The paper notes "Facilities in which proper HVAC maintenance is completed will use at least 15 to 20 percent less energy than those where systems are allowed to deteriorate." Navigant chose conservative estimates of HVAC maintenance savings, not knowing the existing state of facility maintenance.

[8] Drivepower Technology Atlas (Volume IV), eSOURCE. This reference indicates that optimal operations and maintenance practices can save 3 to 10% of all drive power, compared to very poor maintenance practices. Navigant assumes a conservative 1% improvement over existing practices

more savings will be achieved. Increased frequency of O&M activities will create additional savings, though with diminishing returns. Navigant assigned a variable between 0 and 0.7 to the content of O&M activities based on the number of new O&M activities performed for each end-use as a result of the BOC training. We also assigned either a factor of 0 or 0.3 depending on whether the participant reported increased O&M frequency for the end-use as a result of the BOC training.

Net Savings Ratio = Max SR x (content factor + frequency factor)

Gross Savings for End-Uses

As noted previously, the telephone interview included two distinct sections for the impact assessment. The first section asked about equipment retrofit and replacement measures that had been implemented at the participants' sites and the degree to which the BOC training influenced implementation of those measures.[9] This section asked for details for eleven different end-uses (Table 4) and covered 38 specific measures plus open-ended actions for each end use.

The second portion of the impact survey addressed O&M changes made as a result of the BOC training. These changes include new activities, improved processes and/or more frequent execution of these O&M activities. The O&M activities were grouped in similar end-use categories and respondents noted improvements to their O&M practices.

Table 4. Retrofit and O&M Measures Assessed in the Survey

End use	Retrofit Measures Assessed	O&M Measures Assessed
Lighting Control	3	0
Lighting Equipment	7	
Motors	1	4
VFDs	1	
Compressed Air	5	6
Heating	4	7
Domestic Hot Water	3	
Cooling	4	7
HVAC Energy Management	8	7
Economizer/Ventilation	2	
Electrical PM	0	2

[9] Respondents were asked to rate, on a scale of 0 to 10, the influence of the BOC training on each action taken. Actions with an influence rating of less than 3 are assumed to be only marginally influenced by the BOC training; no savings are credited to the program for these actions. See also discussion later in this section.

Table 5 lists the end use actions taken as a result of the BOC training, the number of respondents who took each action, and the estimated gross savings. When interviewees could not furnish site-specific data for actions taken, the analysis assumed average influence at the site based on the rest of the sample respondents. For example, if the building operator reported lighting controls were installed but could not provide the affected area, Navigant estimated the site affected area based on the average percent of area receiving new lighting controls at other sites.

Table 5. End Use-Level Gross Energy Savings from Actions at Sample Sites

Action	# of Respondents with Action	% of Sample Floor Area Affected	Gross Savings		
			kWh	kW	Therms
Equipment Installations					
Lighting Controls	24	11%	1,754,413	398	
Energy Efficient Lighting	30	21%	3,584,237	896	
High Efficiency Motors	13	66%	37,423	10	
Variable Speed Drive Controls	18	44%	758,562	0	
Compressed Air	10	27%	359,467	54	
Heating	25	61%	190,835	0	92,414
Domestic Hot Water	9	11%	9,989	1	2,207
Cooling	10	24%	441,433	574	
HVAC Energy Management	11	29%	1,406,649	0	90,040
Economizer/Ventilation	14	33%	361,045	0	
Total			**8,904,052**	**1,933**	**184,662**
O&M Changes					
Drive power	24	46%	31,411	8	
Compressed Air	14	16%	180,299	27	
Heat	27	54%	27,670	0	46,983
Cooling	16	36%	119,582	130	
HVAC controls	27	53%	58,728	0	
Electrical PM	14	34%	108,220	12	
Total			**525,919**	**203**	**46,983**

Net Savings for Sample Sites

Gross savings represent the savings from actions taken after the BOC training, but do not take into account the level of influence that the BOC training had on these actions.

To determine net BOC training influence, respondents were asked to rate the influence of the BOC training on each action taken, using a scale of 0 to 10, where 0 means no influence and 10 means great influence. Actions with an influence rating of less than 3 (i.e., 0, 1, or 2) are assumed to be only marginally influenced by the BOC training; therefore, no savings are credited to the program for these actions. For actions with ratings of 3 or greater, the percentage of savings attributed to the training was estimated to be ten percent times the stated influence score. For example, if a respondent assigned an influence score of 6 to a particular action, then 60% of the gross savings from that action were attributed to the training and credited to the BOC program. Furthermore for equipment measures, BOC training participants were asked whether they had received utility rebates for the upgrades. Depending on perspective, rebated items could be attributed *solely* to the utility funding the rebates or *shared* between the utility and the BOC training which influenced installation of the rebated equipment.

These two perspectives form the upper and lower bounds on BOC attributable savings. Savings attribution that shares the savings between the BOC training program and utilities is identified as *BOC Attributable Savings* and it forms the upper bound on estimated BOC Training savings. Savings that excludes all utility rebate influence is identified as Savings Net of Utility Rebated.

Net impacts were calculated by multiplying gross impacts by the influence percentage. That is, the net impact of the program on a particular action ("i") for a particular respondent ("s") was computed as:

$$\text{BOC Attributable Savings}_{i,s} = \text{Gross Savings}_{i,s} \times \text{BOC influence}_{i,s}\ (\%)$$

$$\text{Savings Net of Utility Rebated}_{i,s} = \text{BOC Attributable Savings}_{i,s} \times [0 \text{ if utility rebated, 1 if no rebate}]_{i,s}$$

Navigant assumed no utility rebates were awarded for O&M savings.

Tables 6 and 7 present the savings estimates for the eleven end-use groupings for BOC Attributable savings and Net of Utility Programs, respectively.

Table 6. End Use-Level BOC Attributable Savings from Actions at Sample Sites

Action	Net Savings		
	kWh	kW	Therms
Equipment Installations			
Lighting Controls	1,113,458	253	
Energy Efficient Lighting	2,605,496	651	
High Efficiency Motors	29,940	8	
Variable Speed Drive Controls	645,351	0	
Compressed Air	231,941	35	
Heating	13,835	0	57,948
Domestic HW	9,989	1	1,981
Cooling	276,230	359	
HVAC Energy Management	855,062	0	54,024
Economizer/Ventilation	230,067	0	
Total	**6,011,369**	**1,307**	**113,953**
O&M Changes			
Drive power	31,411	8	
Compressed Air	180,299	27	
Heat	27,670	0	46,983
Cooling	119,582	130	
HVAC controls	58,728	0	
Electrical PM	108,220	12	
Total	**525,911**	**203**	**46,983**

Table 7. End Use-Level Savings Net of Utility Rebated Projects from Actions at Sample Sites

Action	Net Savings		
	kWh	kW	Therms
Equipment Installations			
Lighting Controls	228,245	52	
Energy Efficient Lighting	411,074	103	
High Efficiency Motors	4,428	1	
Variable Speed Drive Controls	173,472	0	
Compressed Air	88,191	13	
Heating	9,433	0	39,510
Domestic HW	9,989	1	1,981
Cooling	137,495	179	
HVAC Energy Management	366,835	0	25,329
Economizer/Ventilation	191,722	0	
Total	**1,620,884**	**349**	**66,820**
O&M Changes			
Drive power	31,411	8	
Compressed Air	180,299	27	
Heat	27,670	0	46,983
Cooling	119,582	130	
HVAC controls	58,728	0	
Electrical PM	108,220	12	
Total	**525,919**	**203**	**46,983**

Program Savings

Tables 8 through 10 detail program savings on three bases - Gross Savings, BOC Attributable Savings and Net of Utility Rebated Project Savings - and by different metrics. Navigant defines net savings as the range between BOC Attributable Savings and Savings Net of Utility Rebated projects.

