April 24, 2014
REPORT #E14-277

BOC-Expansion Initiative Market Progress Evaluation Report #1

Prepared by:
Research Into Action Inc.
PO Box 12312
Portland, OR 97212

Northwest Energy Efficiency Alliance
PHONE
503-688-5400
FAX
503-688-5447
EMAIL
info@neea.org

ACKNOWLEDGEMENTS

We wish to thank everyone who contributed to this report. Rita Siong, NEEA's Market Research and Evaluation Project Manager, provided guidance, assistance, and encouragement and showed great patience to help the evaluators navigate a complex landscape. Kim Hughes, NEEA's Senior Initiative Manager, Cynthia Putnam, Karen Schraven, and Teresa Squillace of the Northwest Energy Efficiency Council, and Selena O'Neal, of the International Building Operators Association, responded patiently and thoughtfully to numerous requests for information and clarification. Other NEEA staff, principally Cedric Justice and John Jennings, provided thoughtful review and input on our research products. We also would like to acknowledge the contributions of the eight market experts who provided invaluable information about the building operator market to help guide our research activities as well as the numerous individuals within the building industry who answered our emails and phone calls with additional market information. Finally, we wish to thank all of the building operators who took the time to respond to our survey. Without them, this report would not be possible.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS I

TABLE OF CONTENTS III

EXECUTIVE SUMMARY I

CONCLUSIONS II

RECOMMENDATIONS III

INTRODUCTION 1

SHORT- AND LONG-TERM PROJECT GOALS 1

THE BOC-EXPANSION (BOC-E) "THEORY OF CHANGE" 3

MPER 1 3

EVALUATION ACTIVITIES 5

SCHEDULE OF EVALUATION REPORTS 5

OVERVIEW OF EVALUATION ACTIVITIES 5

DATA COLLECTED FOR MPER #1 6

MARKET CHARACTERIZATION 8

DATA SOURCES 8

BUILDING OPERATOR MARKET SIZE AND BOC MARKET PENETRATION 8

NON-BOC TRAINING INFORMATION 9

BUILDING OPERATIONS BEST PRACTICES 10

CERTIFICATION RENEWAL RATES 11

BOC CERTIFICANT AND WORKPLACE CHARACTERISTICS 11

FINDINGS 12

REVIEW OF PROGRAM THEORY AND METRICS 12

REVIEW OF PROGRAM DATABASE 13

Methods 13

2012 NEEC New and Total Active Certificants and Renewals 14

Attributes of BOC-E Certificants 14

BOC CERTIFICANT SURVEY 15

Survey Methods 15

Sample Description 15

Employment and Veteran Status 17
Value of BOC Training and Certification 17
Barriers to Participation in BOC Training 20
MARKET PROGRESS INDICATORS (MPIS) 24

ACE MODEL ASSUMPTIONS 28

METHODS AND RESULTS 28
Energy Consumption per Square Foot and Energy Savings 28
Percentage of Buildings in Market with Building Operators 30
Number of Operators in the Market 31
Mean Square Feet per BOC Operator 31
Savings Persistence and BOC "Measure Life" 32
Additional Costs Associated with Certification 33
RECOMMENDED ASSUMPTIONS 33

CONCLUSIONS AND RECOMMENDATIONS 36

APPENDIX A: MARKET INFORMANT WRITE-UP A-1

SUMMARY OF KEY POINTS A-1
QUESTION-BY-QUESTION SUMMARIES A-2
Who Are Building Operators A-2
Trends in Building Operations A-3
Current State of Energy Efficiency in Commercial Buildings A-3
BOC Expansion Potential A-4
How Building Operations Staff Apply BOC Knowledge A-5
Attributing Energy Savings to BOC A-5
Market Value of BOC A-6
MARKET AWARENESS OF, AND BARRIERS TO, BOC TRAINING A-6
Underserved Markets A-7
Federal Sector A-8
Final Thoughts A-8

APPENDIX B: LOGIC MODEL MEMO B-1

Brief Statement of the Program B-1
Review of Barriers and Market Progress Indicators (MPIs) B-2
Logic Model Tables B-4
Exit Strategy B-6
Final Comments B-6

APPENDIX C: BOC DATABASE REVIEW MEMO C-1

Methods C-1

Description of NEEC Dataset C-2
Description of 2012 NEEC Certificants C-4
2012 Count of Active NEEC Certificants C-5
2012 Count of Active IBOA Certificants C-8
2012 Count of All Active Certificants C-10

APPENDIX D: MARKET CHARACTERIZATION MEMO D-1

Brief History of BOC "Product" D-1
Estimated Building Operator Market Size D-2
Estimated BOC Penetration into the Building Operator Market D-12
BOC Training – Providers and Accreditation D-12
Non-BOC Training in the Market D-13
Current O&M Best Practices D-16
Certification Renewal Rates D-17
Snapshot of BOC Certificants D-18

APPENDIX E: ACE MODEL REVIEW MEMO E-1

SOURCES E-2
METHODS AND RESULTS E-2
Electric Consumption per Square Foot and Energy Savings (Table 39, Variables 1, 2, 3, and 5) E-2
Percentage of Buildings in Market with Building Operators (Table 39, Variable 7) E-11
Number of Operators in the Market (Table 39, Variable 6) E-12
Mean Square Feet per BOC Operator (Table 39, Variable 4) E-18
Retirement Rate (Table 39, Variable 8) E-19
Additional Costs Associated with Certification (Table 39, Variable 9) E-20
RECOMMENDED ASSUMPTIONS E-21
ATTACHMENT: BASELINE ENERGY CONSUMPTION AND MEASURE-LEVEL SAVINGS METHODS E-24
Establishing Baseline Boiler Energy Consumption E-24
Measure-Level Savings E-24

APPENDIX F: DATA COLLECTION INSTRUMENTS F-1

STAFF INTERVIEW GUIDE F-1
Interview Objectives F-1
Interview Respondents F-1
Interview Approach F-2
Interview Guide F-2

MARKET INFORMANT INTERVIEW GUIDE F-5
Interview Objectives F-5
Introduction F-5
Understanding the Market F-5
Market Awareness of, and Barriers to, BOC Training F-9

BOC CERTIFICANT SURVEY F-12

APPENDIX G: EVALUATION SOURCES G-1

GENERAL SOURCES G-1

MARKET CHARACTERIZATION G-1
NEEA Reports and Memoranda G-1
Census data G-2
Websites G-2
Personal communication G-2

ACE MODEL REVIEW G-3
Online Sources G-3
Technical Reference Manuals G-3

LIST OF FIGURES

Figure 1: BOC-E Logic Model 4

Figure 2: Employer Support for BOC Certification[1] and Renewal[2] (n = 215) 18

Figure 3: Reported Employer Support by Renewal Status 19

Figure 4: Number of Respondents Identifying Alternatives to BOC Training (n = 215) 20

Figure 5: Respondent-Identified Barriers to BOC Participation (n = 215; Multiple Responses Allowed)[1] 21

Figure 6: Respondents' Predicted Impacts of Course Format Changes (n = 215) 24

Figure 7: Certification Tenure and Tenure as Percentage of Total Possible Tenure, by Cohort D-17

Figure 8: Perceived Impact of Splitting Courses into 14 to 16 Evening Sessions, among Older and Recent Certificants (n = 169) D-31

LIST OF TABLES

Table 1: BOC-E Initiative Goals and Associated Market Progress Indicators (MPIs) 2

Table 2: Schedule of BOC-E MPERs 5

Table 3: Overview of Evaluation Activities 5

Table 4: MPER #1 Evaluation Activities, Data Sources, and Sample Sizes 6

Table 5: BOC Expansion Attributes; Multiple Selections Allowed 14

Table 6: Representativeness of Survey Sample, by Section of Survey Completed 16

Table 7: BOC-E Initiative Market Progress Indicators (MPIs) 26

Table 8: BOC-E ACE Model Current and Recommended Key Input Assumptions 34

Table 9: Comparison of Barriers in Tables and Graphic B-4

Table 10: Implementation Staff's Barriers/Activity Matrix B-5

Table 11: Computation of First Year Certified and Last Year Certified C-2

Table 12: Missing Data in BOC Database (n = 1,674) C-3

Table 13: Distribution of Employers and Facilities by Number of Certified Employees in Dataset C-4

Table 14: Distribution of Certificant Work and Home States C-4

Table 15: 2012 Certifications C-5

Table 16: BOC Expansion Attributes; Multiple Selections Allowed (n = 83) C-5

Table 17: Updated Market Status of NEEC Active Certified Building Operators[1] C-6

Table 18: Last Year Certified for those Certified in 2000 or Earlier C-8

Table 19: Updated Market Status of IBOA Active Certified Building Operators[1] C-9

Table 20: Market Status of Active Certified Building Operators C-11

Table 21: Census Totals of Building Operations-Related Occupations in Northwest D-6

Table 22: Comparison of Sample to Regional Population D-10

Table 23: Calculation of Weights for Square Footage per Operator, Buildings At Least 100,000 Square Feet D-11

Table 24: Calculation of Number of Operators in Market D-11

Table 25: Professional Association Certification Programs D-18

Table 26: Distribution of Facility Size D-19

Table 27: Distribution of Total Facility Size in BOC Survey Sample and CBSA D-20

Table 28: Coded Job Title Categories D-21

Table 29: Number of "Included" Building Operators (n = 203) D-22

Table 30: Relationship between Facility Size and Square Footage per Staff D-22

Table 31: Reported Building Operator Categories (n = 203; Multiple Responses Allowed) D-23

Table 32: Mean and Total Number of O&M Staff in Reported Building Operator Categories[1] D-24

Table 33: Association of Operator Types with Employer Types D-25

Table 34: Supervisory Job Categories (n = 203; Multiple Responses Allowed) D-26

Table 35: Employer Support for BOC Certification and Certification Renewal (n = 215) D-27

Table 36: Employer Financial Support for BOC Certification and Renewal, by Renewal History D-28

Table 37: Perceived Barriers to Participation in BOC Training (n = 215; Multiple Responses Allowed) D-29

Table 38: Respondents' Predicted Impacts of Course Format Changes (n = 215) D-30

Table 39: BOC-E ACE Model Current Key Input Assumptions E-1

Table 40: Classification of Survey Respondents into Building Categories E-3

Table 41: Classification of Survey Respondents into Climate Zones E-4

Table 42: Electric Energy Use Intensity (kWh/ft2) by Climate Zone, End-Use, and Building Type[1] E-4

Table 43: Fossil Fuel (1,000 BTU/ft2) Energy Use Intensity by Climate Zone, End-Use, and Building Type[1] E-6

Table 44: Targeted O&M Measures E-8

Table 45: Categorized Job Titles E-13

Table 46: Distribution of Facilities and Respondents by Number of Respondents per Facility E-14

Table 47: Comparison of Sample to Regional Population E-16

Table 48: Calculation of Weights for Square Footage per Operator, Buildings At Least 100,000 Square Feet E-17

Table 49: Calculation of Number of Operators in Market E-17

Table 50: Comparison of Survey Sample with BOC Population on Company Type and Location E-18

Table 51: Comparison of Subsample for Savings Calculations with Other Survey Respondents E-20

Table 52: BOC-E ACE Model Current and Recommended Key Input Assumptions E-21

Table 53: Savings Estimates Calculated With Only O&M Measures and With Non-Incented Capital Improvements, Using CBECS and CBSA Data E-23

Table 54: IECC 2009 Minimum Annual Fuel Utilization Efficiency (AFUE) Ratings for Boilers by Fuel Type and Product E-26

Table 55: Deemed Annual Fuel Utilization Efficiency (AFUE) Ratings for Boilers by Fuel Type E-27

Table 56: Deemed kW Savings Factor for Replacing Standard Efficiency Motors with NEMA Premium Efficiency Motors E-38

EXECUTIVE SUMMARY

This is the first Market Progress Evaluation Report (MPER) of the Building Operator Certification Expansion (BOC-E) Initiative. The Northwest Energy Efficiency Council (NEEC) and the International Building Operators Association (IBOA) have offered BOC training and certification to facility operators in the Northwest since 1997. In 2012, NEEA established BOC-E to accelerate adoption of BOC and increase its market penetration in the Northwest. Through the addition of a new blended online product and the development of new partnerships, the expanded initiative seeks to increase awareness and penetration of BOC among the unemployed, Iraq/Afghanistan veterans, residents of underserved areas, Federal employees, and members of the International Union of Operating Engineers (IUOE).[1]

This evaluation assessed progress toward Initiative goals, characterized the BOC market through primary and secondary research, assessed the BOC-E logic model, and estimated key parameters of the Alliance Cost Effectiveness (ACE) Model. It included a survey of 329 BOC certificants that generated detailed descriptions of operator efficiency actions and provided information on facility characteristics and operator attitudes and perceptions. In addition to supporting the Initiative's assumptions, goals, and approach and documenting progress toward those goals, the research activities for this MPER produced several important findings.

This MPER establishes for the first time a statistically reliable estimate of BOC-attributable savings as a possible alternative to the planning assumption of 2.5% electricity savings per BOC operator used in the BOC ACE Model. The latter has been in use since 1998 when NEEA began funding the program's development. Prior research (MPERs and Long-Term Monitoring and Tracking studies) corroborated the reasonableness of the planning assumption, but did not provide an independently estimated value. This research advances the state of research on BOC not just within the Northwest but nationally, as no other reliable savings data yet exists. The current research includes information on possible savings persistence beyond five years, and the results provide several recommended updates to the Initiative's ACE Model assumptions. We will further refine the recommendations through additional research in upcoming MPERs.

In addition, analyses of data collected through the certificant survey and other sources indicate the target market for BOC training may be considerably larger than previously assumed, meaning that market saturation is less than previously thought. Analysis of survey findings also suggests segmentation of the operator market, which BOC may be able to exploit to achieve greater penetration.

[1] All discussion of BOC-E-related activities in this report pertains only to NEEC, as IBOA was not yet a NEEC Licensed Provider when BOC-E was established. However, this report includes counts of active IBOA BOC certificants to estimate regional BOC savings.

CONCLUSIONS

BOC-E is progressing toward its goals, especially those supporting expanded outreach. To reach Federal employees, NEEC/BOC has taken actions to become a U.S. General Services Administration (GSA) training provider and continues to seek American National Standards Institute (ANSI) accreditation. NEEC/BOC also has established IUOE as a BOC Approved Provider and has established a utility engagement plan to increase awareness among utilities and penetration in underserved markets. Nearly half of 2012 NEEC certificants received certification through BOC-E (returning Iraq/Afghanistan veterans, the unemployed, and those recruited through strategic partnerships and from underserved areas).

Initiative logic is sound but logic and metrics could be clearer. The initiative logic is sound, yet NEEA's program staff could better clarify some of the links between barriers, activities, and outcomes, and further define some metrics to enable assessment. Program staff reported that they have addressed these issues in the revised logic model and assumption tables.

Findings support Initiative assumptions, goals, and approach. Survey data confirmed the assumed barriers to BOC training and supported the plan to offer blended online training. Both employers and certificants value training and renewal: respondents reported employer support; and they said they would get certification even if not required to and would seek other training if BOC were not available. Respondents indicated that employer assistance was important in the decision to pursue certification and renewal, and financial support for renewal appears to translate into higher renewal rates.

The number of active BOC certificants is growing, but the operator market is larger, and thus BOC penetration is lower, than previously assumed. Between 2011 and 2012, the Northwest experienced a net gain of 98 active BOC certificants (those who received or renewed certification within the previous five years). However, previous research underestimated total market size because it overestimated the mean facility square footage per operator. We estimate the total NW market to be about 10,000 building operators. With about 2,000 currently employed BOC operators, market penetration is about 20%.

Exploiting BOC market segmentation could improve penetration. The survey found that certain categories of operations staff are relatively more common among certain employer types: custodial staff in K-12 schools, management staff in colleges, professional staff in health care and property management firms, and general technical/mechanical staff in government and municipally owned facilities. This finding suggests multiple market sub-sectors, which may have implications for marketing, outreach, recruitment, and/or course planning.

BOC-attributed savings comprise approximately 2% of electricity use, 3.6% of fossil fuel use, or 2.7% of BTU consumption from both electricity and fossil fuels.

Certification-related savings may persist beyond five years. We found no evidence that savings percentages decreased after certification had lapsed five or more years, suggesting

possible persistence of savings beyond the currently assumed five-year measure life. However, low statistical power prevents drawing firm conclusions.

RECOMMENDATIONS

BOC should consider adopting a targeted approach to marketing, outreach, recruitment, and/or course planning that accounts for variations among market segments in the mix of building operator types. This may include conducting additional research to investigate differing training needs among various operator types.

BOC should continue and expand efforts to increase employer support of certification and renewal to drive both certification and renewal of certification.

NEEA and BOC should further investigate what employers and operators find beneficial about certification and certification renewal to inform efforts to increase employer support and operator interest.

Program staff should review the initiative logic model and metrics to ensure that all links between barriers, activities, outputs, and outcomes are clear, reasonable, and well supported and that metrics are detailed.

NEEA should revise the Initiative's ACE Model input assumptions:

- Energy use intensity = 15.5 kWh per square foot (kWh/ft^2/year) and .40 therms/ft^2/year.[2]
- BOC-attributable percentage savings per BOC operator = 2.03%, 3.58%, and 2.70% for kWh, therms, and combined kWh and therms (BTUs), respectively.
- Total percentage savings per BOC operator = 4.27%, 6.26%, and 5.13% for kWh, therms, and combined kWh and therms (BTUs), respectively.[3]
- BOC-attributable electricity and fossil fuel savings = 184.0 million kWh and 8.4 million therms, respectively.
- Total electricity and fossil fuel savings = 386.5 million kWh and 14.7 million therms, respectively.

---

[2] As explained fully in Appendix E, these values are consistent with the region-wide mean energy use intensities for the range of BOC-relevant building types (which excludes groceries and restaurants), reported in the Commercial Building Stock Assessment (CBSA).

[3] Total savings combines BOC-attributable savings and savings from efficiency actions that would have occurred in this population without BOC training.

- Average square footage of facility space per BOC operator = 432,768 square feet.
- Estimated number of operators (BOC and non-BOC) in the market = 10,020.
- Percentage of buildings under 100,000 square feet that have in-house building operators = 5%.

1 INTRODUCTION

From 1997 to 2003, the Northwest Energy Efficiency Alliance (NEEA) funded the Building Operator Certification Program (BOC) to provide education, training, and certification of facility operators to perform energy efficient operations and maintenance (O&M) in commercial buildings. NEEA's original funding for BOC saw the initiative to maturity, with the Northwest Energy Efficiency Council (NEEC) and the International Building Operators Association (IBOA) offering BOC as self-supporting ventures since 2000. By 2001, BOC had achieved estimated market awareness over 50% among building employers and operators.[4]

In 2012, NEEA aimed to accelerate adoption of BOC and increase market penetration of commercial building operators who are BOC certified in the Northwest. The stated goal is to achieve 46% market penetration. This new effort, titled BOC Expansion (BOC-E), seeks to expand the adoption of BOC by addressing the following six market barriers:

1. Lack of time
2. Inability to pay (for unemployed operators and veterans)
3. Lack of service in underserved markets
4. Lack of awareness (among International Union of Operating Engineers (IUOE) and WorkSource)
5. Product Performance (does not meet the American National Standards Institute (ANSI), 17024 Standard for certification of personnel, and does not have an online blended learning delivery format)
6. Lack of awareness (about renewal and among utilities)

SHORT- AND LONG-TERM PROJECT GOALS

The initiative organizes its short- and long-term project goals according to ten market progress indicators (MPIs). Table 1 shows the ten MPIs, along with the desired market condition at transition complete and the goal timeframe.

[4] Market Progress Evaluation Report: Regional Building Operator Certification, No. 7. Prepared by Research Into Action, Inc. for Northwest Energy Efficiency Alliance, p.70. Report #E01-088. September, 2001.

Table 1: BOC-E Initiative Goals and Associated Market Progress Indicators (MPIs)

MPI #	Outcome	Time Frame	Market Progress Indicator	Initiative Goal – (Desired Market Condition as of Transition Complete)
I	Increased participation by operators in underserved markets	Short term (1-3 years)	Percent increase in certifications by operators in underserved markets.	BOC courses are available to customers in underserved communities on an ongoing basis.
II	BOC is an approved training provider for GSA	Short term (1-3 years)[1]	BOC listed on GSA training provider roster.	Federal sector building operators participate in two or more BOC courses per year
III	IUOE becomes a BOC Approved Provider	Short term (1-3 years)	Signed AP agreement by NEEC and IUOE.	A formal education partnership is established between BOC and a minimum of one IUOE local in the region
IV	BOC is an authorized provider under ANSI 17024	Short term (1-3 years)	Signed letter of authorization.	BOC meets the ANSI 17024 standard which will make it more credible and competitive in the market, particularly for sectors such as Federal and State government operators.
V	The RTF accepts unitized savings for BOC (Medium term)	Medium term (3-5 years)	Notification letter from RTF.	The RTF establishes unit savings for BOC.
VI	Increased participation by unemployed operators (UE) and returning Veterans	Medium term (3-5 years)	Percent increase in certifications by UE and returning Veteran operators.	Unemployed and returning Veteran building operators participate in BOC.
VII	Increased participation by IUOE-member operators	Medium term (3-5 years)	Percent increase in certifications by IUOE-member building operators.	IUOE-member operators participate in two or more BOC courses per year.
VIII	Increased participation by operators employed in the Federal sector	Not specified in tables, but graphic indicates long term	Percent increase in certifications by Federal building operators; baseline is 2011	Federal sector building operators participate in two or more BOC courses per year.
IX	Was MPI V: Maintenance of certification is valued by employers and operators	Long term (5-10 years)	Percent increase in renewals over 2010 baseline.	BOC certification renewal rate increases 10% from strategy approval date
X	Was MPI VI: Region's utilities incorporate BOC into their EE portfolios	Long term (5-10 years)	Percent increase in utilities integrating BOC into energy efficiency portfolios.	Six or more utilities in OR and WA include BOC in their portfolios.

1 Although the logic model tables indicate this is a short-term MPI, Version 9 of the graphic indicates it is medium-term.

THE BOC-EXPANSION (BOC-E) "THEORY OF CHANGE"

NEEA, in collaboration with NEEC, designed the BOC-E initiative to include six activities aimed at addressing each of the market barriers outlined above. Program theory says that these six activities will produce five outputs, which will then lead to each of the ten outcomes measured by Market Progress Indicators (MPIs) I through X. The initiative logic model graphically illustrates the causal links between the theory's activities, outputs, and outcomes (Figure 1).

BOC-E's theory of change centers on providing *expanded availability and access* to BOC training courses in the Northwest. In its simplest terms, the theory states that if BOC becomes more readily available (via new partnerships with key building operator organizations and through offering blended online course options) to a wider set of targeted audiences (unemployed operators, veterans, federal building operators, and operators in underserved markets), a greater proportion of the building operator population will become BOC certified. Changes in course offerings and delivery approach, the theory goes, will address not only the lack of access barrier, but also lack of awareness and lack of time. Moreover, the program theory assumes that achievement of the ANSI 17024 standard will attract Federal employees.

MPER 1

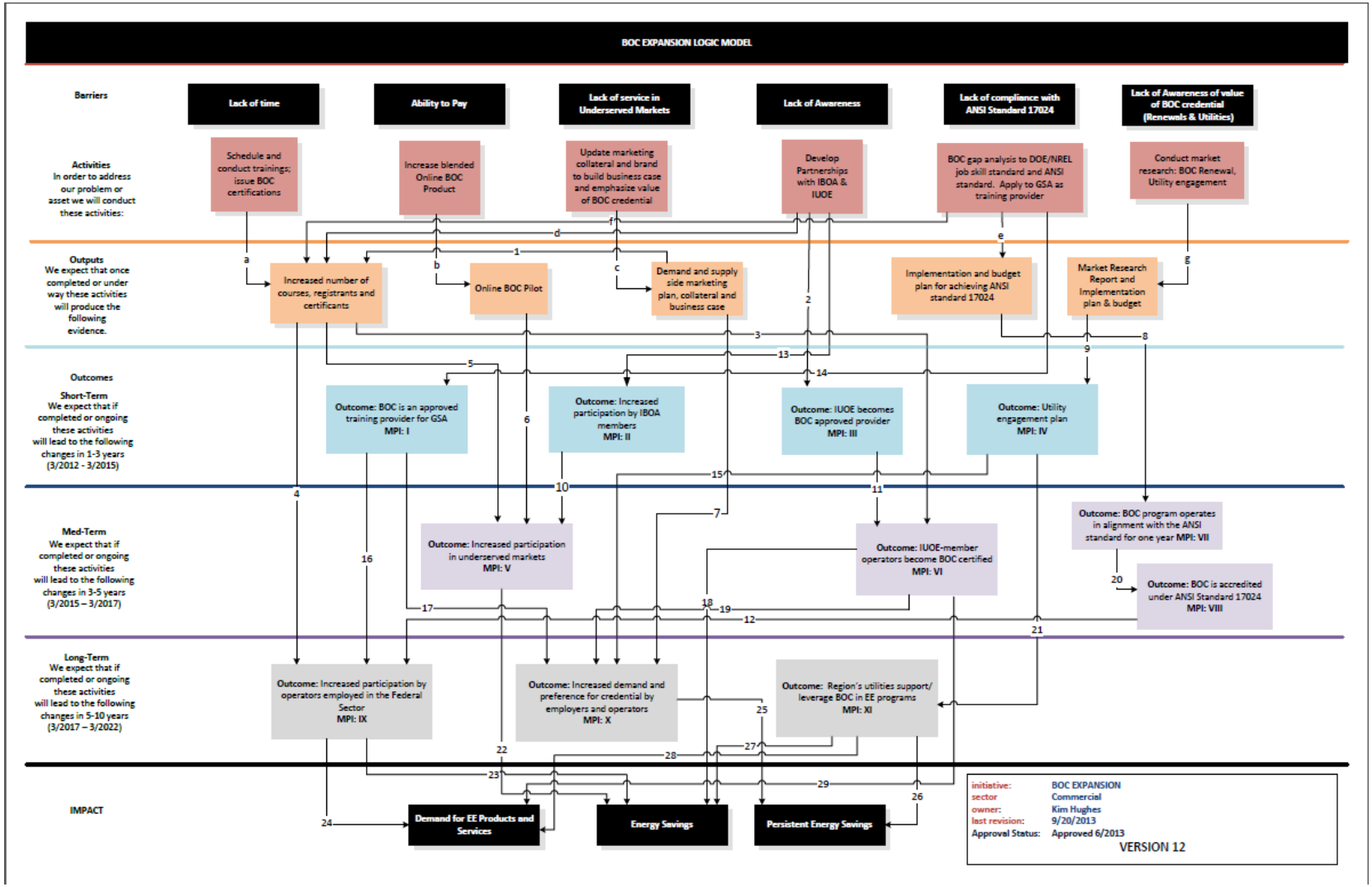
This Market Progress Evaluation Report (MPER 1) is the first of three planned evaluation reports for the BOC-E initiative. It chronicles Research Into Action's evaluation of the BOC-E initiative in 2012-2013. The evaluation focused on answering the following key research questions:

- What is the current market size of building operators in the Northwest?
- Based on estimated market size, what is the current market penetration of BOC?
- What barriers do building operators face in obtaining BOC certification?
- What is the perceived value of BOC certification in the market?
- Does the BOC-E Logic Model clearly illustrate the program theory?
- How is BOC-E progressing against its MPIs?

In addition, we reviewed two important initiative documents, the Alliance Cost Effectiveness (ACE) Model, which contains the assumptions and calculations NEEA uses to estimate the initiative's costs and energy savings; and the NEEC database of BOC trainees.

- ACE Model Review
- NEEC Database Review

Figure 1: BOC-E Logic Model



2 EVALUATION ACTIVITIES

The BOC-E evaluation began in 2012 and will continue into 2015, with three MPERs planned. Chapter 2 presents the schedule of MPER delivery dates, an overview of evaluation activities, and high-level details of the activities we conducted specifically for this report, MPER #1.

SCHEDULE OF EVALUATION REPORTS

Table 2: Schedule of BOC-E MPERs

EVALUATION REPORT	TARGETED DELIVERY DATE
MPER #1	August 2013
MPER #2	May 2014
MPER #3	May 2015

OVERVIEW OF EVALUATION ACTIVITIES

Table 3: Overview of Evaluation Activities

EVALUATION ACTIVITY*	MPER #1	MPER #2	MPER #3
Review Secondary Data on BOC Market	✓	✓	✓
Review Program Logic Model	✓	✓	✓
Review Program ACE Model Assumptions	✓	✓	✓
Review BOC Program Database	✓	✓	✓
Conduct Market Characterization	✓	✓	✓
INTERVIEWS			
NEEA and BOC Program Staff	✓	✓	✓
Market Informants	✓	✓	✓
CERTIFICANT/NON-CERTIFICANT SURVEY			
BOC Certificants	✓		✓
Non-BOC Certificants		✓	
INVESTIGATE QUANTIFIABLE DIFFERENCES BETWEEN			
Classroom-based and blended (classroom + blended online) training		✓	
Impacts between BOC and BOC-E certificants			✓
Impacts between NEEC and IBOA certificants			✓

DATA COLLECTED FOR MPER #1

To answer the key research questions outlined in Chapter 1, Research Into Action focused on seven core research activities (Table 4).

Table 4: MPER #1 Evaluation Activities, Data Sources, and Sample Sizes

ACTIVITY	DATA SOURCE	SAMPLE SIZE
Staff interviews	NEEA and NEEC staff members	4
Market informant interviews	NEEA-provided market informant contacts	8
Logic Model review	BOC Expansion Logic Model, graphical version; and MS Excel tables of market progress indicators and initiative activities	N/A
BOC database review	NEEC and IBOA databases of BOC certificants	N/A
BOC certificant survey	NEEC and IBOA databases of BOC certificants	329
Market Characterization	NEEA program documents	N/A
	BOC certificant survey	329
	Market informant interviews	8
	Secondary data, including: - Information from non-BOC training providers - Previous reports by NEEA contractors (including CBSA) - Other publicly available sources, such as the U.S. Census Bureau	N/A
ACE Model review	Data from BOC certificant survey	329
	Market informant interviews	8
	Various engineering sources	N/A
	Previous NEEA memoranda and reports	N/A

Staff Interviews. In October 2012, we conducted in-depth interviews with one NEEA and two NEEC staff members, as well as with a contracted BOC instructor/facilitator from Lane Community College. These interviews served as a starting point for the evaluation, where we familiarized ourselves with BOC-E, including initiative design, how the expanded product differs from the original BOC product, and the theory of market transformation.

We used the information gathered during staff interviews to inform the design of various data collection instruments, including the market informant interview guides and the BOC certificant survey.

Market Informant Interviews. In December 2012, we interviewed eight market informants representing varying aspects of building efficiency, including BOC course instruction, utility

program management, building/facility management associations, and the commercial buildings non-profit sector.

As with the staff interviews, we drew upon the "insider" perspective the market informants provided to inform the design of the BOC certificant survey. In addition, we assembled this feedback into a summary document for NEEA in January 2013 (See Appendix A).

Logic Model Review. The BOC-E initiative's logic model graphically describes its theory of change. We carefully reviewed both the logic model and the accompanying market progress indicator (MPI) tables to assess the clarity of the causal linkages between activities, outputs and intended outcomes. We presented our findings in a memo to NEEA (draft version dated December 5, 2012, revised April 18, 2013), included in this MPER as Appendix B.

BOC Database Review. Our review of the NEEC and IBOA databases includes a description of database contents, missing data, and various analyses such as the distribution of number of employees certified per facility, and attributes of those building operators who have obtained their BOC certificate as part of BOC-E. We presented our findings in a memo to NEEA (draft version dated February 15, 2013, revised March 20, 2013), included in this MPER as Appendix C.

BOC Certificant Survey. In February 2013, we conducted a primarily online survey of 329 BOC certificants. The survey collected data on characteristics of the survey respondents and their workplace; O&M practices and equipment retrofits, and BOC influence on each; and attitudes and perceptions relating to key research questions. We provide details on survey methods and findings in *Section 4, Findings*.

Market Characterization. Using the sources listed above, we assembled a characterization of the BOC market, including the size of the market and BOC's penetration into it (Appendix D). The market characterization also provided information on non-BOC training in the Northwest; summarized available information on O&M best practices and renewal rates for other building-industry-related certifications; and summarized information on BOC certificants and their workplaces.

ACE Model Review. We reviewed input assumptions of the BOC-E ACE Model, including electric consumption per square foot, percentage of savings for participating buildings, average square footage per operator, and other parameters derived from these statistics (e.g., calculated savings per operator). We also reviewed assumptions about the number of building operators and percentage of buildings with building operators in the smaller-than-100,000-square-feet size tier. We analyzed the relationship between energy savings and interval since certification expiration to review the savings retirement rate assumption (see Appendix E).

The staff and market informant interview guides and the BOC certificant survey instrument are included as Appendix F.

3 MARKET CHARACTERIZATION

Our BOC-E market characterization addressed the estimated size of the building operator market in the Northwest and BOC's penetration into that market; information on sources of non-BOC training for building operators in the Northwest; building operations best practices and renewal rates for comparable types of certification; and BOC operator characteristics identified through our survey of BOC certificants. We have attached the market characterization memorandum we submitted to NEEA (Appendix D).

DATA SOURCES

We utilized several sources of data and information as listed below to create a picture of the building operator market:

1) our review of NEEA documentation on market size and penetration;

2) our survey of BOC certificants;

3) interviews we conducted with eight market informants who are knowledgeable about the regional building operation market;

4) information gathered from other entities that provide building-related training and certification;

5) previous memoranda and reports prepared by NEEA contractors; and

6) other publicly available sources, such as the U.S. Census Bureau.

The market informants included building supervisors, utility staff, instructors of BOC courses, and members of the national BOC advisory committee among other credentials. We provide details on these sources in Appendix G.

BUILDING OPERATOR MARKET SIZE AND BOC MARKET PENETRATION

Using data provided in our survey BOC certificants, we calculated the square footage per operator for 217 facilities.[5] Our sample had relatively few facilities of less than 100,000 square

[5] A total of 329 respondents took the survey. The survey allowed multiple respondents from the same facility, so the 329 respondents represented 240 facilities. Respondents did not provide data for 21 facilities

feet, so it was not feasible to extrapolate from the sample to that size tier in the population. We estimated 2,411 operators in that tier based on data indicating that 5% of buildings in that tier have in-house operators, assuming an average of one operator per building, and estimating 48,217 buildings (for details, see Appendix D).

In the above-100,000-square-foot tier, our sample still had relatively larger buildings than the regional population. Therefore, we calculated data weights for two sub-tiers (100,000 to 500,000 square feet; and more than 500,000 square feet), as explained in Appendix D. Dividing each facility's area by its number of operators and applying the appropriate weight to each value produced a weighted mean value of 72,935 square feet per operator in that tier.

We estimated the number of operators in buildings of at least 100,000 square feet by dividing the mean square feet per operator (72,935) into the total square footage of buildings expected to have operators in that size tier (740,478,400). Based on input from our panel of market informants, we assumed that no more than 75% of buildings in the larger tier have in-house operators. This produced an estimate of 7,609 operators in that tier and a total of 10,020 operators in the market.

The above estimate may not capture any outsourced building operations staff. The NEEC BOC database includes only 15 certificants. Based on an estimated 20 BOC operators in the "facility services" sector[6] and our market informants' estimate that no more than 2% of operators in that sector have BOC certification, we estimate approximately 1,000 building operators in that sector.

Together, NEEC and IBOA have certified 2,147 BOC operators, of whom we estimate up to 5% are retired or deceased, leaving about 2,000 currently employed certified operators. That figure constitutes about 20% of the estimated building operator market, which is at the high end of our market informants' estimate of market penetration.

NON-BOC TRAINING INFORMATION

Several non-BOC training opportunities exist in the Northwest for building operators.

Community Colleges: Three Northwestern community colleges offer Associate Degree programs in energy management or energy and resource management. One of those community colleges, Edmonds Community College[7], is a BOC Approved Provider. Students who complete

---

and we excluded two facilities as statistical outliers (their calculated square footage exceeded the sample mean by more than three standard deviations).

6 The NEEC BOC database lists 15 certified operators in the facility services sector. Assuming the same proportion in the IBOA database, which has about one-third as many certificants as the NEEC database, gives us a total estimate of 20 BOC operators in the facility services sector.

7 Located in Lynnwood, WA, in the Seattle metropolitan area.

their training program are eligible to apply for the BOC certification provided they meet the work experience requirements.

Trade/Technical Schools: A variety of technical schools and institutes offer diplomas and coursework in trades supporting building energy management, such as HVAC technician programs. These institutions offer courses online or in traditional classroom settings. Many technical schools and colleges now offer online courses.

Continuing Education Units: BOC certificants may apply Continuing Education Units through a variety of educational sources toward BOC renewal.

Professional Association Certification Programs: Building operation technicians and managers often seek training through professional organizations. In the past, non-BOC operators as well as current BOC certificants have identified the International Facility Management Association (IFMA), Building Owners and Managers Institute International (BOMI), the Construction Industry Technical Council, the Refrigeration Service Engineers Society, and the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) as key sources of training.

BUILDING OPERATIONS BEST PRACTICES

We asked our panel of market informants for sources for building operation and maintenance "best practices." None cited the NEEA BetterBricks website (http://www.betterbricks.com/). One informant cited a study showing that sharing savings with the operator can improve building efficiency (see Appendix D). Others cited a variety of entities in the building industry as well as the U.S. Department of Energy. From this input, we identified the following possible sources of information on building energy management best practices:

- The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) website references an Operations and Performance Management Professional Certification program and a related handbook.
- The Building Owners and Managers Association (BOMA) website describes a building designation program and lists brief case studies of designated buildings that illustrate energy best practices.
- The APPA (formerly the Association of Physical Plant Administrators) website provides membership resources such as a benchmarking study that covers efficiency.
- The International Facility Management Association (IFMA) website has membership-only "Knowledge Base" with links to energy management articles.

CERTIFICATION RENEWAL RATES

Of 1,329 Northwest BOC certificants in the NEEC database who received their initial certification in 2010 or earlier (and so could have renewed in 2012), 57% have renewed their certification at least once. This is somewhat lower than a reported 80% rate for ASHRAE certifications, which target professional engineers.

BOC CERTIFICANT AND WORKPLACE CHARACTERISTICS

Our survey of BOC certificants provided data on certificants and their workplace characteristics. The 329 survey responses represented 240 separate facilities. Nearly half the respondents reported facilities of more than 500,000 square feet. A large majority (86%) reported that their company either owns the entire facility they work in (83%) or owns part and leases part (3%).

Respondents that reported counts of building O&M staff by title (203 of 329 respondents) reported a mean of 14 staff in their facility that clearly had equipment maintenance responsibilities (technical and custodial staff and their managers and supervisors).[8] Half of all such reported building operators were in facilities with more than 50 operators. The reported number of building operators increased with increasing facility size, but so did the mean amount of facility space per operator, suggesting possible efficiency gains.[9,10]

The most numerous categories of operator were general technical or mechanical staff (34% of all reported operators), professional staff (such as engineers or electricians; 21%), and custodial or custodial management (21%). The type of operations staff was associated with employer type: custodial with K-12 schools, management with colleges, professional with health care and property management firms, and general technical/mechanical with governments/municipalities.

---

[8] Respondents also listed other job titles that did not represent the types of workers likely to be part of the BOC market. These include general office staff, skilled labor that does not typically relate to energy-using equipment (e.g., painters and carpenters), unskilled labor (e.g., janitorial), and miscellaneous other titles. See *Appendix D* for details.

[9] We did not impose a specific definition of "facility" for this study. Volunteered comments by some respondents indicate they are responsible for multi-building facilities or even multi-facility "campuses." Future research should attempt to define the physical scope of operators' responsibilities more exactly.

[10] As described in Appendix D, we asked survey respondents to provide the titles and responsibilities of building O&M staff and the number of staff with each title. We content-coded the titles into the following categories: Manager (O&M); Manager (General); Professional; Technical/Mechanical; Custodial; Custodial Manager or Supervisor; Supervisor, Coordinator, or Assistant Manager; Other Skilled Labor; Unskilled Labor; Office; and Other. Based on the responsibilities of described for the last four categories, we excluded them from our counts of operators.

4 FINDINGS

This section summarizes key findings from our review of the program logic model and database as well as data collection activities other than those presented in Section 3, *Market Characterization, and* Section 5, *ACE MODEL ASSUMPTIONS*. Following the discussion of those key findings, this section summarizes the evaluation's findings to date relative to the BOC-E market progress indicators (MPIs).

The data sources for these findings are the initiative logic model and associated tables, the NEEC BOC database, our survey of BOC certificants, and personal communication with BOC implementation staff.

REVIEW OF PROGRAM THEORY AND METRICS

As part of this evaluation, we reviewed the initiative logic model. To help us understand the model, we also reviewed other program documentation. Based on our initial review of the logic model, we submitted a draft memo on December 5, 2012, which we revised and resubmitted April 18, 2013. We have attached the revised version of the memo as Appendix B.

Generally, the logic model appears to describe the program accurately. As documented in more detail in Appendix B, we have identified some areas where NEEA could revise or clarify the logic model and metrics. NEEA was in the process of revising the logic model as of the preparation of this report and provided information in response to the draft report. As a matter of documenting the history of the initiative, we still note the findings of our review of the logic model but we also have incorporated NEEA's additional information in our comments below.

First, the causal link between barriers and program activities in the logic model tables is not clear in some cases. For example, Activity 3 – Promote Scheduled Courses – links to four barriers: Limited Time to Attend Training, Tuition Affordability, Lack of Service in Underserved Markets, and Integration in Utility Programs. It is not clear how promoting scheduled courses addresses tuition affordability.

Second, it also is not clear how program staff expect some activities to bring about linked outcomes. Specifically, the logic model and tables do not reference the initiative's Utility Engagement Plan, and so it is not clear how initiative activities and their outcomes address the barrier "Lack of Awareness (Renewal & Utilities)" and result in the long-term outcome, "Region's utilities incorporate BOC into their EE portfolios (MPI: X)." It also is unclear how the program activities flow to the long-term outcome, "Maintenance and certification is valued by employers and operators (MPI: IX)." For example, how will BOC's becoming an approved training provider for GSA, and an increase in number of course registrants, result in employers and operators valuing BOC?