Table 8. Program Savings – Total for Sample (n=50)

	kWh	kW	Therms
Gross	9,429,963	2,136	231,644
BOC Attributable	6,537,280	1,510	160,936
Net of Utility Rebated Projects	2,146,795	552	113,803

Table 9. Program Savings – per Participant (Sample n=50)

	kWh	kW	Therms
Gross	188,599	43	4,633
BOC Attributable	130,746	30	3,219
Net of Utility Rebated Projects	42,936	11	2,276

Table 10. Program Savings – per Square Foot (Sample n=50)

	kWh	Watts	Therms
Gross	1.040	0.236	0.026
BOC Attributable	0.721	0.167	0.018
Net of Utility Rebated Projects	0.237	0.061	0.013

Savings can also be examined for actions that are due solely to O&M practice changes that were induced by the program. Since utility incentives did not influence O&M savings this portion of program savings does not change among savings calculations. O&M savings comprise roughly 8 to 29 % of BOC Attributable Savings and 24 to 41% of Savings Net of Utility Rebated Projects (Table 11).

Table 11. O&M Activity Savings – per Square Foot

	kWh	Watts	Therms
O&M Savings	0.058	0.022	0.00518
O&M Savings% vs. BOC Attributable	8%	13%	29%
O&M Savings% vs. Net of Utility Rebated Projects	24%	37%	41%

NAVIGANT CONSULTING

5. Summary and Recommendations

This final section provides our key conclusions and recommends changes that will enhance program execution as well as future BOC program process and impact evaluations.

Key Process Conclusions

Overall the BOC courses and their administration by MEEA received very positive marks by both participants and instructors. There are no particular areas in course content, administration or instruction that are highly problematic, and communication mechanisms are very positively viewed. There are a few additional, more focused conclusions that stand out:

- Some individual courses can be brought a bit more up to date, and several instructors have submitted such suggestions to the national organization responsible for the course.
- Additional hands-on work, real life examples and facility tours would be valued by many participants, particularly in Level I, and the course length would appear to allow for this. Further as discussed later in this section, homework and projects that would enhance evaluators' impact estimates can also meet this particular need.
- The utilities are doing an excellent job attracting participants to the BOC classes and, overall, appear to be one of the most effective mechanisms for doing so. If there are ways to enhance their reach, then these should be pursued.
- The plan to release on-line BOC courses appears to be on target in reducing a major barrier to more participants taking the course and in line with the participants preferred method for addressing this issue.
- Participants do appear to be benefiting in terms of job title and responsibility from obtaining the certification. The impacts should be better understood and/or quantified and used in the utilities' marketing campaigns.

Key Impact Conclusions

Navigant's impact evaluation assessed kWh, kW and Therms savings on four bases:

- Gross Savings
- BOC Attributable Savings
- BOC Attributable Savings Net of Utility Rebated Projects
- BOC Attributable Savings Due to O&M Actions

BOC Attributable Savings are considered the top end of the BOC program net savings range while BOC Attributable Savings Net of Utility Rebated Projects represents the minimum attributable savings. These data were then converted into per square foot and per participant savings. (Table 12.)

Table 12. Net Program Savings

	kWh	Watts	Therms
Gross per Participant	188,599	43	4,633
Net per Participant	42,936-130,746	11,000-30,000	2,276-3,219
Gross per Square Foot	1.040	0.236	0.026
Net per Square Foot	0.237-0.721	0.0601-0.167	0.013-0.018
O&M Only per Square Foot	0.058	0.022	0.00518

O&M savings per square foot comprise roughly 8% to 29 % of BOC Attributable Savings and 24% to 41% of Savings Net of Utility Rebated Projects.

Recommendations to Facilitate Future Evaluations

Future evaluation plans should include both process and impact evaluations conducted as they have been in this instance, but enhanced by the collection of additional information during the BOC training course, as feasible, and an assessment of the PAs' relative success at reaching the appropriate market.

Process Evaluation Enhancement Potential

There is plentiful data available to assess the participants' satisfaction with their training with the combination of the course evaluations done at the end of the courses and the evaluation surveys. The overall course evaluations identify students' satisfaction with each individual course component, ask how they learned about the course, and ask for suggestions as to how to improve the course. One minor addition would be to ask for overall satisfaction with the course in addition to the four components. Conceivably one additional question that could be valuable is a request for recommendations as to how to recruit participants for future sessions.

The telephone survey process-related questions conducted for this evaluation add to the evaluator's knowledge about how satisfied the participants are with the course once they are back at work for some time. This provides valuable additional feedback, as do the questions specifically addressing impact on job responsibilities and the like. Some of the questions' response options should be modified to reflect respondents' answers, but otherwise the process questions in the survey attached as Appendix A collect additional valuable data for continuing to enhance the course.

There are several success metrics that would be easy to collect. One potential and simple metric of course success is the percent of enrollees graduating from the class. This metric has the additional advantage of reassuring employers that their investment of their employee's time is likely to bear fruit. Another possible metric that would also have marketing benefits is the average savings achieved in the projects undertaken by the enrolled students to obtain their tuition rebates. This metric could be reported separately for Level I and Level II graduates. A third metric of success would be the percentage of Level I graduates who went on to Level II.

There is one area where evaluation is a challenge presently and that is in assessing the PAs' success at both raising awareness of the course in the target market and attracting a significant number of building operators to the course. Ideally MEEA would be able to track the number of building operation staff that

has attended the BOC courses relative to the total target market of all building operator staff. The target market can be sized either through a detailed bottom-up or a rougher top-down approach. The top down approach would involve identifying the customer/facility types (greater than 50,000 square feet) and position titles and estimating the numbers of related staff and comparing the number of participants to the total potential participant pool. Alternatively, a bottom-up approach would be to obtain customer data from the PA's and estimate the number of potential participants based on their detailed customer knowledge. At a minimum, this exercise would give MEEA and the PAs a sound sense for the potential number of participants in Minnesota who may benefit from the training.

Impact Evaluation Enhancement Potential

The impact evaluation is presently constrained to some degree by the participants' relatively limited understanding of their own facilities' energy use and of the potential impact of various measures on that energy use. Because a number of the classes are shorter than the hours allotted to them, there is potential to add some hands-on real world exercises to the classes either as homework or as in-class exercises that will benefit both the participants and the evaluators. The results of this homework and in-class exercises would then feed into subsequent impact evaluations. Such activities could include the following:

- Have the participant provide the square footage and major processes at the facilities that they are responsible for overseeing
- Have the participants report at the end of each session on any changes that they have made at their facilities as a result of the training and any estimated savings
- Have the participants report on any changes they would like to make at their facilities and how they plan to go about doing so
- Have the participants obtain their annual energy consumption for their facilities and report them confidentially on their evaluation for that course.
- Have the PAs' also provide MEEA with the final project report that each of the participants do to receive the final rebate, and get the PAs to ensure that the content of that report includes the cost savings specific to the project.

Appendix A: Participant Survey

BUILDING OPERATOR CERTIFICATION TRAINING, LEVELS 1 and 2
FOLLOW-UP SURVEY

INTRO: Hello may I please speak to [FIRST LAST FROM SAMPLE]? My name is _____ and I am calling from The Blackstone Group on behalf of Midwest Energy Efficiency Alliance (or MEEA). According to our records, you participated in the Building Operator [LEVEL FROM SAMPLE] Certification Training Program in [CLASS CITY FROM SAMPLE]. We are conducting an evaluation of the program and would like to ask you some questions regarding your experience. The survey will take about 15 minutes. Is now a good time?

[If not a good time, schedule call back.]

If [Respondent no longer works with company], then ZA
ZA "Can you tell me where [FIRST LAST FROM SAMPLE] is working now?

[01] Yes, skip to Z1

[02] No, then [Thank and Terminate]

Z1 [Open End with fields for company name, city, state, phone number] [DO NOT REQUIRE ANSWERS FOR ALL FIELDS]

SCREENER

S1. Do you recall participating in the BOC training program from [**INSERT CLASS DATES** FROM SAMPLE]? [If necessary prompt with course topics.]

1. Yes
2. No [THANK AND TERMINATE]
8. (Don't know) [THANK AND TERMINATE]
9. (Refused) [THANK AND TERMINATE]

S2. Do you conduct or manage operations or maintenance activities at your facility?

1. Yes [**SKIP TO P1**]
2. No

8. (Don't know)
9. (Refused)

[ASK IF S2=2]
S3. Why did you enroll in the training program? [OPEN END; 98=DK, 99=Ref]

S4. At the time of the BOC training, what was your position or title? [OPEN END; 98=DK, 99=Ref]

S5. Did you find the training useful given your reason for taking it?

1. Yes
2. No
8. (Don't know)
9. (Refused)

S6. Why was it useful/not useful? [OPEN END; 98=DK, 99=Ref]
Thank and terminate.

PROCESS BACKGROUND

P1. How did you first hear about the course? [OPEN END; 98=DK, 99=Ref]

P2. Why did you originally decide to enroll in the course? [OPEN END; 98=DK, 99=Ref]

ASK P3 IF UCODE=1
P3. How important was the tuition rebate from [**INSERT UTILITY** FROM SAMPLE] in your ability to take the course? **(READ LIST)**

1. Very important
2. Moderately important
3. Somewhat important
4. Not a factor
5. Not aware of rebate

P4. How satisfied were you with the course overall? **(READ LIST)**

1. Very satisfied
2. Moderately satisfied
3. Somewhat satisfied

4. Not satisfied at all

P5. How satisfied were you with the course content? **(READ LIST)**

1. Very satisfied
2. Moderately satisfied
3. Somewhat satisfied
4. Not satisfied at all

P6. How satisfied were you with the course schedule – timing between classes, class length and the like? **(READ LIST)**

1. Very satisfied
2. Moderately satisfied
3. Somewhat satisfied
4. Not satisfied at all

P7. How satisfied were you with the course instructors? **(READ LIST)**

1. Very satisfied
2. Moderately satisfied
3. Somewhat satisfied
4. Not satisfied at all

P8. How satisfied were you with the course facilities? **(READ LIST)**

1. Very satisfied
2. Moderately satisfied
3. Somewhat satisfied
4. Not satisfied at all

P9. What did you like best about the course? [OPEN END; 98=DK, 99=Ref]

P10. What did you like least about the course? [OPEN END; 98=DK, 99=Ref]

P11. Do you have any suggestions for improving the course? [OPEN END; 98=DK, 99=Ref]

FACILITY INFORMATION

D2. What type of business is run at your facility? **(DO NOT READ LIST)** [MULTIPLE RESPONSE, UP TO 3]

1. (School/University)
2. (Office)
3. (Retail)
4. (Restaurant)
5. (Hospital/Medical)
6. (Grocery)
7. (Warehouse)
8. (Process Industrial)
9. (Other Industrial)
10. (Residential/Apartment Building)
11. (Hotel/Motel)
12. (Mixed Use)
13. (Government)
14. (Real estate/property management)
15. (Corrections/Jail)
16. (Waste water treatment)
00. (Other, specify)
98. (Don't know)
99. (Refused)

F1. What is the approximate size, in square feet, of your building or buildings? [NUMERIC OPEN END, UP TO 9,999,999; DK, Ref]

F1a. For what percentage of this space are you responsible for operations? [NUMERIC OPEN END, UP TO 100%; DK, Ref]

F2. What is the primary heating fuel used in your facility? **(DO NOT READ LIST)**

1. (Gas)
2. (Oil)
3. (Electric)
4. (Purchased steam)
5. (Other, specify)
8. (Don't know)

9. (Refused)

F2a. What is the primary heating system type? **(DO NOT READ LIST)** [Confirm fuel type]

1. (Hot air furnace)
2. (Wall or floorboard radiator (steam, Hot Water or electric resistance)
3. (Steam, hot water or electric resistance coils in ventilation system.)
4. (Space heaters)
5. (Heat pump, air source)
6. (Heat pump, ground source)
7. (Heat pump, water loop)
00. (Other, specify)
98. (Don't know)
99. (Refused)

F3. Do you have a secondary heating system?

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF F3=1 ELSE SKIP TO F4]

F3a. What is the secondary heating fuel? **(DO NOT READ LIST)**

1. (Gas)
2. (Oil)
3. (Electric)
4. (Other, specify)
8. (Don't know)
9. (Refused)

F3b. What is the secondary heating system type? **(DO NOT READ LIST)** [Confirm fuel type]

1. (Hot air furnace)
2. (Wall or floorboard radiator (steam, HW or electric resistance)
3. (Steam, hot water or electric resistance coils in ventilation system.)
4. (Space heaters)
5. (Heat pump, air source)

6. (Heat pump, ground source)
(Heat pump, water loop)
00. (Other, specify)
98. (Don't know)
99. (Refused)

F4. What is the cooling system type at your facility? **(DO NOT READ LIST)**

1. (Direct Expansion – air-cooled packaged or split system cooling or like a heat pump)
2. (Chiller – air-cooled)
3. (Chiller – water or evaporatively cooled)
4. (Evaporative cooler)
6. (Geothermal heat pump)
7. (Window units)
8. (Fans)
00. (Other, specify)
98. (Don't know)
99. (Refused)

F5. What is the primary fuel used for water heating at your facility? **(DO NOT READ LIST)**

1. (Gas)
2. (Electric)
3. (Oil)
4. (Solar)
5. (Steam)
00. (Other, specify)
98. (Don't know)
99. (Refused)

IMPACTS

I1. I'm going to run through a list of possible projects to improve the energy efficiency of your facility. For each type of project, I'll be asking if you have installed or supervised installation of this type of project BEFORE as well as AFTER participating in the BOC training program. Later I will ask about operational changes you might have implemented. [ASK YES=1, NO=2, DK=8, REF=9 FOR EACH]

A1. BEFORE the training: Had you installed any lighting controls?

A2. How about AFTER the training?

B1. BEFORE the training: Had you installed efficient lighting?

B2. How about AFTER the training?

C1. BEFORE the training: Had you installed a new or expanded an existing Energy Management System?

C2. How about AFTER the training?

D1. BEFORE the training: Had you installed new premium efficiency motors?

D2. How about AFTER the training?

E1. BEFORE the training: Had you installed new VSDs on existing motors?

E2. How about AFTER the training?

F1. BEFORE the training: Had you installed new air compressors or compressed air controls?

F2. How about AFTER the training?

G1. BEFORE the training: Had you made any heating efficiency improvements?

G2. How about AFTER the training?

H1. BEFORE the training: Had you made any A/C efficiency improvements?

H2. How about AFTER the training?

I1. BEFORE the training: Had you made any water heating efficiency improvements?

I2. How about AFTER the training?

J1. BEFORE the training: Had you installed or retrofit an economizer on an air handler?

J2. How about AFTER the training?

K1. BEFORE the training: Had you completed any other energy conservation steps?

K2. How about AFTER the training?

If **ONE OR MORE "YES" (01)** ANSWERS in I1A2-I1K2
I2A. Were the projects you implemented AFTER taking the training done at one facility or more than one facility?

(1) one facility
(2) more than one facility
(8) DK
(9) Ref

If I2A=1 [one facility]
I2AA. What is the address of the facility where you implemented projects? (Open fields for address, city, state, zip.) [DO NOT REQUIRE ANSWERS FOR ALL FIELDS]

If I2A=2 [more than one facility], skip to I2AB
I2AB. At how many facilities did you implement these projects? (Numeric Open End)

[The answer for I2AB should determine how many addresses are asked for. Set a maximum of 10 address questions.]
I2AB1. What is the address of the first facility where you implemented the projects? (Open fields for address, city, state, zip.) [DO NOT REQUIRE ANSWERS FOR ALL FIELDS]

I2AB2. What is the address of the second facility where you implemented the projects? (Open fields for address, city, state, zip.) [DO NOT REQUIRE ANSWERS FOR ALL FIELDS]

[IF MORE THAN ONE "**YES" (01)** ANSWERS in I1A2-I1K2, GO TO I2B.]
For every I2AB1(-I2AB10) question, there should be a I2B question.

I2B1. Which projects were done at (facility address from I2AB1 piped in here)? [Mark all that apply. Read list if necessary]

I2B2. Which projects were done at (facility address from I2AB2 piped in here)? [Mark all that apply. Read list if necessary]

Lighting Controls

[ASK IF I1a2=1 ELSE SKIP TO I6a]

I5a. You mentioned that you installed lighting controls after taking the BOC training. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to install lighting controls?

0	1	2	3	4	5	6	7	8	9	10	DK	Ref
Not at all										Very much		

[SKIP I5b-f IF I5a<3]

I5b. What is the square footage of the area that new lighting controls were installed in? [NUMERIC OPEN END, UP TO 9,999,999; DK, Ref]

I5c. Did you receive a rebate from your utility for the installation of new lighting controls?