Third, the documentation does not sufficiently define some metrics and indicators to measure change. Specifically:

- NEEA expects to exit the BOC-E Initiative in 2016, in the medium-term range of outcomes. Three medium-term outcomes describe "increased" participation or program activity (by unemployed operators and returning veterans, International Union of Operating Engineers (IUOE) member operators, and operators employed in the Federal sector). Supporting documentation does not appear to indicate the success criteria for these outcomes (e.g., 10% increase). The documentation does provide the data sources and metrics, but does not *consistently* indicate the success threshold.
- Section 9.1 of the Strategy Approval document indicates that the goal relating to Federal operators is that such operators participate in two or more courses per year. This is different from a percent increase goal. Moreover, it is not clear what constitutes achievement of this goal – that a single Federal operator each attend two courses in a year?

NEEA has reported that the revised logic model addresses the two above issues related to definition of metrics and indicators.

REVIEW OF PROGRAM DATABASE

For this evaluation, NEEC provided Research into Action with a copy of its BOC database, containing records on the 1,674 individuals that had received certification in Oregon and Washington through 2012. When we excluded 14 individuals who reported work locations outside the Northwest, the total number of certificants was 1,660. NEEA provided Research Into Action with copies of IBOA datasets, which we combined into a single set with 515 certification records through 2012.

Methods

Each NEEC record included contact information as well as the years of certification and expiration of certification for both BOC Level I and Level II. As maintaining certification requires annual renewal, we were able to infer that certificants had renewed certification if the year of expiration was more than two years after the earliest year of certification.

We calculated the number of new and retired BOC certificants for each year from 1997 through 2012. For any given year, new BOC certifications are those certified for the first time in that year and retired certificants are those who have not received certification or renewal (Level I or Level II) within the previous five years (the assumed measure life of the certification). We calculated year-by-year cumulative totals of active BOC certificants as the sum of those that had received certification up to and including that year minus the total number of retired certificants up to and including that year. (Appendix C provides details on the database analysis.)

2012 NEEC New and Total Active Certificants and Renewals

A total of 204 individuals received first-time certification in 2012 – 179 through NEEC and 25 through IBOA. In 2012, 106 certificants (73 NEEC and 33 IBOA) had gone five years since expiration of their certification and so had retired savings. As of 2011, there were 1,252 active BOC certificants (922 NEEC and 330 IBOA). When we added the 204 new 2012 certificants and subtracted the 106 2012 retirees, the total was 1,350 active certificants in 2012. Note: "active certificants" refer to all those currently certified **and** all those whose certification lapsed in past 5 years.

Maintaining the BOC credential requires annual renewal of certification, beginning the second year following initial certification. Of all 650 NEEC BOC certificants who remained certified up to 2012, 319 renewed their BOC certification in 2012. That figure includes 56 of the 109 individuals (51%) who first certified in 2010 and so received their first invitation to renew that year. In total, of all individuals that had certified in 2010 or earlier, 57% of eligible certificants had renewed their certification at least once.

The IBOA dataset did not provide sufficient information to determine renewals prior to 2012; however, IBOA staff reported to us that 99 individuals renewed their certification in 2012.

Attributes of BOC-E Certificants

The NEEC BOC database includes information relevant to the BOC expansion (BOC-E) efforts, which included recruiting returning veterans, the unemployed, and trainees from underserved markets. Of 179 individuals who received BOC certification in 2012, 83 received certification as part of BOC-E, all in Level I. Table 5 shows the attributes of certificants in the BOC-E program, returning Iraq/Afghanistan veterans, unemployed individuals, and the type of special class taken. Individuals may contribute to the counts in more than one of the table rows. For example, a BOC-E student may be unemployed and a returning veteran.

Table 5: BOC Expansion Attributes; Multiple Selections Allowed

BOC-E Attributes	Count	Percent of BOC-E Students (*n* = 83)	Percent of All 2012 BOC Students (*n* = 179)
BOC-E Special Class Type			
Underserved	24	29%	13%
Strategic partnerships	35	42%	20%
Returning Veteran (2001-2012)	43	4%	2%
Unemployed	22	27%	12%

BOC CERTIFICANT SURVEY

We conducted a survey of BOC certificants that covered their characteristics (employment and veteran status), workplace characteristics (facility size and number and types of operators), their operations and maintenance (O&M) activities, their perceptions regarding barriers to BOC training, and their employers' support for BOC certification and renewal of certification. We discuss results pertaining to workplace characteristics and O&M activities in Section 3, *MARKET CHARACTERIZATION,* and Section 5, *ACE MODEL ASSUMPTIONS*. This section addresses findings on respondent characteristics, perceptions of barriers, and employer support. Following a summary of the survey methods, key findings are organized under three subsections: 1) respondents' employment and veteran status; 2) value of BOC training and certification; and 3) barriers to BOC training.

Survey Methods

In February 2013, we conducted a primarily online (with some telephone) survey of BOC certificants. The survey collected data on characteristics of the survey respondents (their title, employment status at training, veteran status) and their workplace (e.g., facility size and whether owned or leased); O&M practices and non-incented equipment retrofits completed, and BOC influence on each; and attitudes and perceptions about BOC's value, barriers to BOC training, course format, and alternatives to BOC training.

We pilot-tested the survey with a panel of 70 recent certificants, then launched the survey with a panel of all 1,106 NEEC BOC certificants, for whom the BOC database provided email addresses. The survey invitation explained the purpose of the survey and assured the recipient of confidentiality. It included a link to the survey and a respondent-specific identification number. We sent up to three reminders over a two-week period.

A survey goal was to examine whether energy savings differed based on when operators received certification (five or more years ago vs. fewer than five years ago) or whether or not operators had renewed certification. We monitored survey completions by those variables. After receiving relatively few responses from those who received certifications at least five years ago and did not renew, we attempted to contact operators with those characteristics by phone to complete the survey.

Sample Description

A total of 329 respondents started the survey – 304 online and 25 by telephone. Of those respondents, 144 certified five or more years ago and 185 certified within the past five years; 171 had renewed and 157 had not renewed. Not all respondents completed all sections of the survey.

As Table 6 shows, operators who received their certification five or more years prior to the survey were somewhat underrepresented relative to the population, and those who had renewed

certification were slightly overrepresented. The sample was representative of the BOC population on two key demographic variables: employer type and location.

Table 6: Representativeness of Survey Sample, by Section of Survey Completed

		Part of Survey Completed		
	BOC Population	Started Survey (*N* = 329)	Up to Employment and Veteran Status Section (*N* = 282)	Up to Barriers and Employer Support Section (*N* = 214)
Certification and Renewal				
Certified 5+ years	60%	44%	44%	45%
Certified <5 years	40%	56%	56%	55%
Renewed	46%	52%	53%	52%
No Renewal	54%	48%	47%	48%
Employer Type				
Government	8%	9%	9%	10%
Other	10%	12%	12%	10%
Manufacturing	7%	5%	5%	4%
Municipality	22%	16%	15%	17%
College	9%	11%	11%	12%
Healthcare	11%	13%	13%	14%
K-12 School	21%	26%	26%	26%
				Continued
Employer Type (cont.)				
Property Management	7%	8%	7%	7%
Blank	4%	2%	2%	1%
Location (Zip3)				
97xxx	28%	29%	31%	31%
98xxx	64%	62%	59%	58%
99xxx	8%	9%	9%	10%
Other	0%	0%	0%	0%

Not all respondents completed all questions. Of the 329 who started the survey, 282 (86%) completed the survey up to and including the questions on employment and veteran status, which occurred near the end of the survey. Two-thirds of respondents (n = 215) responded to the later section addressing value of BOC training and barriers to training. The sample size for all sections

of the survey well exceeds the size required for 90% confidence and 10% precision, and in fact provides 90% confidence and 5% precision. Both the sample as a whole and subsets described above were representative of the BOC population on the key demographic variables, employer type and location.

Employment and Veteran Status

Of 293 respondents that provided information on employment and veteran status, two reported they were unemployed at the time they registered for the BOC class, one of whom was employed by course completion; eight (3%) reported they were returning Iraq/Afghanistan veterans. Seven of the eight returning veterans were recent certificants, and those seven veterans constituted 4% of the recent certificants in the sample.

Value of BOC Training and Certification

One of the BOC-E initiative's desired outcomes is that employers and operators value maintenance of certification. The relevant MPI for that outcome (MPI IX) is the percent increase in renewals over the 2010 baseline of 51% renewals. However, it is not yet possible to calculate the percentage of the 2011 BOC cohort that has renewed, as the 2011 cohort is not eligible for renewal until 2013; therefore, we cannot determine the number of renewals for the 2011 cohort until the 2013 data are available.

We can provide information on the value of BOC certification and renewal from our survey of BOC certificants. In that survey, we asked a variety of questions concerning employer requirements and support for certification and certification renewal and whether the respondent would have pursued certification and renewal without such influences. We also asked respondents about their awareness of alternatives to BOC training and whether they would have sought out or taken such alternative training if BOC training were not available. Responses speak to the value of BOC training, as they address the importance of that type of training and the awareness of alternatives to BOC.

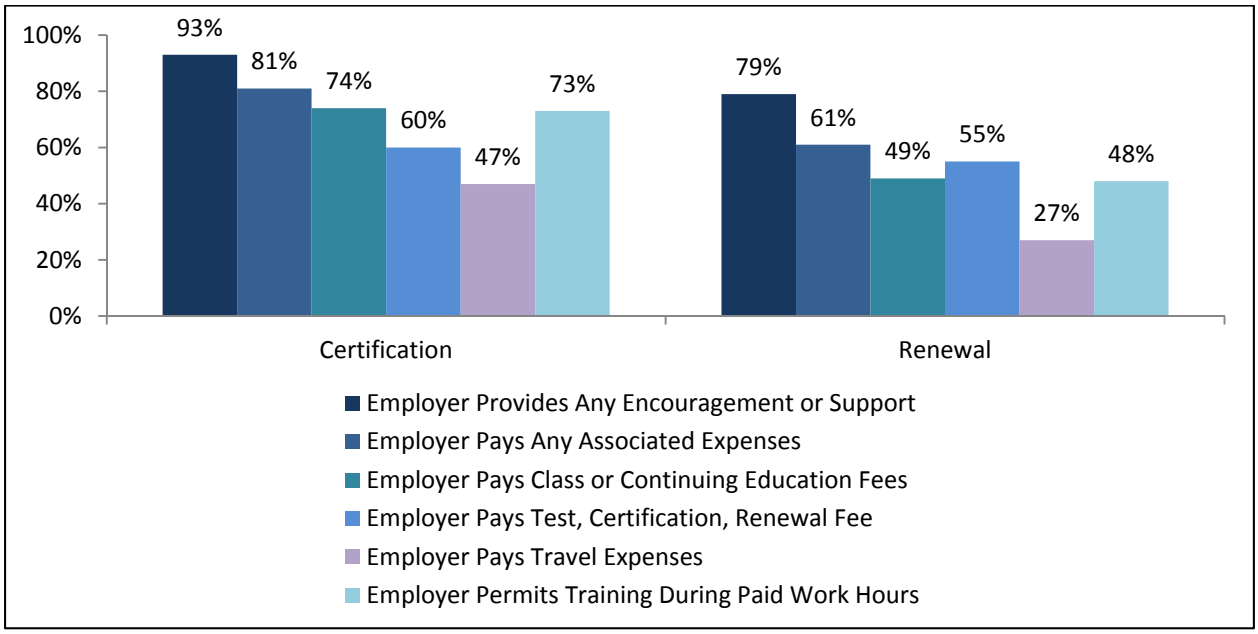
Employer Requirements and Support for Certification and Renewal

Of the 329 survey respondents, 215 answered this section of the survey. Results show that employers generally do not require certification but provide important support, without which most respondents would not have gotten certification.

More than three-quarters (78%) of the respondents said their employer does not require BOC certification for any staff. Of the 33 respondents who said their employer requires certification for them, 21 (64%) said they would have taken the training even if they had not been required to do so, indicating the certification was valuable to them.

We also asked whether, and in what ways, the employer supports BOC certification and renewal. As Figure 2 shows, large percentages (47% to 93%) of respondents reported various types of certification support, including employer coverage of at least some related expenses (81%) and permission to take the BOC training during paid work hours (73%). Somewhat smaller percentages (27% to 79%) of respondents also reported support for certification renewal, but just less than half reported permission to take renewal-related continuing education courses during paid work hours. These findings suggest that employers perceive value for both initial certification and renewal, but the fact that fewer respondents report support for renewal suggests that fewer employers value renewal.

Figure 2: Employer Support for BOC Certification[1] and Renewal[2] (n = 215)



1 Survey Question: "Which of the following are true of your company? Your company (select all that apply): (1) encourages BOC certification for building O&M staff that do not have certification, (2) pays class fees for initial BOC certification, (3) pays the test/certification fee for initial BOC certification, (4) pays travel expenses associated with initial BOC certification pays other expenses associated with initial BOC certification (please specify), (5) allows you to attend BOC training during paid working hours."

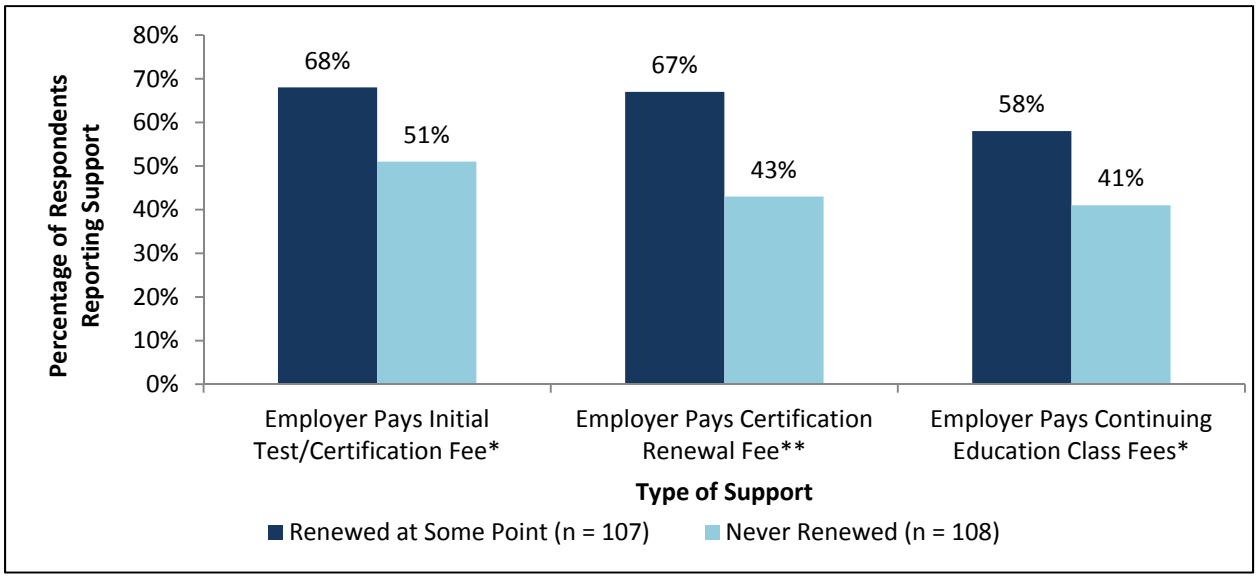
2 Survey Question: "Which of the following are true of your company regarding RENEWAL of BOC certification? Your company (select all that apply): (1) encourages building O&M staff to renew BOC certification, (2) pays fees for continuing education classes for BOC renewal, (3) pays the BOC certification renewal fee, (4) pays travel expenses for continuing education for BOC renewal, (5) pays other expenses associated with BOC renewal (specify), (6) allows you to attend continuing education for BOC renewal during paid working hours."

Two-thirds of respondents said they would not have gotten BOC certification without their employer's financial support (13% said they would have done so, and 22% did not know). Thus, employer financial support is important for encouraging certification. Permission to take BOC

training on company time also appeared to be important but somewhat less critical: just over half (55%) of respondents said they would not have gotten the certification if they had to do it on their own time.

Employer financial support appears to be associated with greater likelihood of renewal. We compared the responses of respondents who had versus had not ever renewed certification. Those who had ever renewed were more likely to say their employer pays the fees for initial certification, renewal, and continuing education classes (all differences statistically significant at $p \leq .01$[11]; Figure 3). Thus, greater employer valuation of certification appears to translate into higher renewal rates.

Figure 3: Reported Employer Support by Renewal Status



Note: Same survey questions as for Figure 2.

*Difference between renewed and never renewed is statistically significant at $p = .01$; ** $p < .001$.

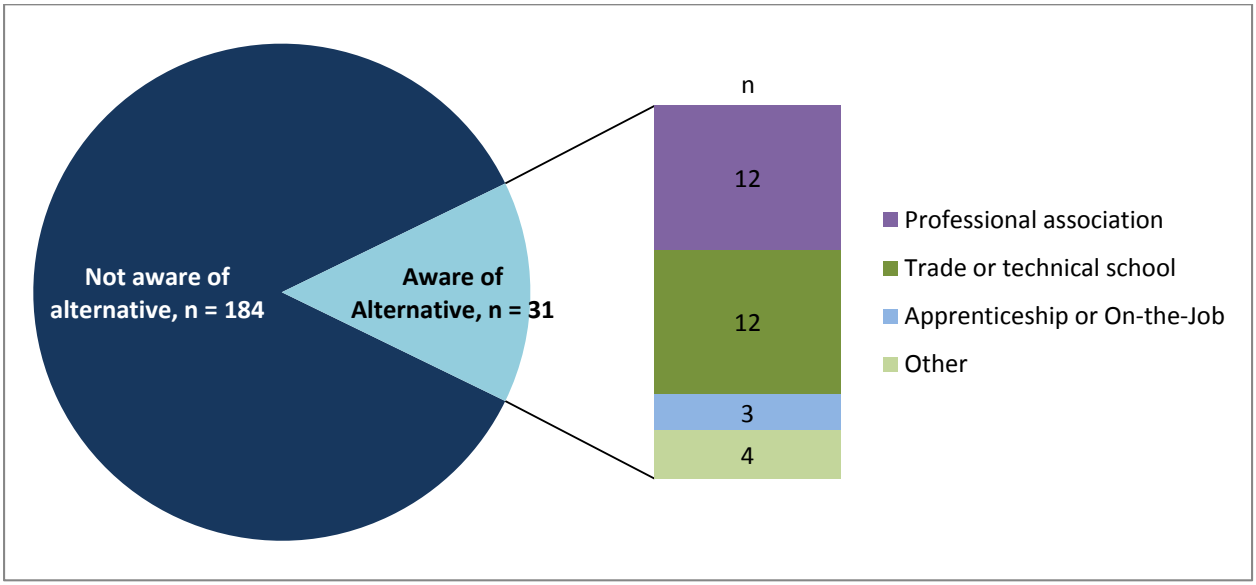
We also analyzed levels of employer support by whether respondents first received certification within the past five years (2008 or later) or more than five years ago (2007 or earlier). The analyses suggest that general employer support for initial certification has increased over the last several years: more recently certified respondents were significantly more likely to agree that their employer "encourages BOC certification for uncertified O&M staff" (55% vs. 39%; $p = .01$). However, the two groups did not differ significantly in likelihood of reporting that employers provided financial support for certification.

[11] A statistically significant difference is one with a small probability (represented by the "*p* value") of occurring by chance in a given sample if there is no actual difference in the population.

Alternatives to BOC Training

We asked respondents if they were aware of any other place they could have obtained training equivalent to BOC training and, if so, where they would have obtained such training. Of 215 reporting respondents, 31 (14%) reported awareness of an alternative to BOC. Most of those cited either professional associations or trade or technical schools or colleges (Figure 4).

Figure 4: Number of Respondents Identifying Alternatives to BOC Training (*n* = 215)



Survey Question: Do you know any other place you could have gotten equivalent training if BOC training and certification were not offered? If yes, where?

Nineteen of the 31 respondents (61%) who were aware of alternatives to BOC said they likely would have taken that training if BOC were not offered (a response of 4 or 5 on a 5-point scale of likelihood). Of the other 184 certificants, 114 (62%) said they would have exerted least moderate effort (at least 3 on a 5-point scale) trying to find similar training if BOC were not offered.

Taken together, the above results show that most respondents are not aware of alternatives to BOC training but value it sufficiently that they would likely take known equivalent training if BOC were not available or exert at least a moderate level of effort to find equivalent training.