1. (Yes)
2. (No)
8. (Don't know)
9. (Refused)

I5d. Please describe the function of your new lighting controls **(DO NOT READ LIST)** [98=DK, 99=Refused].

1. (Motion sensors)
2. (Timers)
3. (Night lighting)
00. (Other, specify)

I5e1. What are the estimated energy savings per month from installing lighting controls, in terms of Kilowatt hours per month?

[If necessary, PROBE with "What about in terms of another measure?"]

[NUMERIC OPEN END UP TO **999,999**]

999998 DK

999999 Ref

999997 Other Measure [specify OPEN END]

Efficient Lighting

[ASK IF I1b2=1 ELSE SKIP TO I7a]

I6a. You mentioned that you installed energy efficient lighting after taking the BOC training. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to install efficient lighting?

0	1	2	3	4	5	6	7	8	9	10	DK	Ref
Not at all										Very much		

[SKIP I6b-e IF I6a<3]

I6b. What is the square footage of the area that new efficient lighting was installed in?
[NUMERIC OPEN END, UP TO 9,999,999; DK, Ref]

I6c. Did you receive a rebate from your utility for the installation of new efficient lighting?

1. (Yes)
2. (No)
8. (Don't know)
9. (Refused)

I6d. Please describe the general retrofit purpose **(DO NOT READ LIST)**
[98=DK, 99=Refused].

1. (Fluorescent replacement T12 to T8 or High-performance T8)
2. (Fluorescent delamping)
3. (Fluorescent lighting redesign T8 or T5)
4. (Incandescent replacement with CFL or metal halide)
5. (High-Intensity Discharge (HID) replacement with
   5a. pulse-start metal halide,
   5b. fluorescent or
   5c. LED)

00. (Other, specify)

I6e1. What are the estimated energy savings per month from installing energy efficient lighting, in terms of Kilowatt hours per month?
[If necessary, PROBE with "What about in terms of other measures?"]

[NUMERIC OPEN END UP TO **999,999**]
999998 DK
999999 Ref
999997 Other Measure [specify OPEN END]

EMS

[ASK IF I1c2=1 ELSE SKIP TO I8a]

I7a. You mentioned that you installed or upgraded an Energy Management System after taking the BOC training. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to install or upgrade your Energy Management System?

0	1	2	3	4	5	6	7	8	9	10	DK	Ref
Not at all										Very much		

[SKIP I7b-e IF I7a<3]

I7b. What is the square footage of the area that the Energy Management System controlled? [NUMERIC OPEN END, UP TO 9,999,999; DK, Ref]

I7c. Did you receive a rebate from your utility for the installation of the energy management system?

1. (Yes)
2. (No)
8. (Don't know)
9. (Refused)

I7d. Please describe the function(s) of your new Energy Management System. **(DO NOT READ LIST)** [98=DK, 99=Ref]. Mark all that apply

1. (On and off schedule)
2. (Does everything)
3. (Cooling plant optimization)
4. Cooling distribution optimization
5. Outdoor air ventilization (economizer)
6. Outdoor air ventilization (demand controlled ventilation with CO sensor)
7. Air distribution optimization
8. Heating plant and distribution optimization
00. (Other, specify)

I7e1. What are the estimated energy savings per month from installing or upgrading the Energy Management System, in terms of Kilowatt hours per month?
[If necessary, PROBE with "What about in terms of other measures, **such as Millions of BTUS (MMBTUS)?"]**

[NUMERIC OPEN END UP TO **999,999**]
999998 DK
999999 Ref
999997 Other Measure [specify OPEN END]

Motors

[ASK IF I1d2=1 ELSE SKIP TO I9a]
I8a. You mentioned that you installed new premium efficiency motors after taking the BOC training. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to install new motors?

0	1	2	3	4	5	6	7	8	9	10	DK	Ref
Not at all										Very much		

[SKIP I8B1-E2B IF I8a<3]
I8B1. How many new motors did you install? [NUMERIC OPEN END, UP TO 9,999; DK, Ref]

I8B2. What is the TOTAL horsepower of ALL new motors? [NUMERIC OPEN END, UP TO 9,999; DK, Ref]

I8d. Did any of these **new motors have VSDs**?

1. (Yes)
2. (No)
8. (Don't know)
9. (Refused)

[SKIP IF I8d=2]
18E1. How many total horsepower of VSDS were installed on the new motors?

I8E1. Did you receive a rebate from your utility to install the new motors?

1. (Yes)
2. (No)
8. (Don't know)

9. (Refused)

I8E2A. What are the estimated energy savings per month from installing new premium efficiency motors, in terms of Kilowatt hours per month?
[If necessary, PROBE with "What about in terms of other measures?"]
[NUMERIC OPEN END UP TO **999,999**]
999998 DK
999999 Ref
999997 Other Measure [specify OPEN END]

VSDs
[ASK IF I1e2=1 ELSE SKIP TO I10a]
I9a. You mentioned that you installed new VSDs on existing motors after taking the BOC training. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to install new VSDs?

0	1	2	3	4	5	6	7	8	9	10	DK	Ref
Not at all										Very much		

[SKIP I9b-f IF I9a<3]
I9b. How many VSDs did you install on existing motors?
[NUMERIC OPEN END, UP TO 100; DK, Ref]

I9c. What is the TOTAL horsepower of existing motors controlled by the new VSDs?
[NUMERIC OPEN END, UP TO 99,999; DK, Ref]

I9d. Did you receive a rebate from your utility to install new VSDs?
1. (Yes)
2. (No)
8. (Don't know)
9. (Refused)

I9e1. What are the estimated energy savings per month from installing new VSDs on existing motors, in terms of Kilowatt hours per month?
[If necessary, PROBE with "What about in terms of other measures?"]
[NUMERIC OPEN END UP TO **999,999**]
999998 DK
999999 Ref

999997 Other Measure [specify OPEN END]

Air Compressor

[ASK IF I1f2=1 ELSE SKIP TO I11a]

I10a. You mentioned that you performed air compressor system upgrades after taking the BOC training. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to perform air compressor upgrades?

0	1	2	3	4	5	6	7	8	9	10	DK	Ref
Not at all										Very much		

[SKIP I10b-d IF I10a<3]

I10b. What is the total horsepower of the motor(s) in the air compressor system?
[NUMERIC OPEN END, UP TO 99,999; DK, Ref]

I10c. Did you receive a rebate from your utility to install upgrades your air compressor system?

1. (Yes)
2. (No)
8. (Don't know)
9. (Refused)

I10d. Please describe the compressed air project in general **(DO NOT READ LIST)**

1. New high efficiency single-speed compressor
2. New high-efficiency variable speed compressor
3. Improved staging controls
4. New efficient refrigerated air dryer
5. New efficient desiccant air dryer
6. Other (specify _____)
7. Don't Know
8. Refused

I10e1. What are the estimated energy savings per month from the air compressor system upgrades, in terms of Kilowatt hours per month?
[If necessary, PROBE with "What about in terms of other measures?"]

[NUMERIC OPEN END UP TO **999,999**]
999998 DK
999999 Ref

999997 Other Measure [specify OPEN END]

Heating System Efficiency Improvements

[ASK IF I1g2=1 ELSE SKIP TO I12a]

I11a. You mentioned that you installed heating system efficiency improvements after taking the BOC training. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to install the heating system efficiency improvements?

0	1	2	3	4	5	6	7	8	9	10	DK	Ref
Not at all										Very much		

[SKIP I11b-E IF I11a<3]

I11b. What heating system efficiency improvements did you implement after the training?

[OPEN END; DK, Ref]

I11c. Did you receive a rebate from your utility to undertake any of these actions?

1. (Yes)
2. (No)
8. (DK)
9. (Refused)

I11d. Please describe the heating system project in general **(DO NOT READ LIST)**

1. New high efficiency boiler
2. New high-efficiency low turn-down burner
3. Oxygen (O2) trim control
4. Heat recovery
5. Other (specify _____)
6. Don't Know
7. Refused

I11E1. What are the estimated energy savings per month from the heating system improvements, in terms of Kilowatt hours per month?

[If necessary, PROBE with "What about in terms of other measures, **such as Millions of BTUS (MMBTUS)?"]**

[NUMERIC OPEN END UP TO **999,999**]

999998 DK

999999 Ref
999997 Other Measure [specify OPEN END]

A/C Efficiency Improvements
[ASK IF I1h2=1 ELSE SKIP TO I13a]
I12a. You mentioned that you installed A/C efficiency improvements after taking the BOC training. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to install the A/C system efficiency improvements?

0	1	2	3	4	5	6	7	8	9	10	DK	Ref
Not at all								Very much				

[SKIP I12b-d IF I12a<3]
I12b. What A/C efficiency improvements did you implement after the training?
[OPEN END; DK, Ref]

I12c. Did you receive a rebate from your utility to undertake any of these actions?
1. (Yes)
2. (No)
8. (DK)
9. (Refused)

I12D1. Please describe the Air-conditioning system project in general **(DO NOT READ LIST)**
1. New high-efficiency chiller(s)
2. New cooling towers
3. New terminal units
4. Other (specify _____)
5. Don't Know
6. Refused

I12DA. What are the estimated energy savings per month from the A/C efficiency improvements for air conditioning, in terms of Kilowatt hours per month?
[If necessary, PROBE with "What about in terms of other measures, **such as Millions of BTUS (MMBTUS)?"]**
[NUMERIC OPEN END UP TO **999,999**;]
999998 DK

999999 Ref
999997 Other Measure [specify OPEN END]

Water Heating Efficiency Improvements

[ASK IF I1i2=1 ELSE SKIP TO I14a]

I13a. You mentioned that you made efforts to improve water heating efficiency after taking the BOC training. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to improve water heating efficiency?

0	1	2	3	4	5	6	7	8	9	10	DK	Ref
Not at all										Very much		

[SKIP I13b-d IF I13a<3]

I13b. What specific actions did you take to improve water heating efficiency? **(DO NOT READ LIST)**

[OPEN END, 98=DK, 99=Ref]

1. insulate pipes
2. Install time clock to turn off circulation pump after hours
3. Heat recovery
4. Other (specify _____)
5. Don't know
6. Refused

I13c. Did you receive a rebate from your utility to undertake any of these actions?

1. (Yes)
2. (No)
8. (DK)
9. (Refused)

I13D1. What are the estimated energy savings per month from water heating efficiency improvement, in terms of Kilowatt hours per month?

[If necessary, PROBE with "What about in terms of other measures, **such as Millions of BTUS (MMBTUS)?"]**

[NUMERIC OPEN END UP TO **999,999**]
999998 DK
999999 Ref

999997 Other Measure [specify OPEN END]

Economizer on An Air Handler
[ASK IF I1J2=1 ELSE SKIP TO I14a]

I14aa. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to install or retrofit the economizer on the air handler?

0	1	2	3	4	5	6	7	8	9	10	DK	Ref
Not at all										Very much		

[SKIP I14b-c IF I14a<3]
I14ab. Did you receive a rebate from your utility to undertake this action?

1. (Yes)
2. (No)
8. (DK)
9. (Refused)

I14C2. What are the estimated energy savings per month from installing or retrofitting the economizer on the air handler, in terms of Kilowatt hours per month?
[If necessary, PROBE with "What about in terms of other measures, **such as Millions of BTUS (MMBTUS)?"]**

[NUMERIC OPEN END UP TO **999,999**]
999998 DK
999999 Ref
999997 Other Measure [specify OPEN END]

Other Efforts
[ASK IF I1K2=1 ELSE SKIP TO I15a]
I14a. You mentioned that you took other energy conservation steps after taking the BOC training. What are these other steps that you took? [OPEN END **PROBE**.]

I14b. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to take those steps?

0	1	2	3	4	5	6	7	8	9	10	DK	Ref
Not at all										Very much		

[SKIP I14-e IF I14b<3]

I14ca. Did you receive a rebate from your utility to undertake any of these actions?

1. (Yes)
2. (No)
8. (DK)
9. (Refused)

I14D1. What are the estimated energy savings per month from these efforts in terms of Kilowatt hours per month?

[If necessary, PROBE with "What about in terms of other measures, **such as Millions of BTUS (MMBTUS)?"]**

[NUMERIC OPEN END UP TO **999,999**; DK, Ref]

999998 DK

999999 Ref

999997 Other Measure [specify OPEN END]

Maintenance Activities

I15. Now I'd like to ask you about changes in maintenance activities you may have implemented at your facility SINCE TAKING THE BOC TRAINING. For each of the following activities, please indicate if you have performed them DIFFERENTLY or MORE FREQUENTLY or BOTH since participating in the BOC training.

	DIFFERENTLY	MORE FREQUENTLY	BOTH	No Change	Don't Know	REF
a. maintenance on the cooling system equipment?	(1)	(2)	(3)	(4)	(8)	(9)
b. maintenance on the heating equipment?	(1)	(2)	(3)	(4)	(8)	(9)
c. motor maintenance, including belt alignment and tension?	(1)	(2)	(3)	(4)	(8)	(9)

d. maintenance on compressed air system?	(1)	(2)	(3)	(4)	(8)	(9)
e. electrical panel maintenance?	(1)	(2)	(3)	(4)	(8)	(9)
f. ventilation maintenance?	(1)	(2)	(3)	(4)	(8)	(9)

If **ONE OR MORE (01) DIFFERENTLY, (02) MORE FREQUENTLY or (03) BOTH** answers in I15A-I15F, continue with to I16A

I16A. Were the maintenance projects you performed AFTER taking the training done at one facility or more than one facility?

(1) one facility
(2) more than one facility
(8) DK
(9) Ref

If I16A=1 [one facility]
I16AA. What is the address of the facility where you performed the maintenance projects? (Open fields for address, city, state, zip.) [DO NOT REQUIRE ANSWERS FOR ALL FIELDS]

If I16A=2 [more than one facility]
I16AB. At how many facilities did you perform these maintenance projects? (Numeric Open End)

[The answer for I16AB should determine how many addresses are asked for.]

I16AB1. What is the address of the facility where you performed the maintenance projects? (Open fields for address, city, state, zip.) [DO NOT REQUIRE ANSWERS FOR ALL FIELDS]

I16AB2. What is the address of the facility where you performed the maintenance projects? (Open fields for address, city, state, zip.) [DO NOT REQUIRE ANSWERS FOR ALL FIELDS]

[IF ONE OR MORE (O1) DIFFERENTLY, (02) MORE FREQUENTLY or (03) BOTH ANSWERS in I15A-I15F, GO TO I16B.]

[*For everyI16AB1(-I16AB10) question, there should be a I16B question.]*

I16B1. Which maintenance projects were done at (facility address from I16AB1 piped in here)? [Mark all that apply. Read list if necessary]

I16B2. Which maintenance projects were done at (facility address from I16AB2 piped in here)? [Mark all that apply. Read list if necessary]

Now I would like to ask you about the specific changes in maintenance that you just indicated that you made.

Cooling system

[ASK IF I15a=1, 2 or 3 ELSE SKIP TO I18a]

I17a. You mentioned that you have changed how you perform maintenance on cooling system equipment since taking the BOC training. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to change your maintenance practices?

0	1	2	3	4	5	6	7	8	9	10	DK	Ref
Not at all										Very much		

[SKIP I17b-c IF I17a<3]

I17b1. Please tell me all the changes you have made to your cooling system maintenance practices. **(DO NOT READ LIST)**

FOR EACH CHANGE MENTIONED, ASK:

I17b2. How frequently do you now do this? **(DO NOT READ LIST)**

Possible Actions	**MADE**	**Frequency**				
		Done first time in years; scheduled in future	**Monthly**	**Quarterly**	**Annual**	**Other (SPECIFY)**
Water treatment						
Cooling tower service						
Chiller bundle cleaning						
Condenser cleaning						
Refrigerant charge adjustment						

Sensor calibration						
System diagnostics						
Other (SPECIFY)						

I17c. How many tons is the cooling system equipment that you performed maintenance on? [NUMERIC OPEN END, UP TO 9,999; DK, Ref] **Heating equipment**
[ASK IF I15b=1, 2 or 3 ELSE SKIP TO I19a]
I18a. You mentioned that you have changed how you perform maintenance on heating equipment since taking the BOC training. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to change your maintenance practices?