Barriers to Participation in BOC Training

Our survey also provided data on perceived and actual barriers to certification and renewal. Specifically, we asked respondents what they thought were the primary barriers to participation in BOC training. In addition, we asked questions to address two specific barriers identified in the program logic model: 1) limited time to attend training; and 2) lack of understanding of the

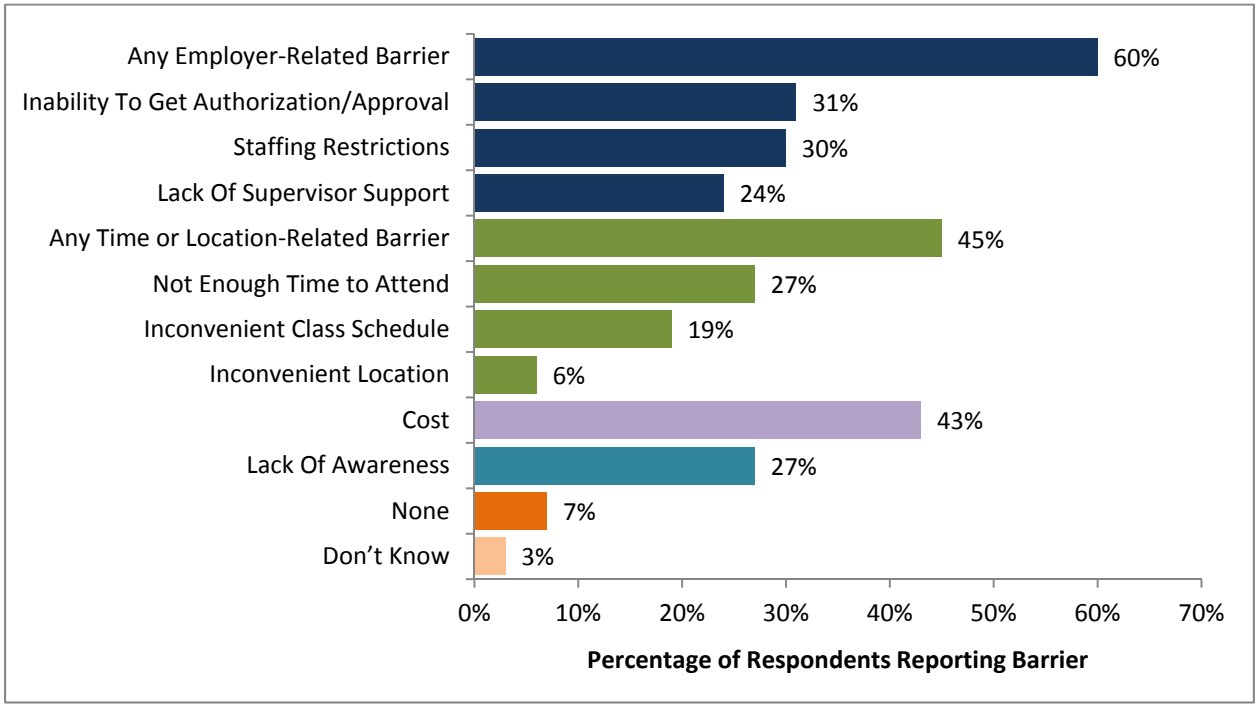
renewal process and its value. BOC certificants' perceptions should have more relevance to those barriers than to some other barriers identified in the logic model (e.g., lack of education partnership with IUOE and not meeting the ANSI standard).

To address the barrier of limited time to attend training, we posed several possible course schedule modifications to respondents and asked them what effect they thought those modifications would have on attendance. Second, to address the barrier of lack of understanding of the renewal process and its value, we asked respondents that had not yet renewed if they were aware of the renewal requirement. (Limitations on survey length prevented us from delving deeper into understanding of the renewal process.)

Respondent-Identified Barriers

We asked respondents what they thought were the three largest barriers to getting building operators to participate in BOC training. About three-fifths of respondents cited employer-related issues, such as inability to get approval or lack of supervisor support, as the greatest barriers to participation in BOC training (Figure 5).

Figure 5: Respondent-Identified Barriers to BOC Participation (*n* = 215; Multiple Responses Allowed)[1]



Survey Question: First, what do you think are the three largest barriers to getting building operators to participate in the BOC training?

1 Each bar color represents a different barrier or related group of barriers. Where the chart shows multiple bars with the same color, the top-most bar represents the percentage of respondents that cited any of the specific

barriers in that group. For example, 60% of respondents reported any employer-related barrier, including inability to get authorization of staffing restrictions.

Nearly half the respondents cited time or location-related issues and cost as barriers. However, respondents certified since 2008 were half as likely as those more certified earlier to report inconvenient class schedule as a barrier (27% vs. 13%, $p = .01$), suggesting that class schedules have become less of a barrier over time.

Perceived Effect of Modifications to Course Schedule

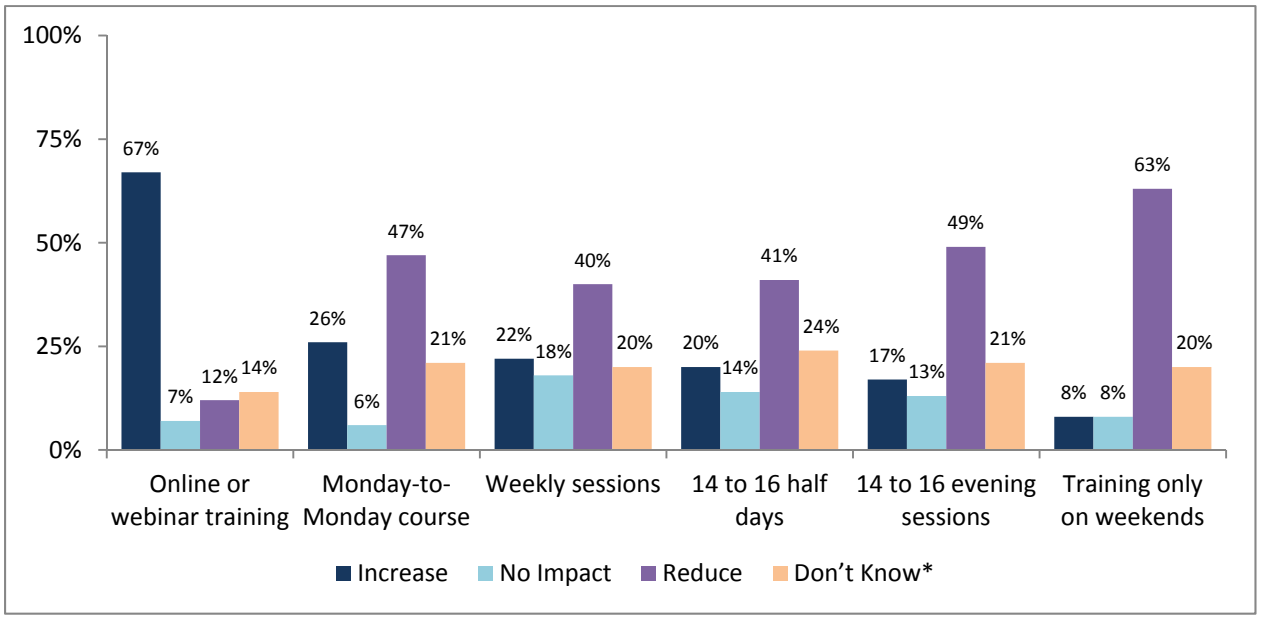
We asked respondents to indicate the effect they thought certain changes to course format might have on course attendance. The changes were:

- Provide online or webinar training
- Provide an intensive Monday-to-Monday course
- Change from monthly to weekly sessions
- Split courses into 14 to 16 half days
- Split the courses into 14 to 16 evening sessions
- Have training only on weekends

As

Figure 6 shows, two-thirds said that online or webinar-based training would increase attendance. Responses indicated that other format changes – a one-week intensive course, weekly sessions, half-day or evening sessions, or weekend-only training – would not increase attendance and may decrease attendance. Those certified since 2008 were more likely than other respondents to say that splitting courses into 14 to 16 evening sessions would reduce attendance ($p = .015$).

Figure 6: Respondents' Predicted Impacts of Course Format Changes (*n* = 215)



Survey Question: We'd like your opinion on how some possible changes to the BOC course format might affect attendance. For each of the following possible changes, please select the option that best describes what impact you think it might have: 1 = greatly reduce attendance to 5 = greatly increase attendance.

* Includes respondents that did not answer the question.

The above findings provide some support for BOC's plan to provide a blended online training module. However, given that the survey did not differentiate between a completely online course or a mixed-mode course, we cannot conclude that the results provide complete support for that plan.

Renewal Awareness

We asked respondents that had not renewed certification (*n* = 108) whether they were aware that maintaining BOC certification requires annual renewal. Most (89%) of those respondents were aware of the annual renewal requirement. We observed a trend for a higher percentage of recent certificants to be aware of the renewal requirement, compared to earlier certificants, but the difference did not achieve statistical significance (91% vs. 84%; $p = 0.294$).

MARKET PROGRESS INDICATORS (MPIs)

This subsection summarizes the evaluation's findings to date relative to the 10 BOC-E MPIs. Table 7 shows those 10 MPIs, the outcome associated with each, the timeframe in which the BOC implementation team expects the outcome to occur, the data source the program logic model specifies for assessing progress, and a brief summary of the evaluation's findings so far.

BOC-E is still in the early stages of implementation, and the initiative has so far achieved one MPI: IUOE became a BOC Approved Provider in February of 2013 (MPI III). The implementers stated most of the other MPIs in terms of increase in number of certifications or other events that we cannot evaluate until 2013 data are available.[12] With that understood, we summarize the progress so far:

- 25% of the 2012 BOC cohort are from underserved markets (MPI I)
- NEEC BOC staff have done outreach to GSA about becoming an approved education provider (MPI II)
- NEEC has established a utility engagement plan and is pursuing new sponsorship agreements with utilities in underserved areas in 2013 (MPI X)

[12] The initiative has tracked participation by underserved, unemployed, and Federal workers and Afghanistan/Iraq veterans only since 2012. We cannot assess the renewal rate for the 2011 cohort as they are not eligible for renewal until 2013.

Table 7: BOC-E Initiative Market Progress Indicators (MPIs)

MPI #	OUTCOME	TIME FRAME	MPI	DATA SOURCE	EVALUATION FINDINGS
I	Increased participation by operators in rural markets	Short term (1-3 years)	Percent increase in certifications by operators in rural markets.	NEEC student database: urban/rural column count of sites affected.	As of 2012, there were 44 underserved students in the NEEC database (25% of the 2012 BOC cohort).
II	BOC is an approved training provider for GSA	Short term (1-3 years)[1]	BOC listed on GSA training provider roster.	GSA	Staff interviews indicated that NEEC has done outreach to regional GSA office to assess interest in hosting BOC course; GSA is awaiting direction from headquarters as to training requirements and approved training programs under the Federal Building Personnel Training Act (FBPTA).
III	IUOE becomes a BOC Approved Provider	Short term (1-3 years)	Signed AP agreement by NEEC and IUOE.	NEEC's signed agreement	IUOE became a BOC Approved Provider on February 28, 2013 (Source: "IUOE Approved Provider Letter_RTC," on the NEEA SharePoint folder.)
IV	BOC is an authorized provider under ANSI 17024	Short term (1-3 years)	Signed letter of authorization.	ANSI-authorized providers posted on ANSI website (give URL)	As of March 2013, NEEC will continue seeking ANSI accreditation for BOC (Source: "ANSI Legal Issues Memo," dated March 25, 2013, located on the NEEA SharePoint folder.)
V	The RTF accepts unitized savings for BOC (Medium term)	Medium term (3-5 years)	Notification letter from RTF.	RTF	NEEA implementation staff has decided to drop this outcome from the program logic, as BOC represents a "poor fit" with the RTF's regional unitized energy savings. (Source: personal communication.)
VI	Increased participation by unemployed operators (UE) and returning Veterans	Medium term (3-5 years)	Percent increase in certifications by UE and returning Veteran operators.	NEEC student database: count students associated with "returning veteran" association type	As of 2012, there were 20 returning veteran students in the NEEC database 17 pre-2001 and 3 2001-2012 (9% and 2% of the 2012 BOC cohort, respectively).

CONTINUED

MPI #	OUTCOME	TIME FRAME	MPI	DATA SOURCE	EVALUATION FINDINGS
VII	Increased participation by IUOE-member operators	Medium term (3-5 years)	Percent increase in certifications by IUOE-member building operators.	NEEC student database: year over year count of students associated with "IUOE" association type	As IUOE became a BOC Approved Provider in 2013, we cannot yet assess progress toward this goal.
VIII	Increased participation by operators employed in the Federal sector	Not specified in tables, but graphic indicates long term	Percent increase in certifications by Federal building operators; baseline is 2011	NEEC student database: year over year count/comparison of students associated with "Federal" association type	As of 2012, there were 2 “Federal” students in the NEEC database (1% of the 2012 BOC Cohort).
IX	Was MPI V: Maintenance of certification is valued by employers and operators	Long term (5-10 years)	Percent increase in renewals over 2010 baseline.	NEEC student database: count renewals	As the 2011 cohort is not eligible for renewal until 2013, we cannot determine the number of renewals for the 2011 cohort until the 2013 data are available.
X	Was MPI VI: Region’s utilities incorporate BOC into their EE portfolios	Long term (5-10 years)	Percent increase in utilities integrating BOC into energy efficiency portfolios.	NEEC: Count of utility MOUs and sponsorship agreements.	As of April 17, 2013, NEEC has established a utility engagement plan.

[1] Although the logic model tables indicate this is a short-term MPI, Version 9 of the graphic indicates it is medium-term.

5 ACE MODEL ASSUMPTIONS

As part of our program evaluation activities, we reviewed key input assumptions for the following parameters of the BOC-E program ACE Model as of March 31, 2013: electric consumption per square foot, percentage of savings for participating buildings, square footage per operator, calculated savings per operator, number of building operators, percentage of buildings with building operators in the smaller-than-100,000-square-feet size tier, retirement rate, and additional costs associated with having a certified building operator.

Our sources for this review included: data from our survey of BOC operators on work practices and workplace characteristics; memoranda and reports from previous evaluations, including those cited in the ACE Model; interviews conducted with eight informants knowledgeable about the building operations market; the Commercial Building Stock Assessment (CBSA) and Commercial Buildings Energy Consumption Survey (CBECS); the Regional Technical Forum (RTF) UES Measure Protocols; a variety of technical reference manuals; and data from retro-commissioning, building tune-up, and O&M programs implemented by Nexant Inc. (a member of the Research Into Action team), which include project- and measure-specific data for 50 to 60 typical O&M measures.

METHODS AND RESULTS

The following subsections describe how the evaluators used the above sources to address the ACE Model input assumptions and the results we obtained. The order does not strictly reflect the order in which the assumptions appear in the table, as the evaluation of some assumptions depend to some degree on the evaluation of assumptions later in the table.

Energy Consumption per Square Foot and Energy Savings

Our survey of BOC certificants captured detailed data on facility system characteristics and operator activities across nine energy-using building categories: boilers, chilled-water systems, economizers and ventilation control, compressed air, fans and air distribution, domestic water heaters, lighting, pumps, and motors. We used these data to calculate electric consumption per square foot for each facility and energy savings (as a percentage of total energy use) from operators' activities. Of the 329 survey respondents, 212 completed the survey sections on O&M actions, allowing the evaluation team to calculate energy usage and savings values. (As shown in *Section 4, FINDINGS*, those 212 respondents were representative of all 329 who started the survey as well as the BOC population.) We estimated savings on a per-respondent and per-square-foot basis to enable extrapolation to other BOC operators.

Building Energy Consumption

We classified each survey respondent building type into one of the Commercial Buildings Energy Consumption Survey (CBECS) building type categories and sub-categorized respondent by Climate Zone using the CBECS U.S. Climate Zone Map available on the U.S. Energy Information Administration website. We determined annual baseline energy consumption using CBECS Energy Use Intensity (EUI) data by fuel type, principal building activity (category type), climate zone, and end use.[13] We captured building square footages from survey responses or the BOC database.

Savings Estimates

The survey instrument captured energy savings from operations and maintenance (O&M) activities that BOC training targets, including modifications to existing control systems and set-points, the adoption of new maintenance practices and activities, and/or more frequent execution of these O&M activities. Although the primary goal was to assess O&M-related savings, the survey also assessed savings from equipment retrofits and replacements that did not receive utility incentives.

We calculated end-use total savings (kWh/ft^2 or % of EUI) for each type of equipment-specific activity. We used multiple approaches to calculate savings: 1) extrapolation from the RTF UES Measure Protocols and various Technical Reference Manuals; 2) engineering analysis for measures amendable to stipulated assumptions and for equipment replacement and retrofit measures covered in the survey; 3) actual program data from Nexant-implemented retro-commissioning, building tune-up, and O&M programs, which include project- and measure-specific data for 50 to 60 typical O&M measures.

The equations we used to calculate total energy savings generally included the measure-appropriate EUI for the building category; a savings ratio/factor or per-unit savings; and the total or conditioned square footage of the facility. We used conditioned square footage, provided by a portion of the survey respondents, to estimate savings for any weather-dependent measures. We used total building square footage in instances where respondents did not provide conditioned square feet.

---

[13] We chose CBECS rather than CBSA because CBECS has more data points in each climate-zone-building-type combination than CBSA does. Subsequent analyses showed that CBECS and CBSA yield similar results. First, we recalculated the CBSA regional weighted mean electric and gas EUIs, excluding groceries and restaurants (which typically use mechanisms other than building operators for building operations savings), as 15.6 kWh/ft^2 and .42 therms/ft^2, which are nearly identical to our CBECS-based sample means. Second, we repeated the analyses with EUI values from CBSA rather than CBECS values, yielding very similar results. See *APPENDIX E: ACE MODEL REVIEW MEMO* for more details

For each respondent, we calculated the total electricity or gas savings as the sum of the calculated savings for the various equipment-specific O&M activities. To determine the effect of the non-incented retrofit savings on total savings, we calculated each respondent's total electricity and gas savings both with and without the savings from non-incented retrofits. We calculated the mean percentage electricity and gas savings as the summed electricity or gas savings across all respondents divided by the summed baseline electricity or gas usage for those respondents' facilities. The formula was:

$$\sum_{j=1}^{k}\sum_{i=1}^{n} a_{ij} \Big/ \sum_{i=1}^{n} c_j$$

where k = number of equipment-related activities
n = number of respondents
a_{ij} = the energy savings associated with the ith respondent and the jth activity
c_i = the baseline energy consumption associated with the ith respondent

We adjusted the calculated total savings based on the rated influence of BOC training on participant activities. For each equipment-specific activity category that any respondent reported responsibility for, the survey asked the respondent to rate the influence of the BOC training on their activities, using a scale from 0 to 10. We converted each equipment-specific BOC influence rating for each respondent into a 0% to 100% influence score (where a rating of 1 indicates 10% influence, 2 indicates 20% influence, and so forth). We then multiplied the calculated savings for each equipment-specific activity for each respondent by the appropriate influence percentage to establish the value of the BOC-influenced savings for that activity or retrofit for that respondent.

For each respondent, we calculated the BOC-influenced electricity or gas savings as the sum of the BOC-influenced savings for the various equipment-specific O&M activities that the respondent reported. We calculated the mean percentage BOC-influenced electricity and gas savings across all respondents as the summed BOC-influenced electricity or gas savings divided by the summed baseline electricity or gas usage for those respondents' facilities. The formula was the same as that shown above for total savings, except that in this case, a_{ij} represents the BOC-influenced energy savings associated with the ith respondent and the jth activity.

Based on the above methods, we propose adjusting some of the ACE Model's input assumptions for electric consumption and savings and computed comparable input assumptions for gas consumption and therm savings. Our proposed electric and new gas input assumptions appear in Table 8, at the end of this section.

Percentage of Buildings in Market with Building Operators

NEEA currently assumes that 100% of buildings above 100,000 square feet, and 50% of those below that size, have in-house building operators. As detailed in our *2012 BOC Program ACE Model Review* memorandum (Appendix E), the 50% figure appears to be a misinterpretation of a

previous evaluator's assumption. Based on input from market experts we interviewed for this evaluation as well as research that Research into Action conducted for the BOC Initiative's 2001 MPER #7, we estimated that about 4% to 6% of the total number of buildings at least 5,000 but less than 100,000 square feet have in-house operators. Based on market informant statements about the prevalence of outsourcing O&M, we conservatively assume that only 75% of the buildings in the larger tier have in-house operators.

Number of Operators in the Market

We relied on data from the BOC certificant survey to estimate mean square feet of facility area per facility operator, both those with and without the BOC credential. We used this figure to estimate total size of the building operator market in buildings of at least 100,000 square feet (large-tier buildings). As detailed below, we estimated the number of operators in smaller buildings (small-tier buildings) based on an estimated percentage of buildings in that tier with operators.

The 329 survey respondents represented 240 facilities. The survey provided data on facility size and number of operators for 219 of those facilities. We calculated square footage per operator for each of the remaining 219 facilities. Of those facilities, 183 were at least 100,000 square feet in size. We used the data from those facilities to estimate the mean square footage per operator among large-tier buildings in the regional population. As the proportion of very large facilities (at least 500,000 square feet) was greater in our sample than in the regional population, we applied weights to adjust the sample.

We calculated a weighted mean value of 72,935 square feet per operator in large-tier buildings. We divided that figure into the total square footage of buildings expected to have operators in that size tier (75% of the total square footage). This produced an estimate of 7,609 operators in that tier. From data in the CBSA, we estimated a total of 48,217 small-tier buildings in the region. Assuming that 5% of those buildings have operators (see Appendix E for details), with an average of one operator per building, we estimated 2,411 operators the small tier. Together, these calculations produced a total of 10,020 operators.

Mean Square Feet per BOC Operator

We also used data from the BOC certificant survey to estimate mean square feet of facility area per *active* BOC-credentialed operator, where active operators are those that have received or renewed the BOC credential since 2007. This is the "ft^2/operator" figure (Variable 4 in Table 8) used to calculate total BOC savings. As with the mean square footage for *all operators*, used to estimate market size (see above), each unique facility in the survey sample comprised a single data point. For each facility, we calculated the mean facility area from the square footage data from all respondents for that facility.