0	1	2	3	4	5	6	7	8	9	10	DK	Ref
Not at all								Very much				

[SKIP I18b-c IF I18a<3]
I18b1. Please tell me all the changes you have made to your heating system maintenance practices. **(DO NOT READ LIST)**
FOR EACH CHANGE MENTIONED, ASK:
I18b2. How frequently do you now do this? **(DO NOT READ LIST)**

Possible Actions	**MADE**	**Frequency**				
		Done first time in years; scheduled in future	**Monthly**	**Quarterly**	**Annual**	**Other (SPECIFY)**
Water treatment						
Steam trap service						
Heat exchanger cleaning						
Blowdown frequency						
Sensor						

Calibration						
System diagnostics						
Other (SPECIFY)						

I18c. How many square feet does the heating system that maintenance was performed on affect? [NUMERIC OPEN END, UP TO 9,999,999; DK, Ref]

Motor Maintenance

[ASK IF I15c=1, 2 or 3 ELSE SKIP TO I20a]

I19a. You mentioned that you have changed how you perform motor maintenance since taking the BOC training. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to change your maintenance practices?

0 1 2 3 4 5 6 7 8 9 10 DK Ref

Not at all Very much

[SKIP I19b-d IF I19a<3]

I19b. Please tell me all the changes you have made to your Motor maintenance practices. **(DO NOT READ LIST)**

FOR EACH CHANGE MENTIONED, ASK:

I19b2. How frequently do you now do this? **(DO NOT READ LIST)**

	MADE	**Frequency**				
Possible Actions		**Done first time in years; scheduled in future**	**Monthly**	**Quarterly**	**Annual**	**Other (SPECIFY)**
Lubrication						
Belt alignment/tensioning/replacement						
Coupling alignment						
Notched/Cogged/X-belts						
Other (SPECIFY)						

I19c. How many motors did you perform maintenance on?

[NUMERIC OPEN END, UP TO 999; DK, Ref]

I19d. What is the average horsepower of the motors you performed maintenance on?

[NUMERIC OPEN END, UP TO 99,999; DK, Ref]

Air Compressor Maintenance

[ASK IF I15d=1, 2 or 3 ELSE SKIP TO I21a]

I20a. You mentioned that you have changed how you perform maintenance on air compressors since taking the BOC training. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to change your maintenance practices?

0 1 2 3 4 5 6 7 8 9 10 DK Ref

Not at all Very much

[SKIP I20b-c IF I20a<3]

I20b. Please tell me all the changes you have made to your Compressed Air maintenance practices. **(DO NOT READ LIST)**

FOR EACH CHANGE MENTIONED, ASK:

I20b2. How frequently do you now do this? **(DO NOT READ LIST)**

	MADE	**Frequency**				
Possible Actions		**Done first time in years; scheduled in future**	**Monthly**	**Quarterly**	**Annual**	**Other (SPECIFY)**
Audible leak detection						
Ultra-sonic leak detection						
Pressure optimization						
End-use isolation						
Filter changes						
System diagnostics						
Other (SPECIFY)						

I20c. What is the total horsepower of the air compressor(s)? [NUMERIC OPEN END, UP TO 99,999; DK, Ref]

I20c1. What is the average CFM (Cubic Feet Per Minute) of the air compressor(s)? [NUMERIC OPEN END, UP TO 99,999; DK, Ref]

Electrical Panel Maintenance

[ASK IF I15e=1, 2 or 3 ELSE SKIP TO I22a]

I21a. You mentioned that you have changed how you perform maintenance on electrical panels since taking the BOC training. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to change your maintenance practices?

0 1 2 3 4 5 6 7 8 9 10 DK Ref

Not at all Very much

[SKIP I21b IF I21a<3]

I21b. Please tell me all the changes you have made to your electrical maintenance practices. **(DO NOT READ LIST)**

FOR EACH CHANGE MENTIONED, ASK:

I21b2. How frequently do you now do this? **(DO NOT READ LIST)**

		Frequency					
Possible Actions	**MADE**	**Done first time in years; scheduled in future**	**Monthly**	**Quarterly**	**Annual**	**Other (SPECIFY)**	
Thermal analysis and connection tightening							
Other (SPECIFY)							

Ventilation Maintenance

[ASK IF II5f=1, 2 or 3 ELSE SKIP TO B1]

I22a. You mentioned that you have changed how you perform maintenance on ventilation system since taking the BOC training. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", how much did the training affect your decision to change your maintenance practices?

0 1 2 3 4 5 6 7 8 9 10 DK Ref

Not at all Very much

[SKIP I22b-c IF I22a<3]

I22b. Please tell me all the changes you have made to your Ventilation system maintenance practices **(DO NOT READ LIST)**

FOR EACH CHANGE MENTIONED, ASK:

I22b. How frequently do you now do this? **(DO NOT READ LIST)**

	MADE	**Frequency**				
Possible Actions		**Done first time in years; scheduled in future**	**Monthly**	**Quarterly**	**Annual**	**Other (SPECIFY)**
Economizer optimization/repair						
Sensor Calibration						
Set point optimization						
Balancing						
Filter changes						
System diagnostics						
Sealed leaks / replaced door gaskets						
Other (SPECIFY)						

I22c. What is the total horsepower of the serviced fans?

[NUMERIC OPEN END, UP TO 99,999; DK, Ref]

I22c1. What is the total affected area (sqft) of the serviced fans?

[NUMERIC OPEN END, UP TO 99,999; DK, Ref]

Now I would like to ask you some questions about the program more generally.

BARRIERS

B1. What do you think is the best way to recruit building operators to participate in the BOC training? **(DO NOT READ LIST)** [MULTIPLE RESPONSE, UP TO 3]

1. (Educate management about the program)
2. (Advertise in industry journals)
3. (Provide financial support for attendance)
4. (More advertising)
5. (Word of mouth/referrals)
6. (Distribute materials at supply stores)
7. (Certification: offer or require)

00. (Other, specify)
98. (DK)
99. (Refused)

B2. What do you think are the barriers to getting building operators to participate in the BOC training? **(DO NOT READ LIST)** [MULTIPLE RESPONSE, UP TO 3]

1. (Cost)
2. (Time)
3. (Not aware of it)
4. (Getting authorization/approval)
5. (Not enough time)
6. (Supervisor support)
7. (Staffing restrictions)
8. (None)

00. (Other, specify)
98. (DK)
99. (Refused)

Read If B2=2. Else skip to B4

B3. You indicated that time is a barrier to getting operators to participate in the BOC training, what course format do you think could reduce or eliminate this barrier? Would it be better to [**Read List**]:

1. Condense the schedule to one day every week
2. Provide on-line/Webinar training

3. Split the courses into 14 to 16 half day sessions, possibly at night
4. Provide an intensive 8 days of training Monday through Monday including the weekend.
5. Other, (specify)

B4. What kinds of barriers have prohibited you from implementing Operations & Maintenance improvements to your facility? **(DO NOT READ LIST)** [MULTIPLE RESPONSE, UP TO 3]

1. (Money)
2. (Time)
3. (Lack of support from management)
4. (No appropriate situations)
5. (No barriers)
00. (Other, specify)
98. (DK)
99. (Refused)

ADDITIONAL IMPACTS

A1. I'd like to know if you have accomplished any of the following AS A RESULT OF PARTICIPATING IN THE BOC TRAINING PROGRAM. Have you… [ASK YES=1, NO=2, DK=8, Ref=8 FOR EACH]

a. Developed an energy budget for your facility
b. Tracked energy use systematically over time
c. Set energy savings goals
d. Achieved savings goals
e. Saved energy or reduced energy demand at your facility.
f. Saved your facility money.
g. Enhanced the comfort of your facility's occupants.
h. Made any changes that have improved the Indoor Air Quality of your facility.