Calculating the mean square feet of facility area per *BOC* operator was simpler than calculating the comparable figure for *all* operators. For each facility, we counted the number of *currently active* BOC operators in the BOC database that work at that facility. Of the 240 unique facilities represented in the survey sample, 197 had at least one *currently active* BOC operator and facility square footage data. For those 197 facilities, we calculated the square footage per active BOC operator.

We then calculated the simple, unweighted mean of those 197 records. It was not necessary to apply data weights in this case because we are extrapolating the sample results to the population of BOC operators, and the complete survey sample was representative of the population on several key parameters (see Table 6 in *Section 4 Sample Description*). These methods produced a mean of 432,768 square feet per BOC operator.

Savings Persistence and BOC "Measure Life"

The sample included respondents that had initially received certification as long ago as 2000 (BOC's fourth cohort). Nearly half (45%) of those that provided savings data first received certification before 2007. This allowed us to examine whether, and to what degree length of time since certification affected savings from operator practices. Number of years since initial certification did not correlate with percentage for kWh or therm savings (r = -0.05 and .00, respectively). Therefore, time since certification did not appear to affect savings.

As noted previously, NEEA assumes a five-year "measure life" for BOC certification – i.e., NEEA assumes that a BOC-credentialed operator will continue to generate savings for up to five years after his or her certification lapses but not beyond that. We examined whether the survey data supported the assumed five-year measure life by comparing the mean savings for respondents whose certification had been lapsed at least five years (and so they were outside the assumed five-year "measure life" for BOC-related savings) with the mean savings for all other certificants (i.e., those still within the five-year measure life). A large majority (87%) of the respondents were still within the measure life. Because of the highly unequal sample sizes, we used both the parametric ANOVA test and the nonparametric Mann-Whitney test to examine the differences.[14]

The mean kWh and therm savings for those outside the five-year BOC measure life were slightly higher than for those within the five-year measure life (3.9% vs. 1.6% and 4.2 vs. 3.5%, respectively), but neither of these differences was statistically significant. These findings do not support the idea that savings drop off after the five-year measure life. However, the subsample of

[14] Very unequal sample sizes challenge the validity of ANOVA results, but there is no rule of thumb for determining how big a difference is too big, so we report both ANOVA and Mann-Whitney results. (See Keppel, G. and Wickens, T. (2004). *Design and Analysis: A researcher's Handbook* (4th International Edition). Englewood, NJ: Prentice Hall.)

respondents outside the five-year measure life was small (n = 28), and so the precision of the savings estimate for that group is low, as is the statistical power for comparisons. Moreover, the survey response rate was lower for certificants who were outside the five-year measure life than for others (they made up 13% of the sample but 32% of the BOC population), dictating caution in drawing conclusions. It may be worth conducting additional research with greater effort to reach this group.

Since one-third (117 of 329) of survey respondents did not provide sufficient data to calculate savings, we examined whether those respondents had certified earlier, or had allowed their certification to lapse earlier, on average, than those in the savings analyses. Such a finding would weaken the conclusions we could draw from the above analyses. However, respondents that did and did not provide savings data were nearly identical on length of time since either initial certification or certification lapse.

Based on the above findings, we recommend maintaining the retirement criterion (BOC "measure life") at a minimum of five years.

Additional Costs Associated with Certification

Implementation staff provided documentation of the cost assumptions. Based on our review of that documentation, we believe the costs are reasonable. Therefore, we do not recommend any changes.

RECOMMENDED ASSUMPTIONS

Based on the considerations discussed in the previous sections, we summarize our recommended ACE Model input assumptions in Table 8. In this table, "total" savings represent the combined savings of all reported O&M activities, regardless of BOC influence. "BOC-influenced" savings are those derived by applying the percentage influence of BOC training to total training (see *Savings Estimates*, above). The difference between total and BOC-influenced savings represents savings from efficiency actions that would have occurred in this population without BOC training. We discuss these recommendations below.

Table 8: BOC-E ACE Model Current and Recommended Key Input Assumptions

Var. No.[2]	Variable	Definition	Input Assumptions		
				Recommended[1]	
			Current	Total	BOC-Influenced
		kWh Savings			
1a	kWh/ft^2/year	Electric consumption per sq. ft.	16.7	15.5	15.5
2a	% savings	Percentage of savings for participating buildings.	2.50%[3]	4.27%	2.03%
3a	kWh-saved/ft^2/year	Consumption * % of savings.	0.418	0.662	0.315
5a	kWh/operator	Calculated savings per operator.	119,405	286,299	136,272
		Therm Savings			
1b	Therms/ft^2/year	Gas consumption per sq. ft.	n/a	0.40	0.40
2b	% savings	Percentage of savings for participating buildings.	n/a	6.16%	3.58%
3b	Therms-saved/ft^2/year	Consumption * % of savings.	n/a	0.025	0.014
5b	Therms/operator	Calculated savings per operator.	n/a	10,872	6,218
		BTU Savings (kWh and Therms Combined)			
1c	BTU/ft^2/year	Total consumption per sq. ft.	n/a	93,981	93,981
2c	% savings	Percentage of savings for participating buildings.	n/a	5.13%	2.70%
3c	BTU-saved/ft^2/year	Consumption * % of savings.	n/a	4,770	2,511
5c	BTU/operator	Calculated savings/ operator.	n/a	2,064.1M	1,086.7M
		Other Parameters			
4	ft^2/BOC operator[4]	Researched square footage per BOC operator.	286,000	432,768	
6	Number of operators	Number of building operators, currently used.	5,856	10,020	
7	% of market	Percentage of buildings <100K sq. ft. with building operators.	50%	5%	
8	Years	Retirement rate.	5	No change	
9	Dollars	Any additional costs associated with having a certified building operator.	$1,129.29	No change	

1 Total savings are the combined savings of all reported O&M activities. BOC-influenced savings are the savings influenced by BOC training (see *Savings Estimates*, above). Total minus BOC-influenced savings represent savings from efficiency actions that would have occurred in this population without BOC training.

2 The variable numbers correspond to the numbering in Table 39 in *ACE MODEL ASSUMPTIONS*.

3 2.5% is a NEEA planning assumption based on a Northwest Power and Conservation Council estimate of electricity savings achievable through building operations. There was no similar source for gas savings.

4 This is the square footage per BOC operator, not the square footage per operator for all "included" operators, which we used to calculate number of operators in the market.

When comparing our recommended input assumptions with existing assumptions, note the following:

First, the current ACE Model assumption of 2.5% average savings per operator is the NEEA planning assumption, derived by halving a Northwest Power and Conservation Council estimate of potential savings of 5% achievable from building O&M.[15] While previous MPERs and LTMTs have collected data to corroborate this planning assumption, the current research is the first effort to produce a statistically reliable estimate of savings to replace that assumption.

Second, that 2.5% represents savings for electricity only and does not include other fuel types. All other current ACE Model assumptions refer to electricity (kWh) consumption or savings. Our research included gas savings as well as electricity savings, which results in savings that exceed those that could be claimed with the existing ACE Model assumption.

Third, NEEA has not previously distinguished between total electricity savings achieved through BOC operator practices and the proportion of those savings attributable specifically to the BOC training. It is possible that BOC operators may have achieved some of the energy savings they achieved even without BOC training. The fact that they sought and took the training may be *prima facie* evidence of an interest in saving energy. Therefore, even without BOC training, they possibly would have sought energy savings and saved energy relative to what energy consumption would have been with standard practices. Our calculation of BOC-influenced savings represents the savings that resulted from BOC training (see *Savings Estimates*, above).

With the current total of 1,350 active NW BOC operators (see *FINDINGS* and *APPENDIX C: BOC DATABASE REVIEW MEMO*), the above input assumptions yield total operator-related savings of 386,503,866 kWh and 7,479,265 therms and BOC-influenced savings of 183,967,079 kWh and 4,190,699 therms.

[15] Source: Market Progress Evaluation Report: Building Operator Certification, No. 3 (5/00) (Report #E01-052). Prepared by Research Into Action, Inc., with Stellar Process, Inc. for Northwest Energy Efficiency Alliance. May, 2000.

6 CONCLUSIONS AND RECOMMENDATIONS

The BOC-E Initiative is in the early stages, and there is little data for assessing its progress in expanding availability and access to BOC training courses in the Northwest. With that caveat, it appears to be on track to achieving its goals. The implementation team has accomplished several of its short-term goals to expand outreach to Federal employees, union members, and underserved markets. The team has conducted outreach to the U.S. General Services Administration (GSA) to become listed on the GSA training provider roster, continues to seek American National Standards Institute (ANSI) accreditation for BOC, has established the International Union of Operating Engineers (IUOE) as a BOC Approved Provider, and has established a utility engagement plan. The team has developed and implemented a blended online module, which it is piloting in Washington and Oregon in 2013.

Survey data show that the primary barriers are employer-related barriers, inconvenient training time or location, and cost. These all correspond to barriers that the implementation team has identified and targeted for reduction through initiative activities.

Other survey findings underscore the importance of employer support for certification. Most certificants value BOC training sufficiently that they likely would take equivalent training, and would exert at least moderate effort to find equivalent training, if BOC were not available. However, the fact that most certificants would not get the credential without employer financial assistance and other types of support underscores the importance of employer support and, hence, of program efforts to increase employer understanding of the value of certification.

One unexpected survey finding was the fact that certain categories of operations staff were relatively more common among certain employer types: custodial staff among K-12 schools, management staff among colleges, professional staff among health care and property management firms, and general technical/mechanical staff among government and municipality facilities. This finding suggests different market sub-sectors with varying training needs.

Survey results also provided at least partial support for the plan to offer a blended online course. However, other potential format changes, such as offering an intensive weeklong course, weekly sessions, or multiple half-day or evening sessions, or weekend-only sessions likely would reduce attendance.

Although the initiative logic is sound, in some cases the logic model and supporting documentation do not provide clear links between barriers, activities, and outcomes. Specifically, it is not clear how promoting scheduled courses (Activity 3) addresses tuition affordability (Barrier 2), how the activities in the logic model address the lack of utility awareness (Barrier 6) and result in the incorporation of BOC into utility EE portfolios (MPI X), or how program

activities (such as BOC becoming an approved training provider for GSA) result in employers' and operators' valuing maintenance and certification (MPI IX).

Similarly, program documentation does not sufficiently define some metrics to allow assessment. Three desired outcomes are increased participation or program activity by unemployed operators and returning veterans, IUOE member operators, and operators employed in the Federal sector, but initiative documentation does not consistently indicate the success threshold. Moreover, the Strategy Approval document indicates a different goal relating to Federal operators (participating in two or more courses per year), without specifying the number of trainees needed to satisfy that goal.

Our research for the market characterization led us to the conclusion that previous estimates of the building operator market in the Northwest region are too small, as they derive from an overestimate of the regional mean facility size per operator (see *Appendix D* for details). Estimates may also reflect differing assumptions about what defines a building operator (anyone who has any responsibilities relating to energy-using equipment, including changing light bulbs, or only the staff responsible for setting controls or making equipment upgrade decisions) or differing assumptions about what defines the "market" (all operators or only those thought likely to enroll in BOC training). In previous research for NEEA, we estimated 92,000 operators in the northwest, based on respondents' reports of the number of building operators in their facilities, but fewer than 6,000 operators that their supervisors would likely send to BOC training.[16] One could argue that the market should encompass all operators that might benefit from training, not just those the supervisor would "likely" send.

Finally, our research provides updated input assumptions for the initiative's ACE Model, including the first statistically reliable empirically derived estimates of per-operator BOC-influenced energy savings (see *Section 5, ACE MODEL ASSUMPTIONS*). We found no evidence of lower savings percentages among certificants whose certification had lapsed five or more years previously, suggesting that savings may possibly persist beyond the currently assumed five-year measure life. However, a low survey response rate among such certificants prevents drawing firm conclusions.

Based on the above considerations, we offer the following recommendations:

- **Logic Model:** NEEA should review the initiative logic model and metrics to ensure that all links between barriers, activities, outputs, and outcomes are clear, reasonable, and well supported and that metrics are sufficiently detailed to allow the implementation team and evaluators to assess whether or not they have been achieved. For example, specify percentage increases or counts of BOC enrollees.

[16] *Market Progress Evaluation Report: Regional Building Operator Certification, No. 7 (Report #E01-088).* Prepared by Research Into Action, Inc. for Northwest Energy Efficiency Alliance. September, 2001.

- **ACE Model:** NEEA should revise the initiative's ACE Model to incorporate our recommended input assumptions.

- **Marketing:** BOC should consider adopting a targeted approach to marketing, outreach, recruitment, and/or course planning that accounts for differences among employer types in the types of building operators used. For example, marketing to and/or course planning for health care entities and property management firms should take into consideration that they use higher percentages of high-skilled professional staff than do other employer types, while activities aimed at K-12 schools should consider the high proportions of custodial staff.

- **Employer Support:** As employer support is important to drive both certification and renewal of certification, BOC should continue and expand efforts to increase employer support of certification and renewal.

- **Employer and Operator Motivations:** NEEA and BOC should further investigate what employers and operators find beneficial about certification and certification renewal to inform their efforts to increase employer support and operator interest. In particular, a deeper understanding of how operators have benefited from certification (beyond changes in work responsibilities and pay) might inform messaging to convince operators that certification is in their interest, even if their employers do not fully support it.

APPENDIX A: MARKET INFORMANT WRITE-UP

January 1, 2013

To obtain a high-level view of Northwest building operators' activities, backgrounds, training, and interest in further training, we interviewed eight key market informants from December 3 to December 14, 2012. We had planned to interview a ninth informant, but that person was not available during the interview period. The interviewed informants included building supervisors, utility staff, instructors of BOC courses, and members of the national BOC advisory committee among other credentials. We combined, analyzed, and distilled their responses to our interviews. We first provide a high-level summary of the key points, followed by question-by-question summaries of interview responses.

SUMMARY OF KEY POINTS

- The perception is that **the typical BOC-certified operator is a self-starter** with encouragement and support from the operator's employer.
- Informants could not shed much light on the Northwest's BOC "potential."
- Informants did not recommend any differences in approach to outreach between owner- and tenant-occupied buildings.
- Informants indicated that building operators vary in how and to what extent they **disseminate learning**.
- Informants suggested that some employers see the **value** of BOC but that there is not universal recognition of its value.
- There was a lot of focus on **empirical evidence** of value to show benefits to would-be certificants and to make it more visible (badges were recommended).
- One informant identified English as a Second Language (**ESL) as a barrier** but the BOC-E program theory does not explicitly reflect that barrier. NEEA may wish to further investigate the pervasiveness of this as a barrier and, if appropriate, revise the program theory and logic model to include language as a barrier.

QUESTION-BY-QUESTION SUMMARIES

Who Are Building Operators

1. What are the typical responsibilities of a building operator?

SUMMARY: Typical responsibilities are:

- Managing people, processes, and places.
- Performing preventive maintenance on all building systems including HVAC, plumbing, and other mechanical systems, such as elevators. Can range from light bulb changing to major equipment teardowns and repairs, depending on the operator's skills. (In the case of elevators, the work is primarily acting as the company's point of contact with certified elevator repair people.)
- Setting up master maintenance plans for each building and an expected replacement program for each piece of equipment.
- Ensuring occupants are happy with the building infrastructure.
- Ensuring building safety.
- Recently, addressing quality of indoor environment.

What are the typical qualifications or backgrounds of a building operator?

SUMMARY: Operators usually come up through the ranks: limited education (high school), on-the-job training, some two-year degrees. Very few "building engineers" are actually certified engineers. Main qualifications are strong working ability with all HVAC equipment, both main equipment and support ventilation; the ability to troubleshoot and diagnose controls issues, program direct digital controls (DDC), and balance loads on electrical systems; and understanding of lighting controls.

2. Thinking about the population of building operators, who among them typically seeks out BOC certification?

SUMMARY: The ones who want to improve themselves or who want a pay raise and who have supportive management.

3. What motivates a building operator to become BOC certified?

SUMMARY: To learn what you do not know in a formal setting, undistracted by work; the perception that certification results in a higher wage; employer recognition for knowledge (could be job advancement).

4. Conversely, what types of things stand in the way of building operators becoming BOC certified?

SUMMARY: Lack of employer recognition for it; lack of financial support; time away from the job; lack of program awareness; lack of decision-maker awareness of value of training. In addition, one respondent mentioned limited command of English as a barrier.

Trends in Building Operations

5. Thinking back to 10 years ago, what key trends and changes in the field of building operations have you seen since then?

SUMMARY: Greater awareness of energy efficiency; greater emphasis on sustainability; more outsourcing; fewer staff; lower wages; increased regulation; larger proportion of staff for whom English is a second language; more technically complex buildings; increased use of controls and availability of interval data; equipment is much more electronically controlled and driven.

Is there a change in the skill sets of the people (i.e. minimum qualifications) who do this work?

SUMMARY: As some older workers have retired, their replacements are more technically proficient, with computer fluency and programming skills. On the other hand, in the last five years because of the economy, more construction workers are entering the field.

Current State of Energy Efficiency in Commercial Buildings

6. How familiar are you with the types of energy efficiency measures that BOC training addresses?

SUMMARY: Most responses indicated good familiarity, with respondents able to describe the types of measures and systems covered in training or providing other indication of familiarity (e.g., had taught courses). One respondent reported no familiarity, and so did not respond to the following question.

7. What do you think is the overall state of energy efficiency in commercial buildings with respect to those types of measures?

SUMMARY: Responses varied from, “There is still a lot of opportunity,” to “middle of the road,” to “good.”

8. Are you aware of any studies, sources, or reference guides on current, "state-of-the-art" or "best practices" for building operation and maintenance activities?

SUMMARY: Respondents cited several organizations as sources: ASHRAE; BOMA; APPA (higher education, formerly known as the Association of Physical Plant Administrators); PMI (Project Managers Institute); IFMA's "World Workplace," and DOE. One cited an Australian study[17] that showed the best way to improve building efficiency is to share the savings with the operator.

BOC Expansion Potential

9. What is your estimate of the portion of commercial space that has internal operations staff vs. outsourced building operations staff (e.g. to Johnson Controls, etc.)?

SUMMARY: Estimates of portion of commercial space with in-house O&M staff ranged from 25% to 75%. One contact reported it varies by building size with 33% of buildings over 50,000 square feet having internal operations staff, compared to 10% of smaller buildings.

Most respondents could not answer the three follow-up questions, but we show the range of responses given.

a. Of the internal operations staff, what is your estimate of the portion that is BOC certified vs. non-certified? Less than 20% are certified (four responses).

b. What is your estimate of the portion of building operations companies that have any BOC-certified staff? From 25% to almost all (two responses).

c. And what's your estimate of the proportion of these contract staff that are BOC-certified? From 1% to 2% to 75% to 80% with "some certification" (two responses).

10. How do owner-occupied buildings compare to tenant-occupied buildings in terms of interest in BOC certification?

SUMMARY: Most respondents surmised it is probably higher with the owner-occupied buildings.

11. How should BOC administrators approach outreach to these two occupant types to build awareness of BOC?

SUMMARY: Same approach to both: through BOMA and other trade organizations, same business case, although there may be more pride of ownership to use as a draw with owner-occupied buildings.

---

[17] *http://thewarrencentre.org.au/wp-content/uploads/2011/11/LEHR-Research-Survey-Report-Ver-5.2.pdf*

How Building Operations Staff Apply BOC Knowledge

12. Could you please describe common ways in which the job responsibilities of building operations staff are organized? For example, if one is BOC-certified, are they responsible for some portion of square footage, or a single piece of equipment, etc.?

SUMMARY: Informants provided a range of responses based on their personal experience. One provided a description of a typical hierarchy: At the top is a chief engineer responsible for the entire site or a building or buildings based on square feet; then a finance and resource manager; then assistant chief who is labor manager and who does some hands-on work; below them are engineering staff with varying (three) levels of skill: janitorial, mechanical, and senior operators for more technical. None offered details on how the responsibilities of BOC-trained staff differed from those of other staff, although two indicated that BOC-trained staff had a broader skill set (e.g., were familiar with more types of equipment and O&M activities), one of whom further indicated that BOC staff were in a better position to answer questions from other staff, present information to a company board, and prioritize projects.

13. To what extent, and how, is knowledge passed on from the trained staff to the other staff?

SUMMARY: Depends on 1) the person and the relationships they have with staff with whom they are teamed, 2) the eagerness of untrained staff, and 3) the interest of trained staff in mentoring and sharing. Some engineers hold knowledge to protect their jobs; some are willing to train, but do not have the skills, so they train staff incorrectly; some identify mentors and use them to work alongside newer or junior staff.

14. Do building owners or managers typically send only supervisors, or multiple operations staff for BOC training?

SUMMARY: Responses varied, but they were roughly balanced between informants who reported that building owners or managers mainly send supervisors and those who reported that owners or managers send multiple rank-and-file staff.

15. What are the common ways that trained staff disseminate BOC knowledge among building staff (e.g. operations manuals, updates to manuals, etc.)?

SUMMARY: *Ad hoc* on-the-job training.