[ASK IF A1a=1 ELSE SKIP TO A4]
A2. Approximately, as a percentage of your energy bill, how much energy did you save from all of the energy savings actions that you implemented? **(DO NOT READ LIST)** [NUMERIC OPEN END, UP TO 100%; DK, Ref]

1. (None)
2. (5% or less)
3. (6%-10%)
4. (11-25%)
5. (Over 25%)

A3a. Approximately how many kilowatt-hours of electricity per month did you save from all of the energy savings actions that you implemented? [NUMERIC OPEN END, UP TO **9**99,999; DK, Ref]

A3b. Approximately how many Millions of Btus (MMBTUs) of natural gas per month did you save from all of the energy savings actions that you implemented? [NUMERIC OPEN END, UP TO **9**99,999; DK, Ref]

[ASK IF A1b=1 ELSE SKIP TO A5]

A4. Approximately, how much money on average did you save on your energy bill per month? [NUMERIC OPEN END, UP TO $999,999; DK, Ref]

1. (Less than $1,000)
2. ($1,000-4,999)
3. ($5,000-9,999)
4. ($10,000-19,999)
5. (Over $20,000)

A5. Since completing the BOC training program has your job title changed?

1. (Yes)
2. (No)
8. (DK)
9. (Refused)

A6. Since completing the BOC training program is your compensation different than what it otherwise would have been?

1. (Yes)
2. (No)
8. (DK)
9. (Refused)

A7. Since completing the BOC training program have your job responsibilities changed or increased?

1. (Yes)
2. (No)
8. (DK)
9. (Refused)

[ASK IF ANY A5-A7=1 ELSE SKIP TO O1]

A8. On a scale from 0 to 10 where 0 is "not at all" and 10 is "very much", do you think your completion of the BOC training program helped bring about these changes?

0	1	2	3	4	5	6	7	8	9	10	DK	Ref
Not at all										Very much		

OTHER

O1. Have you recommended the BOC training program to colleagues?

1. (Yes)
2. (No)
8. (DK)
9. (Refused)

[ASK O2 IF LEVEL=1]

O2. Do you plan to enroll in the BOC Level 2 program?

1. (Yes I plan to)
2. (Yes I have already signed up)
3. (Maybe)
4. (No)
5. (Yes, already enrolled)
8. (DK)
9. (Refused)

DEMOGRAPHICS

D1a. What is your current job title? **(DO NOT READ LIST)**
[OPEN END, 98=DK, 99=Ref]

1. (Operations/Facilities operations manager)
2. (Maintenance manager)
3. (HVAC supervisor or technician)
4. (Engineering manager)
5. (Facilities manager)
6. Engineer)
7. (Maintenance manager)
8. (General contractor)
9. (Building management specialist)
10. (Other engineering position)
11. (Other manager, team leader, supervisor)

D1b. How many years have you worked in this role?
[NUMERIC OPEN END, UP TO 50 YEARS; DK, Ref]

D3. How many hours per week is your site open for business? [NUMERIC OPEN END, UP TO 168; DK, Ref]

D4. What is your site's estimated total annual energy cost (electricity and natural gas) ($/year)? [NUMERIC OPEN END, UP TO 999,999; DK, Ref]

D5. What is your site's estimated total electricity cost ($/year)? [NUMERIC OPEN END, UP TO 999,999; DK, Ref]

D6. What is your site's estimated total natural gas cost ($/year)? [NUMERIC OPEN END, UP TO 999,999; DK, Ref]

Those are all the questions I have for you.
Thank you for your time and participation in this survey.

Appendix B: Case Studies

- Duluth International Airport
- Cirrus Aircraft
- Nortech Systems

Duluth International Airport

Duluth International Airport, Duluth, Minnesota

Facility Types: ..... 6 airport buildings including terminal, air traffic control tower, hangars, and commercial space.
Facility Square Footage: 1,000,000
Dates Built: 1930-1973 (new terminal under construction)
Number of Facilities Personnel:..... 5
BOC Participant Profiled: .... Blaine Peterson, Facilities Manager

In the past two years, the Duluth International Airport facilities staff has taken a new approach to saving energy and proactively maintaining energy-using equipment in its six buildings. Taking the lead on these efforts is facilities manager Blaine Peterson, who oversees everything that happens from the moment travelers step off the airplane to when they depart the airport.

Challenges

"Always-on" Equipment Wasting Energy

A few years ago, the operating schedules of energy-using equipment did not take into account the ebbs and flows of activity at the airport. The baggage conveyor belts operated continuously, whether or not any bags were in the system. All parking lot lights were on from dusk to dawn every day, despite periods of very low traffic in the early morning hours.

Blaine Peterson, Facilities Manager

Competing Priorities among Decisionmakers

One of the challenges to achieving significant energy savings through efficiency measures is that there is often an additional upfront cost. Blaine found that even when there are additional funding sources such as the FAA to support energy efficiency projects, there was some inertia from upper management and resistance to the additional paperwork needed to obtain funding assistance.

New terminal building under construction.

Blaine has observed growing upper management acceptance of the additional upfront costs of energy efficiency over the years and he has been able to implement smaller projects under his own budget relatively easily. He hopes to see the new terminal building under construction incorporate the lessons he learned through the BOC, including more advanced lighting technologies such as compact fluorescents and LEDs and conservation measures such as gray water retainage.

Results

Being Proactive is the Key Lesson

The overarching lesson that Blaine learned through the BOC training is that taking a proactive approach to energy conservation and equipment maintenance saves money and labor in the long run.

The training raised his awareness of actions that can be taken to improve energy efficiency through equipment maintenance and to prepare for unexpected events which can have environmental consequences. Blaine implemented annual tune-ups

A lot of that advanced technology is longer life. Doubling the life of the light bulb saves money on both the cost and the labor.
-Blaine Peterson

of HVAC and boiler equipment to make sure that everything is running to its full ability.

Reduced Equipment Operating Hours

One of the first energy conservation measures implemented was a sensor on the baggage conveyor system to shut off the belts when the system hasn't registered any bags for five minutes. Blaine identified this as an obvious opportunity for saving energy by correcting a deficiency in system operations.

Baggage conveyor system with new sensors for automatic shut-off.

Blaine also installed a timer on the parking lot lights to reduce lighting by half during the hours from midnight to 3am, when virtually no one is at the airport.

New Lights

In addition to installing a timer on the parking lot lights, Blaine also installed advanced ceramic discharge metal halide lamps which are 49% more energy-efficient than the original specification. Not only do the new lights save energy, but they are much easier to maintain and replace; he describes them as "plug and play" lights which don't require the maintenance staff to pull out their entire toolbox to replace one burnt-out light. He also notes that the useful life of highly efficient lights is much longer, which reduces both equipment and labor costs.

Blaine also upgraded the lights in the snow removal equipment building. The old metal halides had an orange glow that made it difficult for the staff to check oil and perform other routine duties. After installing the new high bay 23W fluorescent tubes, the building's electricity use was cut in half and the staff no longer have to carry flashlights to be able to perform their duties.

Pursuing Additional Opportunities

The BOC training also helped Blaine become familiar with the wide variety of programs and incentives available for energy efficiency and other sustainability initiatives such as storm water safety. Through the training, he built useful relationships within the energy efficiency community that enable him to take advantage of utility rebates and other opportunities with minimal hassle.

The BOC training made me a lot more aware of the different technologies and assistance programs that are out there, and assisted me in being more proactive in saving energy. As a result, we have reduced our energy consumption by up to 50% in some buildings.
-Blaine Peterson

Cirrus Aircraft

Cirrus Aircraft, Duluth, Minnesota

Facility Types: ...2 buildings: production facility and customer service building.
Facility Square Footage: 270,000
Dates Built: ..... 1993-2006 (including additions)
Number of Facilities Personnel:..... 8
BOC Participants Profiled: ..... Alan Jusczak, Facilities Director, and Bill Carlson, Mechanical Technician

At Cirrus Aircraft's production facility in Duluth, facilities director Alan Jusczak has overseen several major projects designed to save energy and streamline operations. Alan has been at Cirrus Aircraft since 2002, starting as Facilities Manager and later becoming Facilities Director. Alan completed the Building Operator Certification course in 2005; the following year, his colleague Bill Carlson took the course, on Alan's recommendation.

Challenges

Economic Downturn Requires Creativity

Although Cirrus management has always been very supportive of energy-saving projects, the recent economic downturn has forced Alan to become very focused in his pursuit of energy efficiency. To obtain management approval for their projects, Alan and his staff have to look for low-cost projects with paybacks of 12 to 24 months, as well as energy-saving process improvements and behavioral changes. They have also focused on identifying projects that can be undertaken in stages and primarily with internal staff.