Attributing Energy Savings to BOC

16. In thinking about how BOC training results in energy savings, can you provide any insight into the important variables the program should consider when determining energy savings?

SUMMARY: Study specific facilities; compare energy bills before and after BOC training; use International Performance Measurement and Verification Protocol (IPMVP) standards.

(IPMVP is an international standard for quantifying the results of energy efficiency actions. It was developed by an international coalition, led by the US Department of Energy, starting in 1994. For more information see *EVO-world.org* or *Wikipedia's page on IPMVP*.)

Market Value of BOC

17. How valuable an asset is BOC certification to employers of building operators?

SUMMARY: All informants agreed that certification is objectively valuable (i.e., certified operators deliver more savings): four spoke only to the objective value of certification, while four also spoke to employers' perceptions of the value. The latter four all indicated that employers vary in the degree to which they recognize the value of certification, commenting that there is "not nearly enough" perception of value or that it is "limited," "depends on the owner," or "has to be demonstrated to employers."

18. How valuable an asset is BOC certification to the building operators themselves?

SUMMARY: The knowledge is valuable from a personal-satisfaction perspective, from a peer-relationship perspective, and a career-advancement perspective, but the certification per se has little value.

19. Is there any evidence of market value for BOC certification?

SUMMARY: Some job postings, but generally, not much evidence.

20. What will it take to increase employer perceptions of the value of BOC certification?

SUMMARY: Empirical results such as lower energy bills or improvement in building performance, but especially dollar savings. Some informants suggested a post-certification letter to decision makers at attendee's facility to tell them of the certification and its value and benefits.

21. What will it take to increase building operator perceptions of the value of BOC certification?

SUMMARY: Empirical evidence of career advancement or higher pay. Greater awareness of the training among their supervisors and managers, and among themselves (peer pressure).

MARKET AWARENESS OF, AND BARRIERS TO, BOC TRAINING

22. One of the barriers the BOC-Expansion initiative is trying to address is "lack of awareness" about BOC training and certification opportunities. Do you have any insights to share on how aware building operators are of BOC in the northwest?

SUMMARY: The market informants' views of northwest building operators' awareness of BOC training were mixed, but the predominant view is awareness exists, that is, lack of awareness is not a problem.

23. What are your thoughts on the most effective strategies and methods to inform building operators about BOC training opportunities?

SUMMARY: Informants' suggestions included utility bill inserts about BOC training, Linked In social networking, and going where you can find the operators: trade shows, periodicals. Go through the union to reach hospital employees.

24. Do you anticipate that it would be effective for the initiative to partner with the International Union of Operating Engineers (IUOE) as a means of increasing awareness?

SUMMARY: Possibly, unless BOC presents competition to any of the union's apprenticeship programs; several informants were unaware of IUOE.

Underserved Markets

25. What markets do you think might be underserved?

SUMMARY: Smaller population centers, smaller properties (under 50,000 square feet), properties occupied by start-up businesses, and public K-12 schools because of limited funding.

26. Do you think the outreach and promotional strategies need to differ for underserved markets?

SUMMARY: Perhaps offer discounted tuition or web-based training.

27. What do you think are the key barriers to building operators obtaining BOC certification in underserved markets?

SUMMARY: Unawareness of the value of the training, distance, limited funding.

28. How might BOC content, structure, or delivery need to change to increase its uptake among firms in underserved markets?

SUMMARY: Perhaps add course material on indoor air quality, safety, OSHA compliance, or offer webinars or courses in Spanish.

29. Soon, BOC training will occur via a "blended learning course," which offers 20-25% of the curriculum online, with the rest being classroom-delivered. How will the blending learning course help mitigate these barriers?

SUMMARY: Helps overcome the barrier of time away from job, but shouldn't replace all classroom activity, which is needed for peer relationships and face time with instructors.

Federal Sector

30. What do you think are the key barriers to building operators obtaining BOC certification in the Federal Sector?

SUMMARY: The approval process (bureaucracy), funding, and lack of awareness of or indifference to the value of BOC.

31. What are some methods that you think would be effective at increasing federal sector participation?

SUMMARY: Identify key decision-making personnel and pitch the benefits to them, especially for military facilities (for example, the commanding officer) including specifically the Coast Guard and local National Guards.

32. For BOC training, how would becoming an ANSI authorized provider help build interest in the federal sector?

SUMMARY: It might help.

Final Thoughts

33. Is there anything else you'd like to add regarding expanding BOC certification in building operations market?

SUMMARY: Demonstrate the value proposition. Consider providing badges to BOC graduates to indicate certification. In Oregon, allow SB1149 school funds to be used for building operator training.

B APPENDIX B: LOGIC MODEL MEMO

MEMORANDUM

To: Rita Siong, NEEA

From: Michelle Bruchs, Marjorie McRae, Ryan Bliss, Research Into Action

Date: April 18, 2013

Re: 2012 BOC-E Program Logic Model and MPIs

This memo provides a review of the program logic model for the Building Operator Certification Expansion (BOC-E) Initiative. We based this review on the following two sources: 1) the graphic BOC Expansion Logic Model, version 9, last revision 12/10/2012; and 2) logic model tables contained in MS Excel workbook BOC 2 Logic Model Doc Tables_v4, last revision 1/28/2013.

Note: We acknowledge that NEEA is in the process of revising the BOC-E initiative logic model, including removing some activities they are no longer pursuing. With that in mind, we intend this memo to report on the aforementioned versions of the logic model graphic and tables, with the understanding that some of the recommendations contained herein may no longer be relevant.

Brief Statement of the Program

From 1997 to 2003, NEEA funded the Building Operator Certification Program (BOC), which was created to educate, train, and certify facility operators to perform energy-efficient operations and maintenance. NEEA's original funding for BOC saw the initiative to maturity, achieving market awareness over 50% among building employers and operators.

Then, in 2012, NEEA aimed to accelerate adoption of BOC and increase market penetration of commercial building operators who are BOC certified in the Northwest. This new effort, titled BOC Expansion (BOC-E), seeks to address the following six market barriers:

1. Lack of time
2. Ability to pay (Unemployed operators and Veterans)

3. Lack of service in underserved markets
4. Lack of awareness (among International Union of Operating Engineers (IUOE) and WorkSource)
5. Product Performance (does not meet the ANSI 17024 Standard for certification of personnel)
6. Lack of awareness (About renewal and among utilities)

The program logic model describes the activities, outputs, and outcomes the implementation team (the team) will employ to address each of the above barriers and contribute to meeting program goals.

Review of Barriers and Market Progress Indicators (MPIs)

The NEEA BOC-E implementation team has indicated that the graphic version of the BOC-E logic model is the source of "record" for the program logic. Therefore, we first offer the following comments on that version. We have organized our comments by barrier, numbered as above with corresponding activities, listed in order (left to right) of their appearance on the graphic.

Barrier 2 – Ability to Pay (UE & Veterans)

The graphic makes it appear as if only one program activity (Activity 2: Develop Online BOC product) addresses Barrier 2. In comments on an earlier iteration of this memorandum, program staff indicated that the blended online product *may* address Barrier 2, but more pertinent activities are "schedule and conduct trainings — issue BOC certificates; develop partnerships with IUOE, WorkSource, and utilities; and develop utility engagement plan." These correspond with Activities 1, 4, and 6.

Current implementation team discussions suggest an online product may not result in lowered delivery costs. If this is the case, the implementation team may consider removing Activity 2 as related to Barrier 2.

Furthermore, it is not clear how Activity 1 addresses Barrier 2 and, in fact, the BOC-E logic model tables do not associate that activity with that barrier (see additional discussion of logic model tables, below).

Barrier 6 – Lack of Awareness (Renewal & Utilities)

Given that the team has decided not to pursue RTF action to unitize BOC savings, we pose questions and provide suggestions for possible updates to the logic model:

➡ **Activity 6: Conduct market research**

- Revise language to reflect decision to exclude RTF.
- Is the team intending to explore non-RTF-dependent approaches to increasing utility awareness and interest? If so, revise linked output (link g) to clarify desired utility-related output.
- Suggested addition to activity: "Promote advantages to utilities"
- Note: NEEA completed these suggested revisions on April 15, 2013

➡ **Medium-Term Outcome: RTF accepts unitized savings for BOC – MPI: V**

- Revise MPI V to reflect the team's updated desired outcome with respect to utility awareness and interest, if one exists. If one does not exist, delete MPI V and revise subsequent MPI numbering scheme.
- Note: NEEA completed these suggested revisions on April 15, 2013

➡ **Long-Term Outcome: Region's utilities incorporate BOC into their EE portfolios – MPI: X**

- The current version of the logic model graphic and tables do not explicitly show how the activities under the "Lack of Awareness," and the outputs from those activities (numbered link 9) will result in this long-term outcome. For example, NEEA mentions a utility survey; however, the link between the survey results and the Long-Term outcome of utilities incorporating BOC into their portfolios is unclear.
- NEEA created a Utility Engagement Plan with specific activities listed, however the logic model and tables do not reference this plan. We suggest including these activities, along with their linkages to the desired long-term outcome measured by MPI X.

➡ **Long-Term Outcome: Maintenance and certification is valued by employers and operators – MPI: IX**

- Ensure the language is consistent with program intention; ensure active voice. We suggest the following phrasing: "Employers and operators value up-to-date BOC certification."
- Note: NEEA completed these suggested revisions on April 15, 2013
- It is unclear how the program activities flow to this outcome. For example, how will BOC becoming an approved training provider for GSA, and an increase in number of course registrants, result in employers and operators valuing BOC?

Logic Model Tables

In addition to the logic model graphic, we reviewed the logic model's related tables. An overarching comment is that the barriers identified in the BOC-E logic model graphic differed from the barriers identified in the logic model tables (Table 9). While some differences were largely superficial, in two cases, the tables identify barriers that relate to those identified in the graphic but are logically different and may entail different program strategies. These were: 1) "Lack of education partnership with IUOE" (tables) versus "Lack of awareness (IUOE & WorkSource)" (graphic); and 2) "Integration in utility programs is limited" (tables) versus "Lack of awareness (renewal & utilities)" (graphic). Finally, the tables identify one barrier ("Renewal value and process is not well understood") that the graphic does not identify.

Table 9: Comparison of Barriers in Tables and Graphic

BARRIERS IDENTIFIED IN TABLES	BARRIERS IDENTIFIED IN GRAPHIC
Limited time to attend training	Lack of time
Tuition affordability for UE and returning veterans	Ability to pay (UE & Veterans)
Rural markets underserved due to expense of delivery	Lack of service in underserved markets
Lack of education partnership with IUOE	Lack of awareness (IUOE & WorkSource)
BOC does not meet ANSI standard	Product performance standard (ANSI)
Renewal value and process is not well understood	(none)
Integration in utility programs is limited	Lack of awareness (renewal & utilities)

These above differences complicate evaluation of the logic model graphic, specifically, of linkages between actions and barriers. We suggest the initiative team bring the barriers identified in the graphic and tables into greater alignment.

In addition, we offer the following comments that are more specific:

Barriers & Activities Matrix

- Review the matrix (Table 10) and update as necessary to describe accurately how the activities will address the barriers.
- For example, the third activity, Promote scheduled courses, is shown related to four barriers: Limited time to attend training, Tuition affordability…, Rural markets underserved…, and Integration in utility programs…. The relevance to these barriers is not clear. How will promoting scheduled courses address tuition affordability for unemployed operators and returning veterans? This linkage does not appear on the graphic.

Table 10: Implementation Staff's Barriers/Activity Matrix

		BARRIERS/ACTIVITIES MATRIX	BARRIERS						
			1	2	3	4	5	6	7
			Limited time to attend training	Tuition affordability for UE and ... Vets	Rural markets underserved ...	Lack of ... partner-ship with IUOE	BOC does not meet ANSI standard	Renewal value ...is not well understood	Integration in utility programs is limited
ACTIVITIES	1	Schedule courses, register students, conduct training and issue BOC certifications.	X						X
	2	Evaluate financial model and NME for Online BOC.	X	X	X				
	3	Promote scheduled courses.	X	X	X				X
	4	Partner with WorkSource to recruit UE and returning Veteran operators.		X					
	5	Conduct gap analysis for BOC against DOE/NREL job skill standard.		X			X		
	6	Respond to GSA RFQ for approved training providers under the 2010 FBPTA.					X		
	7	Develop implementation and budget plan for achieving ANSI Standard 17024.		X			X	X	
	8	Develop IUOE-BOC partnership model and market-test model.				X		X	
	9	Survey BOC certified operators to gauge renewal value and barriers to renewing the certification.						X	
	10	Conduct market research to assessment demand for Tool Library; Assess cost of development and operation.						X	
	11	Survey utilities to gauge interest in BOC and barriers to engagement, including RTF unitized savings.							X
	12	Identify implementation steps, timetable, and risk/success factors involved with BOC evaluation by the RTF.							X

➡ As noted above, the implementation team has indicated that Activities 1, 4, and 6 relate to Barrier 2. The tables do not associate Barrier 2 with Activity 1, but associate it with several other activities. Two of those activities are consistent with the graphic's Activities 2 and 4. One of the table's activities is the same as the graphic's Activity 3 – Promote Scheduled Courses – but the graphic does not clearly associate Activity 3 with Barrier 2 (nor does there appear to be a logical relationship between that activity and that barrier).

Finally, the tables associate Barrier 2 with two activities that are related to the graphic's Activity 5: (1) conduct gap analysis for BOC against DOE/NREL job skill standard; and (2) develop implementation and budget plan for achieving ANSI Standard 17024. It is not clear how those activities relate to Barrier 2.

We have considered the possibility that the team intends the Barriers/Activity Matrix to be an ongoing working chart to inform ongoing evolution of the logic model graphic. If so, then the team does not need to consider the above comments.

Remaining Tabs in Excel Logic Model Tables File

We reviewed the remaining tables in the Excel Logic Model Tables file, including the identified MPIs and data sources. We find the information appropriate. However, if the team adopts the suggestions offered above, the team will need to update these tables accordingly.

Exit Strategy

NEEA hopes to exit the BOC-E Initiative in 2016, in the medium-term range of outcomes. Two of the three outcomes (exclusive of the RTF outcome, which is likely to be eliminated) describe "increased" activity. Supporting documentation does not appear to indicate the success criteria for these outcomes (example: 10% increase). The documentation does provide the data sources and metrics, but do not indicate the success threshold.

Among long-term outcomes, MPI #8 does not explicitly state the success criterion. For example, the desired outcome is "increased participation by operators employed in the Federal sector." Is there a desired percent increase?

Finally, when the baseline and the initiative goal speak of "one or fewer BOC courses" and "two or more BOC courses," we understand that NEEA is referring to the complete course sequence. However, the term "course" might be confused for a single, stand-alone course.

Final Comments

The remaining elements of the logic model graphic appear to accurately describe the program (barriers, activities, outputs, and outcomes).

C APPENDIX C: BOC DATABASE REVIEW MEMO

MEMORANDUM

To: Rita Siong, Project Manager, Northwest Energy Efficiency Alliance (NEEA)

From: Ryan Bliss, Research Into Action

Date: February 15, 2013 (Revised March 20, 2013)

Re: 2012 BOC Program Database

This memo documents Research Into Action's analysis of the Northwest Energy Efficiency Council (NEEC) and International Building Operators Association (IBOA) Building Operator Certification (BOC) program databases as of 2012. The primary goal of this analysis was to describe the 2012 new BOC certificants and update the count of active BOC certificants as of 2012. "Active" certificants are all individuals who have received or renewed the BOC credential since 2007. These are individuals for whom NEEA counts energy savings for 2012. This memo also describes and tabulates the NEEC database contents.

Methods

NEEC created an Excel database of BOC certificants in 2006 from existing paper copies of BOC records. Since then, NEEC has continued to update the electronic database with new certifications, renewals, and other pertinent information (such as address changes). On November 20, 2012, NEEC provided Research into Action with a copy of the BOC database, containing records on the 1,625 individuals that had received certification in Oregon and Washington to that date. NEEC provided an update on January 24, 2013, bringing the total to 1,674 records. In January to February, 2013, NEEA provided Research Into Action with copies of various IBOA datasets, which we combined into a single set with 515 certification records through 2012.

Each record included the following data on the certificant and his/her employer as well as the years of certification and expiration of certification for both BOC Level I and Level II. As maintaining certification requires annual renewal, the year of "expiration of certification" is the year following the last year of renewal or the year of certification if the certificant did not renew certification.

To update the count of active BOC certificants, we followed the procedure described in the *Long-Term Monitoring and Tracking Report on 2011 Activities* (LTMT) report.[18] We calculated the number of new and retired BOC certificants for each year from 1997 through 2012. For any given year, new BOC certifications are those certified for the first time in that year and retired certificants are those who have not received certification or renewal within the previous five years (the assumed measure life of the certification). The total number of active BOC certificants in any given year is the total number that have ever received certification up to and including that year, minus the total number of retired certificants up to and including that year. Following the 2011 LTMT, we calculated year-by-year totals of active BOC certificants by adding the number of new certificants for each year to the previous total and subtracting the number of that year's retired certificants from that sum.

Note that individuals may have both BOC Level I and Level II certification, with different certification and expiration years for the two levels. For each individual, we assigned a single "first year certified" as the earlier year in which the individual received Level I or Level II certification; and we assigned a single "last year certified" as the last year in which that individual was certified at either level – i.e., the year before the first year in which both levels were expired. Table 11 illustrates this.

Table 11: Computation of First Year Certified and Last Year Certified

LEVEL I	YEAR	LEVEL II	YEAR	ANY CERT.	YEAR
Certification	2003	Certification	2004	First year	2003
Expiration	2009	Expiration	2010	Last year	2010

For any individual, the year of BOC retirement is the fifth year after the last year certified.

Description of NEEC Dataset

The BOC dataset included fields for the following data on the certificant and his/her employer: name, title, company, work and home address and phone, email, company type, facility size, and associations the certificant belongs to. The database is missing certain information for some individuals (Table 12). The amount of missing data is relatively low (except for email address) and will not affect the validity of the certificant survey.

[18] *Long-Term Monitoring and Tracking Report on 2011 Activities (Report #E12-239).* Prepared for Northwest Energy Efficiency Alliance by Navigant Consulting, Inc., July 23, 2012. Available at: *http://neea.org/docs/reports/long-term-monitoring-and-tracking-report-on-2011-activities.pdf?sfvrsn=16*. Last accessed Jan. 14, 2013.

Table 12: Missing Data in BOC Database (*n* = 1,674)

ITEM	COUNT	PERCENT
Work phone number	69	4%
Email address	417	25%
Company name	62	4%
Work street address	74	4%
Work city	135	8%
Work state	24	1%

In many cases, two or more certificants in the dataset worked for the same employer. We could not obtain an exact count of such cases based on the company name, work address, or work telephone for three reasons. First, the dataset often recorded a given company name under multiple variants (e.g., "ABC Corp." and "ABC Corp. Inc." or "WA State Dept. of XXX" and "XXX Dept., State of WA"). Second, a given work address similarly could be recorded differently in multiple cases. Third, two individuals working for the same employer could have different phone numbers. However, we developed an algorithm that identified any *set* of records where any record shared company name, work street address, or work phone with any other record as all indicating the same employer. For example, if record 1 shared company name with record 2, which shared work street address with record 3, which shared work phone with record 4, then we considered records 1 through 4 to share the same employer.

Using that approach, we identified 678 unique employers.[19] Within each such set with multiple records, we used the address fields to identify different facilities – we identified a total of 1,083 unique facilities.[20] We then counted the number of individuals from each unique employer and each unique facility. As Table 13 shows, three-fifths of employers had one certified employee in the dataset, and most of the rest had two or three certified employees. When we examined counts for unique facilities, we found that more than three-quarters of facilities had just one certified employee and only 6% had more than three. Note that these totals are based on all employees that had received certification at any time, not just those currently considered active.

[19] The process actually was somewhat more complicated. After identifying the initial sets based as described above, we identified many cases that were near-matches on one or more of the three criteria but did not match any exactly. We developed algorithms using Excel formulas to parse address fields and compare on parts of the fields, enabling us to classify most of those cases as belonging to one of the existing sets.

[20] We considered a post office box to be a different facility from a street address, unless we had at least one record that tied them together by including both a post office box and a street address.

Table 13: Distribution of Employers and Facilities by Number of Certified Employees in Dataset

Number of Certified Employees in Dataset	Employers		Facilities	
	Count	Percent	Count	Percent
One	410	60%	846	78%
Two to three	161	24%	174	16%
Four to five	52	8%	34	3%
Six to 10	33	5%	21	2%
11 to 20	18	3%	6	1%
More than 20	4	1%	2	0%
Total	**678**	**100%**	**1083**	**100%**

Fourteen certificants reported working outside of Oregon or Washington (in fact, outside of NEEA territory), despite reporting home addresses within Oregon or Washington (Table 14). We excluded those 14 respondents from our counts of active certificants (and all other subsequent tables in this memo) as they do not contribute to energy savings within Oregon or Washington. Additionally, the work state was missing from the NEEC database for 24 certificants. Since all of those with missing work state data reportedly reside in Oregon or Washington, we included them in our counts of active certificants and other analyses of the NEEC database.