I think a good deal of our energy consciousness came out of that BOC training.
-Bill Carlson

Adding to the challenge, any changes to facility operations must avoid adversely affecting Cirrus' production processes. For quality control and safety reasons, some areas of the production building, particularly the bonding and storage areas, must stay within set limits of temperature and humidity.

Results

Technical Knowledge Aids in Gaining Management Support for Efficiency Projects

The most useful aspect of the BOC training, in Alan's opinion, was learning methods for assessing the "health" of buildings and calculating expected energy savings. With more accurate savings estimates, Alan can better calculate the payback period and make a more effective case to management that the projects will be cost-effective and reap near-term benefits. Now that they have completed several efficiency upgrades and observed meaningful savings, management is more comfortable pursuing additional projects.

The BOC course taught us to study the health of our building and calculate expected energy savings from different measures. This technical knowledge helps us sell management on energy efficiency projects.
-Alan Jusczak

Reduced Usage of Motors and Air Compressors

One of the most significant energy saving projects undertaken at Cirrus was a change to the design of the gritblast booths, which is where the fiberglass

airplane parts are prepped for bonding. By modifying the booths' shape and the fan motors, Alan and his team were able to reduce the motor speed by 50% while actually increasing the airflow through the booths. The redesigned booths not only save energy, but also conserve sand and reduce the frequency of filter changes.

By adding a 20hp variable frequency drive air compressor and additional 1,040 gallon storage tank, they were able to save more energy by taking two large air compressors (125hp and 75hp) offline. Altogether, Alan and Bill have observed reductions in demand charges of approximately 20% (more than $10,000 per year) and significant reductions in energy use as well, from an investment of less than $5,000 in these process modifications and booth redesign.

New Lights and Better Color Accuracy

The BOC training informed Alan about the many options for more effective and efficient lighting. He has since replaced 400W metal halides with fluorescent systems, replaced T12s with T8s, and installed 5000K lamps for color correction.

Change in color accuracy with newly installed efficient lighting. The 5000K lights make the airplane in the foreground look white, not dingy like the same-colored plane still under the old lights (background).

The more efficient lighting saves energy and improves the productivity of the workers by providing higher quality light with more lumens and better color rendering. Under the old lights, the workers on the floor were not seeing what customers will see in daylight.

Alan also replaced the timers on the parking lot lights with photo sensors, which are more effective because they do not have to be adjusted in response to daylight savings time and weather changes.

As a result of our increased focus on energy efficiency in our production processes, our demand charges are down about 20% - savings of more than $10,000 per year from roughly a $5,000 investment.

-Alan Jusczak

Culture Changes Yield Notable Energy Savings

With current tight controls on capital spending, Alan and his staff are focusing on energy conservation projects that can be accomplished with in-house resources. These include training staff that the last one out of a room is responsible for shutting off lights and sending emails to remind employees to shut off their computers at the end of the day. These efforts require no capital expenditures, just a culture change.

Another conservation project that they recently undertook is to turn off the vacuum pumps over the three-day weekend when the company switched to a 4-day production schedule. The facilities staff had to closely coordinate with the production staff to ensure that they didn't do anything to interrupt the production schedule, and now they are saving over $1,000 each year from that schedule change.

Pursuing Additional Opportunities

Alan and his staff have several more projects lined up for when the economy improves and there is capital available for the upfront costs. Alan notes that pursuing these projects will have a positive effect on the local economy, as there are contractors and suppliers out there waiting for companies to start doing retrofits and building improvements.

Nortech Systems

Nortech Systems, Bemidji, Minnesota

Facility Types: ..... 1 building: offices and production space.
Facility Square Footage: 60,000
Date Built: 1979
Number of Facilities Personnel: 3
BOC Participant Profiled: .....Greg Pierce, Facilities Engineer

Facilities engineer Greg Pierce has overseen several significant energy efficiency projects at Nortech Systems' Bemidji facility. Greg and his colleagues are responsible for maintaining the facility's HVAC, lighting, and other building systems as well as the production machines used to build and assemble connecting harnesses and cables for medical equipment such as MRI and CT scanning machines.

Challenges

Gaining Approval for Upfront Costs of Efficiency

One of the challenges that every facilities manager seems to encounter is gaining approval or "buy-in" from upper management for the upfront expenses of efficiency upgrades. The BOC training taught Greg how to identify the "quick hit, short ROI" measures that quickly pay for themselves, which helps him demonstrate to management that he's done the legwork and is knowledgeable about valid efficiency investments. These smaller, short payback projects help pave the way for gaining approval for more significant, longer-term investments in the future.

Uncertainty about Vendor and Equipment Choices

Making purchase decisions about new equipment based solely on the vendor's recommendations and your own gut instincts is challenging. One of the most useful aspects of the BOC training in Greg's mind was learning about the "real world experiences" of other people undertaking similar projects.

Results

Efficiency Goes Beyond the Initial Investment

Greg had already made some significant investments in energy-efficient equipment prior to taking the BOC training course, but through the BOC training, he learned that there's much more to energy efficiency than simply selecting the most efficient equipment. Optimizing operations and maintenance practices helps to maximize energy savings from high efficiency equipment. For instance, Greg had replaced an old, inefficient air compressor with a high efficiency 25hp compressor prior to taking the BOC training course. However, it was the BOC training that taught him that adding a storage tank would allow the compressor to run unloaded for longer periods of time and reduce the overall amount of cycle time, which reduces wear and extends the life of the machine. Greg observed that preventive maintenance has "importance beyond what we see today." He also added a valve bank to eliminate air losses and reduce the need for compressed air.

> *One of the most valuable things I gained from the BOC training was the discipline to set up a schedule of preventive maintenance. There's a cost to not doing certain things.*
>
> *-Greg Pierce*

Upgraded Lighting

One ongoing project has been a gradual replacement of all the building's T12 fluorescent lights with T8s. Some sections of the plant were retrofitted to T8s all at once, as money was available for those projects. On

the maintenance side, all burnt-out fixtures were replaced with T8 lamps and ballasts. This approach allowed a gradual shift to the more efficient lighting without a significant upfront cost.

Programming of HVAC Controls

An HVAC controls system was installed prior to Greg's time at the plant, but was not functional. Through the BOC training, Greg realized the importance of the system and worked with a vendor to repair it, enabling nighttime thermostat setbacks and complete fan shut-downs during unoccupied times. This repair and programming of the HVAC controls system has resulted in significant energy savings and keeps building conditions more stable.

HVAC controls system used to reduce energy consumption during unoccupied hours.

New Computer Monitors

Greg started replacing old CRT monitors with energy-efficient flat screen computer monitors prior to the BOC training course; however, in the training he became aware of Otter Tail Power rebates available for the new monitors which reduced the upfront cost and enabled him to make the upgrades more quickly.

Achievements Yield Nearly 20% Reduction in Electricity Consumption Since 2006

Altogether, Greg has observed a 19% reduction in the facility's average monthly kWh electricity consumption from 2006 to 2010. Some of those savings are due to the more efficient air compressor, which was installed prior to the BOC training, but improved maintenance, the added storage tank and valve bank, the HVAC controls repair, and the lighting and computer monitor upgrades also contributed to the impressive reduction in energy use.

Networking and Sharing Information Builds Confidence in Projects

Greg found that one of the key BOC training lessons was the importance of identifying reliable and qualified vendors and then building a relationship so that you can rely on them for their technical expertise. Building ongoing relationships with the BOC course instructors and other classmates is also extremely useful. In Greg's words, it's crucial to "let the experts be experts" rather than "going it alone and trying to figure it out yourself."

> *We're just one of six facilities in the U.S., but I've gone down to some of our other facilities to share information, look at their HVAC systems, and offer them suggestions based on what I've learned from the BOC training so they can try to duplicate it.*
>
> *-Greg Pierce*

A big advantage of taking the BOC course as opposed to teaching yourself out of a textbook is developing those relationships with the instructors and classmates. Greg and his BOC classmates communicate about their project experiences, what's worked well and what they are struggling with, new technologies and services, and their experiences with different vendors.

Greg has also worked to share the lessons he's learned in the BOC training with his colleagues at Nortech Systems' other facilities. Sharing information among a trusted network of colleagues and experts builds confidence that energy efficiency projects that sound good on paper will be successful in the real world.