Table 14: Distribution of Certificant Work and Home States

Work \ Home	OR	WA	ID	Unknown	Other	Total
OR	397	28	1	18	1	445
WA	5	1101	3	77	5	1191
ID	0	0	0	0	0	0
Unknown	6	18	0	0	0	24
Other	4	10	0	0	0	14
Total	412	1157	4	95	6	1674

Description of 2012 NEEC Certificants

A total of 197 individuals received some certification in 2012 (Table 15). Of those, 179 were certified for the first time and 18 who already had Level I received their Level II certification. Of the 179 new certificants, 178 received Level I certification and three received Level II certification (two received both Level I and Level II).

Table 15: 2012 Certifications

CERTIFICATION CATEGORY	COUNT
First certification, Level I only	176
First certification, Level II only	1
First certification, both Level I and II	2
All first certifications	179
Previously certified at Level I, new Level II	18
All 2012 certifications	197

NEEC's database includes information relevant to the BOC expansion (BOC-E) efforts, which included recruiting returning veterans, the unemployed, and trainees from underserved markets. Eighty-three individuals received certification as part of BOC-E in 2012, all in Level I. Table 16 exhibits the attributes of certificants in the BOC-E program, including number of returning veterans (split by Iraq/Afghan veteran status), unemployed individuals, IUOE class attendants, and the type of special class taken. As many individuals possess more than one of the traits found in the table, the total count does not sum to 83 (the number of unique BOC-E certificants). For example, a BOC-E student may have taken the underserved class from IUOE and is also unemployed and a returning veteran.

Table 16: BOC Expansion Attributes; Multiple Selections Allowed (*n* = 83)

BOC-E ATTRIBUTES	COUNT
BOC-E Special Class Type	
Underserved	24
Strategic partnerships	935
Associations	
Returning Veteran (2001-2012)	43
Unemployed	22

2012 Count of Active NEEC Certificants

This section discusses the counts of active 2012 NEEC certificants. The following sections discuss IBOA certificants and the combined counts from NEEC and IBOA.

The year-to-year tallies of NEEC active certificants in the 2011 LTMT report appear to include some irregularities: for several years, the total number of active certificants did not equal the previous total plus the counts of new certificants minus the count of retired certificants. As discussed below, some limitations in the database may have contributed to these irregularities. NEEC appears to have resolved at least some of the issues. Therefore, in addition to updating the

2011 LTMT totals with new 2012 data, we have recalculated the year-by-year totals directly from the NEEC database. The updated and recalculated counts are in Table 17.

Table 17: Updated Market Status of NEEC Active Certified Building Operators[1]

Year	From 2011 LTMT				Calculated from NEEC Database		
	Annual New	Annual Retired	Total Active	Total Active (Revised)	Annual New	Annual Retired	Total Active
1997	1	0	1	1	1	0	1
1998	45	0	46	46	46	0	47
1999	120	0	166	166	121	0	168
2000	124	0	***289***	290	125	0	293
2001	96	0	***383***	386	96	0	389
2002	155	1	537	540	148	0	537
2003	109	22	624	627	104	0	641
2004	58	54	***627***	631	58	0	699
2005	120	63	684	688	115	79	735
2006	77	62	***697***	703	79	79	735
2007	88	93	***691***	698	90	72	753
2008	143	70	***758***	771	142	88	807
2009	84	51	***788***	804	77	72	812
2010	112	24	876	892	109	56	865
2011	126	101	901	917	152	95	922
Subtotal 97-11	1458	541	901	917	1463	541	922
2012	179	73	1007	1023	179	73	1028
Total to 2012	**1637**	**614**	**1007**	**1023**	**1642**	**614**	**1028**

1 Annual New= building operators certified in that year. Annual Retired = building operators that did not receive a new certification or renewal within the previous five years. All 1997-2011 Annual New and Retired counts are from the 2011 LTMT report and 2012 counts are from the NEEC database. Counts in bold-italic font are not consistent with the formula Total Active (present year) = Total Active (previous year) + Annual New – Annual Retired. We applied that formula to the 1997-2012 Annual New and Annual Retired counts to calculate the Total Active (Revised) counts. All Annual New and Annual Retired values in these columns are from our recent analyses of the NEEC database. The database reports 19 individuals as deceased or having retired from work. As the database did not provide the date of death or work retirement, we could not determine which year was first affected, and so we excluded those 18 individuals from this table entirely.

The first three data columns show the 1997 to 2011 counts of new and retired certificants, along with the annual totals of active certificants, from the 2011 LTMT – the 2012 counts are from our analysis of the NEEC database. The totals shown in bold-italic font are not consistent with the formula "previous total plus new minus retired." The fourth data column shows the active

certificant totals that are consistent with that formula. This analysis produced a total of 917 active certificants as of 2011, compared to the 901 reported in the 2011 LTMT. When we added the 179 new 2012 certificants and subtracted the 73 2012 retirees, the total was 1,023 active certificants in 2012. When we calculated the year-by-year counts entirely from the NEEC database (the fifth through seventh data columns of the table), we arrived at a total of 922 active certificants in 2011 and 1,028 in 2012.

Two issues may have created challenges in constructing year-to-year counts of active certificants in previous year: 1) in some cases, the NEEC database listed a given individual in one year but not the next; and 2) the key "year certified" field did not identify the actual certification year for those certified in 2006 and earlier, but showed only "2006 Prior." The latter issue, in particular, required the previous contractor to create algorithms to identify the year certified for all such individuals. In 2012, NEEC updated the database with an actual certification year for each individual.

Note that in most years our analysis of the NEEC database produced new certificant counts that were similar to those in the 2011 LTMT. In most cases, the differences might easily be the result of one of the two factors noted above. The greatest difference between our counts and those from the LTMT is in the number of retirees. In particular, while the LTMT showed 77 retirees from 2002 through 2004, our first retirement was in 2005, indicating that all those who had received certification from 1997 through 1999 retained certification at least through 2000 (the last year of certification for anyone who retired in 2005).

One possible explanation is that some individuals could have become certified, allowed their certification to lapse, then undertook certification again later. Any such individuals that had waited more than five years from expiration of their initial certification before re-certifying could have been counted as retirees at one point, then as active certificants later. As the database shows, only the year certified and the most recent year of expiration, we would not be able to identify any such individuals, and they would appear to us to have been continuously certified from first to last year certified.

To explore this further, we identified the last year of certification for each individual who, according to the database, initially received certification in 2000 or earlier (Table 18). Although the database shows that certification had lapsed by 2003 for a majority of those individuals, it indicates that almost one-quarter of them were certified until after 2006. While it seems unlikely that many of those individuals had allowed their certification to lapse for at least five years and then re-certified, the possibility that some did so cannot be ruled out. Such a circumstance could account for some of the variance between the 2011 LTMT data and our analyses.

Table 18: Last Year Certified for those Certified in 2000 or Earlier

LAST YEAR CERTIFIED	COUNT	PERCENT
2000	81	27%
2001 to 2003	130	43%
2004 to 2006	21	7%
2007 to 2009	26	9%
2010 to 2012	44	15%
Total	**302**	**100%**

2012 Count of Active IBOA Certificants

This section discusses the counts of active 2012 IBOA certificants. The following section incorporates shows the combined NEEC and IBOA data.

As seen in Table 19, IBOA certified 25 new certificants in 2012.[21] In reviewing the year-to-year tallies of IBOA new, retired, and total active certificant counts in the 2011 LTMT and in the workbook used to generate those counts, we determined that the workbook calculated IBOA retirements slightly differently from the way it calculated NEEC retirements. As noted above, for the NEEC counts, the year of BOC retirement is the fifth year after the last year certified (i.e., the last year that the certification was still in effect) – *last year* + *five*. However, the workbook calculated IBOA retirements as the *fourth* year after the last year certified – *last year* + *four*.

The difference between the two methods of calculating retirement means that certification "measure life" is five years for the NEEC certificants but only four years for the IBOA certificants. There is no reason to consider certification to have different measure lives for NEEC and IBOA; therefore; therefore, we advise using a single method – the *last year* + *five* method – to calculate retirement for both.

However, changing the method of calculating retirements from one year to the next can complicate things. Under the *last year* + *four* method, savings retired for 33 certificants in 2011. Those savings would not retire until 2012 under the *last year* + *five* method, but the 2011 total active count already has taken those retirements into consideration. One solution would be to count zero retirements for 2012, since those who the *last year* + 5 method would have counted as retired in 2012 already were counted in 2011. Going forward, calculating retirements using the *last year* + *five* method would correctly calculate retirements for 2013 and beyond, getting the counts "back on track."

[21] IBOA's 2012 new certificant data only included two courses from Helena, Montana. Accordingly, we assume that no trainings took place in Idaho in 2012. The data showed the course level for only one of the Helena courses (a Level I course).

The alternative to the above approach would be to recalculate the year-by-year totals directly from the IBOA database using the *last year + five* method. Table 19 shows results using both methods – simply updating the 2011 LTMT counts with the total new certificants ($n = 25$) and zero retirements and recalculating year-by-year totals from the IBOA database.

Table 19: Updated Market Status of IBOA Active Certified Building Operators[1]

	From 2011 LTMT			Calculated From IBOA Database		
Year	Annual New	Annual Retired	Total Active	Annual New	Annual Retired	Total Active
1997	2		2	2	0	2
1998	12	0	14	12	0	14
1999	22	0	36	22	0	36
2000	21	0	57	21	0	57
2001	9	0	66	9	0	66
2002	42	1	107	42	0	108
2003	60	3	164	60	1	167
2004	35	9	190	35	3	199
2005	30	11	209	30	9	220
2006	53	13	249	26	11	235
2007	23	22	250	4	13	226
2008	28	32	246	73	22	277
2009	52	23	275	52	32	297
2010	66	37	304	66	23	340
2011	24	33	295	26	36	330
Subtotal 97-11	479	184	295	480	150	330
2012	25	0	320	25	33	322
Total to 2012	**504**	**184**	**320**	**505**	**183**	**322**

1 All 1997-2011 Annual New and Retired counts are from the 2011 LTMT report and 2012 counts are from the IBOA database. All Annual New and Annual Retired values in these columns are from our recent analyses of the IBOA database. Note that the IBOA database included nine consultants who do not manage or operate buildings. We do not count them in the above totals.

The total active counts for 2012 differ by only two for the differing approaches: our total count of annual new certificants through 2012 is one greater than that of the 2011 LTMT, and our total count of retirements through 2012 is one fewer than that reported in the LTMT. Note, however, our year-by-year counts of new certificants for the years 2006 through 2008 vary considerably from those in the LTMT. We are unable to account either for variability in year-by-year counts or for the small difference in the totals.

Given the small difference in the total active counts that the two methods yield and the fact that we recalculated our counts directly from the database for all years (rather than adding counts for the most recent year to counts known only to us from a secondary source), we recommend that NEEA use our calculation of 322 active certificants in 2012.

IBOA staff reported to us that 99 certificants renewed in 2012 (43 in Level I and 56 in Level II), IBOA's database included all activity through 2011 and new certificants for 2012 but did not provide individual-level information on renewals in 2012. However, lack of individual-level renewal data did not affect the results shown in the above table.

2012 Count of All Active Certificants

We combined the data from Table 17 and Table 19 to update the total number of all certifications and the number of operators with active certification status (i.e., those who received their last certification or renewal in the past five years) for both NEEC and IBOA. The results are in Table 20. The values in the NEEC columns come from columns 5 to 7 of Table 17. The IBOA values are from columns 3 to 6 of Table 19.

Combining those certified by NEEC and IBOA, 204 individuals received certification for the first time and savings were retired for 106 certificants in 2012. In all, NEEC and IBOA together have certified 2,147 individuals since 1997, of whom 1,350 are currently active.

Table 20: Market Status of Active Certified Building Operators

Year	NEEC[1]					IBOA			Combined Total		
	Annual New		Annual Retired		Total Active	Annual New	Annual Retired	Total Active	Annual New	Annual Retired	Total Active
	BOC	BOC-E	BOC	BOC-E							
1997	1	0	0	0	1	2	0	2	3	0	3
1998	46	0	0	0	47	12	0	14	58	0	61
1999	121	0	0	0	168	22	0	36	143	0	204
2000	125	0	0	0	293	21	0	57	146	0	350
2001	96	0	0	0	389	9	0	66	105	0	455
2002	148	0	0	0	537	42	0	108	190	0	645
2003	104	0	0	0	641	60	1	167	164	1	808
2004	58	0	0	0	699	35	3	199	93	3	898
2005	115	0	79	0	735	30	9	220	145	88	955
2006	79	0	79	0	735	26	11	235	105	90	970
2007	90	0	72	0	753	4	13	226	94	85	979
2008	142	0	88	0	807	73	22	277	215	110	1084
2009	77	0	72	0	812	52	32	297	129	104	1109
2010	109	0	56	0	865	66	23	340	175	79	1205
2011	152	0	95	0	922	26	36	330	178	131	1252
2012	87	92	73	0	1028	25	33	322	204	106	1350
Total	**1550**	**92**	**614**	**0**	**1028**	**505**	**183**	**322**	**2147**	**797**	**1350**

1 Annual New= building operators certified in that year. Annual Retired = building operators that did not receive a new certification or renewal within the previous five years. Total Active (present year) = Total Active (previous year) + Annual New – Annual Retired. All 1997-2011 Annual New and Retired counts are from the 2011 LTMT report and 2012 counts are from the NEEC and IBOA databases. All Annual New and Annual Retired values in these columns are from our recent analyses of the NEEC database (columns 5-7 in Table 17).

D APPENDIX D: MARKET CHARACTERIZATION MEMO

MEMORANDUM

To: Rita Siong, NEEA

From: Marjorie McRae, Ryan Bliss, Michelle Levy Bruchs, and Jordan Folks, Research Into Action

Date: April 18, 2013

Re: BOC Expansion: 2013 Market Characterization

This memo provides a characterization of the current (early 2013) Northwest market for Building Operator Certification (BOC). BOC is a program intended to educate, train, and certify facility operators to perform energy-efficient operations and maintenance (O&M) in commercial buildings. Following a brief history of the BOC "product," we:

- Discuss the building operator market size and the penetration of BOC into that market
- Summarize available information on BOC training providers and accreditation
- Summarize available information on building operations best practices
- Offer a "snapshot" of BOC certificants that covers certificant and facility characteristics, perceived value of BOC training, renewal awareness, perceptions of factors affecting interest in training, and awareness of and attitudes toward alternatives to BOC training

In addition to drawing on our review of NEEA documentation on market size and penetration, this memo draws on findings from our survey of BOC certificants, interviews we conducted with eight market informants who are knowledgeable about the regional building operation market, information gathered from other entities that provide building-related training and certification, and other publicly available sources. The market informants included building supervisors, utility staff, instructors of BOC courses, and members of the national BOC advisory committee among other credentials.

Brief History of BOC "Product"

From 1997 to 2003, NEEA funded the Building Operator Certification Program (BOC) to provide education, training, and certification of facility operators to perform energy efficient

O&M in commercial buildings. NEEA's original funding for BOC saw the initiative to maturity, with the Northwest Energy Efficiency Council (NEEC) and the International Building Operators Association (IBOA) offering BOC as self-supporting ventures since 2000. As of 2001, BOC had achieved market awareness over 50% among building employers and operators.[22]

Then, in 2012, NEEA aimed to accelerate adoption of BOC and increase market penetration of commercial building operators who are BOC certified in the Northwest. This new effort, titled BOC Expansion (BOC-E), seeks to address the following six market barriers:

1. Lack of time
2. Ability to pay (Unemployed operators and Veterans)
3. Lack of service in underserved markets
4. Lack of awareness (among International Union of Operating Engineers (IUOE) and WorkSource)
5. Product Performance (does not meet the ANSI 17024 Standard for certification of personnel)
6. Lack of awareness (About renewal and among utilities)

Estimated Building Operator Market Size

NEEA currently estimates there are 5,856 building operators in NEEA territory.[23] This estimate uses the total area of buildings assumed to have building operators[24] divided by an estimate of the mean amount of building space per operator (286,000 square feet) times 100% for buildings of at least 100,000 square feet or times 50% for smaller buildings.[25] The multiplication by 100% or 50% is based on the assumption that all larger buildings have operators but that smaller buildings do not necessarily have their own operators.

---

22 *Market Progress Evaluation Report: Regional Building Operator Certification, No. 7*. Prepared by Research Into Action, Inc. for Northwest Energy Efficiency Alliance. Report #E01-088. September, 2001.

23 *Projected Market Size for Building Operator Certification Training in the Northwest*. Memorandum prepared for the Northwest Energy Efficiency Alliance by Navigant Consulting, September 26, 2011.

24 *Northwest Commercial Stock Building Assessment: Final Report.* Prepared for Northwest Energy Efficiency Alliance by The Cadmus Group Inc. December 21, 2009.

25 *Long-Term Monitoring and Tracking Report on 2011 Activities (Report #E12-239).* Prepared for Northwest Energy Efficiency Alliance by Navigant Consulting, Inc., July 23, 2012. Available at: *http://neea.org/docs/reports/long-term-monitoring-and-tracking-report-on-2011-activities.pdf?sfvrsn=16*. Last accessed Jan. 14, 2013.

While the methodology, described above, to estimate number of operators from mean buildings size per operator was sound, there are several reasons to reconsider the result:

- The estimate of 286,000 square feet per operator is based on the mean facility size per BOC operator, which may not represent the mean for the overall operator population.
- The assumptions that 100% of buildings of at least 100,000 square feet and 50% of buildings smaller than that have an in-house operator may not be accurate.
- Other sources, including U.S. Census data and market informants' estimates of BOC penetration into the building operator market, suggest a building operator population that well exceeds 6,000.
- The current NEEA estimate does not consider other factors, such as recent economic growth and the inclusion of outsourced operations capabilities.

We address each of these issues in turn, and then we describe our method of calculating the number of building operators in the market size and the result of that calculation.

Square Feet per Operator

The estimate of 286,000 square feet per operator appears to have come from an analysis of the national BOC database, which records information only for BOC-certified operators, not all operators. The facility sizes reported by BOC operators are much larger, on average, than for the region as a whole (see section *Snapshot of BOC Certificants*, below). Therefore, we cannot assume that data from the BOC population is necessarily representative of the larger population. The potential lack of representativeness may be exacerbated by the fact that a relatively small percentage of records in the database had facility size information: the original document that reports the 286,000 figure speaks of "hundreds" of records with facility size information, out of a database of thousands of records, total.[26]

Moreover, the methodology appears to divide the square footage for a given facility by *the number of BOC operators* – not the total number of operators, BOC and other – for that facility. Since the purpose of this exercise is to estimate the entire population of operators – BOC and other – from the mean square footage per operator, using a mean square footage based only on the number of BOC operators in a facility (where it is reasonable to expect that there are additional, non-BOC operators), is not appropriate.

[26] *Long-Term Monitoring and Tracking Report on 2008 Activities (Report #E09-207).* Prepared for Northwest Energy Efficiency Alliance by Summit Blue Consulting. LLC, July 8, 2008.

Estimate of Percentage of Facilities with Operators

NEEA currently assumes that 100% of buildings above 100,000 square feet, and 50% of those below that size, have in-house building operators. The source for this appears to be a memo from a prior evaluator that states that certification for as many building operators in buildings smaller than 100,000 square feet is not economically feasible, and therefore *assumes* that buildings in the >5,000 up to 99,000 square feet tier have "*about half the number of building operators*" of all larger buildings (emphasis added).[27]

The assertion that the smaller tier has *half the number of building operators* as the larger tier means that one-third of all operators are in the smaller tier and two-thirds are in the larger tier, not that 50% of buildings in the smaller tier have in-house building operators. Because the smaller tier has vastly more buildings than the larger tier, the number of operators in the smaller tier is divided over a much larger number of buildings than the number of operators in the larger tier.

Taking the current NEEA ACE Model assumption of 5,856 operators in the market, if the smaller tier has half as many as the larger tier, then 1,952 are in the smaller tier and 3,904 are in the larger tier. From CBSA, we calculate that there are about 3,300 buildings in the larger tier and about 48,000 in the smaller tier.[28] By dividing the number of operators by the estimated number of buildings in each tier, we get means of about 1.2 and .04 operators per building in the larger and smaller tiers, respectively. Therefore, it is possible for all buildings in the larger tier to have at least one operator. Assuming a maximum of one operator per building in the smaller tier, then 4% of buildings in the smaller tier have operators, not 50%. Starting with an overall population of 9,000 operators yields 1.8 and .06 operators per building in the two tiers.

The idea that 4% to possibly 6% of buildings in the smaller tier have in-house operators is consistent with the opinions of the market experts we interviewed for this evaluation. Those who had an opinion about the proportion of commercial space with in-house O&M staff suggested lower percentages than the NEEA assumptions (100% of buildings at least 100,000 square feet and 50% of smaller buildings). The informant with the most explicit estimate suggested that one-quarter to one-third of buildings over 50,000 square feet and substantially less than 10% of smaller ones have internal operations staff.

---

[27] *Projected Market Size for Building Operator Certification Training in the Northwest*. Memorandum prepared for the Northwest Energy Efficiency Alliance by Navigant Consulting, September 26, 2011.

[28] Table C-GB1 of the CBSA shows the total floor area by building type, and Table C-GB2 shows percentage of floor space of each building type by size tier. From these two sets of figures, we could calculate the total floor space by size tier for each building type. To estimate the number of buildings in a given tier, we divided the total floor space for each tier by the presumed mean value values for that size tier. The presumed mean values were not the midpoint, nor were they the same for each tier; rather, we chose a different value for each tier to approximate the skewed distribution of building size across all tiers. In practice, the results of the above are relatively insensitive to the presumed mean value of each tier.

Another source for this issue is a survey of building operator supervisors that Research into Action conducted for the BOC Initiative's 2001 MPER #7.[29] That survey produced an estimate of 5,128 facilities with in-house O&M staff in the region. If the figure of 5,128 includes all of the 3,300 buildings 100,000 square feet or larger, that leaves 1,828 other facilities with in-house O&M staff. Again, that calculates to about 4% of the total number of buildings in the >5,000 to 99,000 square feet. Even if only 75% of the buildings in the larger tier have in-house operators (consistent with market informant statements that many buildings now outsource O&M), that would mean there are about 2,700 buildings with operators in the small tier – about 6% of the total.

Market Informant Estimates of Market Penetration

It is possible to reason backward from our market informants' estimates of BOC's penetration of the building operator market to an estimate of market size. Three of the eight interviewed informants estimated market penetration – one at about 10%, one at 15%, and one at 15% to 20%. The latter explicitly indicated that this estimate was the percentage of the market that had received certification at any time, not just those currently certified. Together, NEEC and IBOA have certified 2,147 BOC operators.[30] The NEEC database identifies about 1% of the operators as retired or deceased, but that figure may not be completely up to date. Note that about 5% of operators have asked not to be contacted, some of whom may also be retired or no longer doing building operations work.

If up to 5% of ever-certified NEEC or IBOA operators are deceased or retired from building operations, then there are somewhat more than 2,000 currently employed building operators in the Northwest that ever received certification. Assuming that those operators represent about 15% of the market suggests a market size of more than 13,000 operators. If penetration is as high as 20%, then there are about 10,000 operators in the market. This range is consistent with the estimate we calculated from survey data, as described below.

U.S. Census Data

An alternative source of information on market size comes from the U.S. Census, which provides census counts by occupation. We identified six occupation codes (SOC) that closely match most of the work titles of building O&M staff reported in our survey of building operators (see *Estimate of Percentage of Facilities with Operators*, below). The Census Bureau estimates there

---

[29] *Market Progress Evaluation Report: Regional Building Operator Certification, No. 7. (Report #E01-088).* Prepared for the Northwest Energy Efficiency Alliance by Research Into Action, Inc. September 2001.

[30] *2012 BOC Program Database*. Memorandum prepared for the Northwest Energy Efficiency Alliance by Research Into Action, February 15, 2013.

are nearly 80,000 individuals in Oregon and Washington with those occupations codes (Table 21).[31]

Table 21: Census Totals of Building Operations-Related Occupations in Northwest

SOC CODE	NUMBER IN PACIFIC NORTHWEST
Electricians 6355 (SOC 47-2111)	36,950
Heating, Air Conditioning, and Refrigeration Mechanics and Installers 7315 (SOC 49-9021)	14,390
Maintenance Workers, Machinery 7350 (SOC 49-9043)	1,590
Maintenance and Repair Workers, General 7340 (SOC 49-9071)	21,590
Helpers--Installation, Maintenance, and Repair Workers 7610 (SOC 49-9098)	955
Stationary Engineers and Boiler Operators 8610 (SOC 51-8021)	4,290
Total	**79,765**

We note that the above occupation codes may also cover service providers, production machinery operators, and consultants as well as building operators, although we cannot estimate what proportion of those occupation codes such individuals constitute. We also note, however, that the above codes do not cover all work titles that our survey respondents reported, which also included managers and supervisors.

Interestingly, the aforementioned Research Into Action survey of building operator supervisors estimated a regional total of 92,000 in-house building operators, based on a mean of 17 operators per facility. However, based on the percentage of supervisors who reported they likely would send operators for BOC training (35% to 48%, varying by state) and the mean number they likely would send (about 2 to 3, by state), the Research Into Action estimated 5,765 possible BOC students.

The above underscores the importance of how the "market" is defined – is it all building O&M staff or just those considered likely candidates for BOC training? In this context, it is worth noting that the justification for the assumed percentage of operators in the smaller building tier (see *Estimate of Percentage of Facilities with Operators*, below) was that "the economies of scale are not substantial enough in this smaller building tier *to support certification for as many building operators*" (emphasis added). That is, the memo made no assumption specifically about the number of O&M staff in any sized building, but about the number for whom certification might be economically feasible.

[31] U.S. Census Bureau, 2006-2010 American Community Survey. Table EEO-ALL01R. Detailed Census Occupation by Sex and Race/Ethnicity by Oregon, Washington, Idaho, Montana. Accessed March 7, 2012 at *http://factfinder2.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t*

As described below, our estimate of market size assumes the "market" consists of building O&M staff with certain specific job titles. However, we do not make assumptions about the percentage of staff that supervisors are likely to send to training. Such assumptions may inform estimates of the market penetration that the BOC-E initiative is likely to achieve, but they do not establish the total market size.

Additional Considerations

An additional consideration is that the NEEA estimate of 5,856 operators does not take into account any increase in the number of building operators resulting from economic growth occurring in the past two years.

Finally, the estimate of 5,856 operators would not include outsourced building operations staff that were not dedicated to a facility. Our market informants reported a growing trend toward outsourcing building operations capability, with informants estimating that anywhere from 25% to 75% of facilities completely outsource their building operations staff. One informant estimated that no more than 2% of the staff of building operations service firms have the BOC credential. Moreover, only 1% of BOC certificants in the NEEC database identified their company type as "facility services." These data together suggest that facility service providers may represent an important – and as yet not-well-quantified – portion of the building operator market.

Estimated Square Feet per Operator from BOC Certificant Survey

In our survey of 329 BOC certificants, we obtained data on both facility size and the number of operators (BOC and other) employed there. We used this figure to estimate total size of the building operator market in buildings of at least 100,000 square feet. As detailed below, we estimated the number of operators in smaller buildings based on an estimated percentage of buildings in that tier with operators.

Survey Data Used

The survey solicited data on facility size and the total number of building O&M staff employed there. The survey asked each respondent to confirm the square footage from BOC database, if available, or to provide the square footage.[32]

To assess number of building O&M staff, the survey first asked respondents, "About how many building O&M staff work at your facility in total, including both line and supervisory staff?" The survey then asked respondents to "list the kinds of building operators at your facility, starting

[32] The survey also asked respondents how much of the facility was conditioned, but respondents were not consistently able to provide information on this.

with the most senior." For each job title, the survey asked respondents to indicate the number of operators with that title, whether *any* of those operators have the BOC credential, what their main responsibilities are, and what percentage of the facility's area their responsibilities cover.

Respondents identified a wide variety of job titles. We coded those titles into 11 categories. Most of the categories, representing 91% of the reported staff, likely represented the BOC market. Those were:

- Manager (O&M): Managers explicitly with technical, mechanical or operational responsibilities.
- Manager (General): Manager with no explicit reference to technical, mechanical or operational responsibilities.
- Supervisor, Coordinator, Assistant Manager
- Professional: Engineers, electricians, and similar specialized professions.
- Technical / Mechanical: Refers to mechanical, maintenance, or technical staff or to specific energy-using systems.
- Custodial Manager or Supervisor.
- Custodial.

Other categories of job titles did not clearly represent the types of workers likely to be part of the BOC market. These include general office staff, skilled labor that does not typically relate to energy-using equipment (e.g., painters and carpenters), unskilled labor (e.g., janitorial), and miscellaneous other. We included the former group of staff categories in the counts of operators per facility and excluded the latter group.[33]

Calculation of Facility-Level Data in the Sample

We did not exclude multiple BOC certificants from the same facility from taking the survey. The 329 survey responses represented 240 separate facilities. Three-quarters of the facilities had a sole respondent, while the remaining facilities had from two to nine respondents. To allow us to extrapolate from a sample mean to the population of all applicable regional building space, each facility in the sample should count as one data point in the sample mean. Therefore, for each facility with multiple respondents, we calculated the mean facility size (square feet) and number of operators from all the responses for that facility.[34]

---

[33] We describe how we handled survey data in greater detail in *Facility Characteristics*, below.

[34] In calculating means, we excluded six cases for which either the reported square footage or the reported number of operators represented a statistical outlier. Because of the large sample size, we defined statistical

Although nearly all respondents reported total counts of O&M staff, about two-fifths of respondents, representing about one-third of the facilities, did not provide details about specific job titles. Therefore, we could not directly calculate the number of operators that likely represent the BOC market for those facilities.

Excluding those facilities from analysis would significantly reduce the sample size, especially for larger facilities. Therefore, for those facilities we estimated the number operators in the BOC market from the total number of O&M staff with the following approach:

- For respondents that reported both total number of O&M staff and counts of operators by job title, we first divided the number of operators with titles that likely represent the BOC market ("included" operators) by the total count of O&M staff.
- We then applied the resulting proportion to the total O&M staff counts for respondents who did not report counts by operator title.
- However, to ensure that we did not undercount the number of operators for any facilities, we also calculated the total number of BOC certified operators for each facility: if that total exceeded the estimated total of "included" operators, we used it instead of the estimated value.

This approach is justified by the fact that respondents that did and did not report job titles reported nearly identical total square feet of facility space per O&M staff member (70,317 and 70,507). Therefore, the ratio of total O&M staff to "included" operators likely is similar for both groups.

Even replacing missing data with the above approach, 21 of the 240 facilities did not have any data for facility size, number of operators, or both. We calculated square footage per operator for each of the remaining 219 facilities (164 facilities with a single respondent and 55 with multiple respondents). We excluded two of those cases as statistical outliers.[35]

outlier as a case that exceeds the mean value by at least 3.1 standard deviations, which would include 0.1% of the expected distribution.

[35] The calculated square footage per operator for those cases were, respectively, 9,300,000 and 10,000,000 square feet per operator and exceeded the mean for all cases by at least 3.1 standard deviations (SDs). Both cases had a single respondent, neither reported the number of maintenance and outreach staff, and both were the only BOC operator for their facility. Therefore, in both cases, the calculation of square feet per operator had only one operator as the denominator.

Extrapolation to the Population and Estimation of Number of Operators

Our sample represented a higher proportion of large facilities relative to the region as a whole (Table 22).[36] In particular, a relatively small percentage of the facilities in our sample – and a very small percentage of the total square footage represented – was in the size tier below 100,000 square feet, while that tier constitutes most of the regional facilities and square footage.

Table 22: Comparison of Sample to Regional Population

Facility Size (Square Feet)	Number of Facilities in Sample	Percentage of Facilities		Percentage of Total Area	
		Sample	Region (CBSA)*	Sample	Region (CBSA)*
< 100,000	34	16%	94%	1%	63%
100,000 to 500,000	81	37%	6%	8%	32%
≥ 500,000	102	47%	0%	91%	5%
Total (Excludes Outliers)	**206**	**100%**	**100%**	**100%**	**100%**

* The denominators for the regional percentages are the total count and total square footage of buildings at least 20,000 square feet. We estimated number of regional buildings as described in Estimate of Percentage of Facilities with Operators, above.

The large disparity between the sample and regional population in the under-100,000-square-feet tier made it unfeasible to include that tier in our extrapolation from the sample. In other words, we could only accurately estimate the mean square footage per operator – and, hence, the mean number of operators – for buildings of at least 100,000 square feet. Following the discussion in *Estimate of Percentage of Facilities with Operators*, above, we estimated the number of operators in the smaller tier based on the assumption that 5% of the buildings in that tier have a mean of one operator.

Even in the above-100,000-square-foot tier, our sample had relatively larger buildings than the regional population. To extrapolate in that tier from the sample to the population, we applied data weights to the calculated square footage per operator for each facility in that tier. We calculated data weights for two sub-tiers: (1) 100,000 to 500,000 square feet; and (2) more than 500,000 square feet. We calculated each sub-tier weight as the percentage of regional buildings in that sub-tier (out of all buildings at least 100,000 square feet) divided by the percentage of the sample in that sub-tier. Table 23 shows the resulting weights.

[36] *Northwest Commercial Building Stock Assessment: Final Report.* Prepared by The Cadmus Group, Inc. for the Northwest Energy Efficiency Alliance, December 21, 2009. This excludes groceries and restaurants, which typically use different mechanisms than building operators for building operations savings. Source: ACE Model, *Market* tab.

Table 23: Calculation of Weights for Square Footage per Operator, Buildings At Least 100,000 Square Feet

Facility Size (Square Feet)	Number of Facilities in Sample	Percent of Facilities Sample	Percent of Buildings in Region (CBSA)	Weight
100,000 to 500,000	81	44%	97%	2.20
500,000	102	56%	3%	0.05
Total	**183**	**100%**	**100%**	**n/a**

The above methods produced a weighted mean value of 72,935 square feet per included operator in buildings of at least 100,000 square feet. To estimate the number of operators in buildings of at least 100,000 square feet, we divided that figure into the total square footage of buildings expected to have operators in that size tier. Following the discussion in *Estimate of Percentage of Facilities with Operators*, above, we assumed that no more than 75% of buildings in the larger tier have in-house operators. This produced an estimate of 7,609 operators in that tier.

Assuming that 5% *of buildings* at least 5,000 and less than 100,000 square feet in size have operators, with an average of one operator per building, and 48,217 buildings in that tier,[37] we estimated 2,411 operators the small tier. Together, these produced a total of 10,020 operators (Table 24).

Table 24: Calculation of Number of Operators in Market

Facility Size (Square Feet)	Total Square Footage in Tier	Estimated Number of Buildings in Tier	Method Used to Estimate Number of Operators in Tier	Number of Operators
5,000 to 99,999	1,196,328,500	48,217	5% of buildings, mean of one operator per building	2,411
≥ 100,000	740,478,400	3,289	72,935 square feet per operator, 75% of square footage has operators	7,609
Total	**1,936,806,900**	**51,505**	**n/a**	**10,020**

Note that the above estimated number of regional building operators may not capture all outsourced building operations staff. Fifteen of the operators in the NEEC BOC database identified their company type as "facility services." Assuming roughly the same proportion in the IBOA population, we might assume 20 BOC operators in that sector regionally. Market informants estimated BOC penetration to be less than 2% in the facility services sector.

[37] Again, we based this estimate on methods described above, in *Estimate of Percentage of Facilities with Operators*.

Extrapolating from those figures, we estimate about 1,000 building operators in the regional facility services sector.

Estimated BOC Penetration into the Building Operator Market

If NEEA's current regional estimate of 5,856 building operators is correct, then our regional estimate of 2,000 currently employed BOC certificants (see *Market Informant Estimates of Market Penetration*, above) would yield a penetration rate of about 34%. However, we have estimated a larger market size of about 10,020 operators, which yields a penetration rate of about 20% percent. This is closer to our market informants' estimated penetration of about 15%.

BOC Training – Providers and Accreditation

In the four northwest states, the following organizations provide BOC training:

- NEEC (Washington)
- Northwest Energy Education Institute (Oregon)
- IBOA (Idaho and Montana)

The following eight organizations accredit BOC as an approved means of continuing education:

- BOMI
- US Green Building Council (USGBC)
- American Hotel and Lodging Educational Institute
- National Association of Power Engineers (NAPE)
- California State University (CSU)
- University of Maine
- National School Plant Management Association (NSPMA)
- California State Employees Trades Council (SETC)

As part of the BOC-Expansion initiative, NEEC aims to broaden BOC's reach by forming new partnerships. In 2013, NEEC made the International Union of Operating Engineers (IUOE) an "approved provider" of BOC training. With this partnership, IUOE will train its members with its own curriculum, which BOC has approved, but NEEC would still provide certification to graduates of the IUOE training.

Non-BOC Training in the Market

Other training opportunities exist for building operators, beyond the BOC curriculum. These fall into five main categories:

1. Community College degree programs
2. Trade/technical schools
3. Coursework eligible for Continuing Education Units (CEUs)
4. Professional Association Certification Programs
5. United States Department of Energy

Community College

In the Northwest, three notable community colleges offer Associate Degree programs in Energy Management. These are Lane Community College in Eugene, Oregon, Clackamas Community College in Oregon City, Oregon, and Edmonds Community College in Lynnwood, Washington.

Lane Community College

- Offers a 2-year degree program (Associate of Applied Science) in Energy Management
- Prepares students for careers in Energy Management, Resource Conservation Management, and Renewable Energy
- Estimated total cost – $10,000

Edmonds Community College

- Offers two tracks for a 2-year degree program in Energy Management
  - Associate of Technical Arts Degree
  - Associate of Applied Science (transferable to Bachelor degree program)
- Prepares students for careers in Energy Management, Utility company work, community action agency work, and others if students transfer to a Bachelor degree program
- Estimated total cost – $7,000 - $20,000+ depending on state residency and chosen degree track

Note that Edmonds is a BOC Approved Provider. Students who complete their training program are eligible to apply for the BOC certification provided they meet the work experience requirements.

Clackamas Community College

- ➡ Offers two tracks
  - A 1-year certificate in Energy & Resource Management
  - Energy & Resource Management Associate of Applied Science Degree
- ➡ Prepares students with skills to acquire entry-level positions in utility, energy, and resource industries
- ➡ $4,000 - $20,000+ depending on state residency and chosen degree track

Trade/Technical Schools

A variety of technical schools and institutes offer diplomas and coursework in trades supporting building energy management, such as HVAC technician programs. Schools offer courses online or in traditional classroom settings. Many technical schools and colleges now offer online courses.

Continuing Education Hours

BOC certificants may apply Continuing Education Hours through a variety of educational sources toward BOC renewal. One organization in particular, TPC Training Systems (www.tpctraining.com), has a comprehensive training curriculum in building maintenance. Although the curriculum does not lead to a credential and is not focused on efficiency *per se*, the program includes energy efficiency as part of its course load. TPC appears to gear its training toward building operators in the Federal government.

Professional Association Certification Programs

Building operation technicians and managers often seek training through professional organizations. In the past, non-BOC operators[38] as well as current BOC certificants have identified The International Facility Management Association (IFMA), Building Owners and Managers Institute International (BOMI), Construction Industry Technical Council (CITC), the Refrigeration Service Engineers Society (RSES), and the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) as key sources of training.

[38] *Long-Term Monitoring and Tracking Report on 2011 Activities (Report #E12-239).* Prepared for Northwest Energy Efficiency Alliance by Navigant Consulting, Inc., July 23, 2012. Last accessed Jan. 14, 2013 at *http://neea.org/docs/reports/long-term-monitoring-and-tracking-report-on-2011-activities.pdf?sfvrsn=16*.

United States Department of Energy

Finally, as part of President Obama's Better Buildings Initiative, the U.S. Department of Energy and U.S. Department of Commerce are jointly funding three Centers for Building Operations Excellence to create and deploy programs to train current and incoming building operators.[39]

The centers are:

- The Corporation for Manufacturing Excellence in California, partnering with Laney College and the International Union of Operating Engineers Local 39
- Delaware Valley Industrial Resource Center in Pennsylvania, partnering with Pennsylvania State University, Pennsylvania College of Technology, and Drexel University
- NY State Department of Economic Development, partnering with City University of New York and Rochester Institute of Technology

BOC has ongoing relationships with the Centers. The Pennsylvania and New York Centers are BOC licensees and Approved Providers, and BOC is working with the Pennsylvania team to align BOC with building re-tuning, to position BOC to provide foundational training and certification in preparation for building re-tuning.

The program is a pilot, part of a two-year effort to develop a curriculum for building operators built around building re-tuning, which aims to reduce energy usage by 5% to 25%.[40] The curriculum is based on programs developed by the Pacific Northwest National Laboratory and Laney College (which has an HVAC technician program), which was modified to be applicable to building operators.

The format consists of a 40-hour program, of which about half is in the form of classroom lectures, and the remainder is onsite, where operators conduct building tunings. There is also an online follow-up course, which helps operators who have taken the course reevaluate their buildings. The Center in California just began putting its first cohort through the program this month.

---

39 "Energy and Commerce Departments Announce New Centers for Building Operations Excellence." U.S. Department of Energy Press Release. Accessed March 12, 2013 at: *http://energy.gov/articles/energy-and-commerce-departments-announce-new-centers-building-operations-excellence*.

40 Our information comes from personal communication on March 29, 2013, with Kevin O'Brien, a consultant working with the Corporation for Manufacturing Excellence (doing business as Manex Consulting).

Current O&M Best Practices

We asked our panel of market informants whether they were aware of any studies, sources, or reference guides on current, "state-of-the-art" or "best practices" for building operation and maintenance activities. Respondents cited the following sources:

- The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE; https://www.ashrae.org/)
- The Building Owners and Managers Association (BOMA; http://www.boma.org/Pages/default.aspx)
- APPA (formerly the Association of Physical Plant Administrators, now focusing on educational facilities management; http://www.appa.org/)
- The Project Managers Institute (PMI; http://www.pmi.org/)
- The International Facility Management Association (IFMA), "World Workplace" (http://www.worldworkplace.org/)
- The U.S. Department of Energy (DOE; http://energy.gov/)

In general, the informants did not identify specific documents or materials. One cited an Australian study[41] that showed the best way to improve building efficiency is to share the savings with the operator.

In addition to ASHRAE, we identified two other entities that provide building-related training and certification as possible sources of best practices information:

- The Association of Energy Engineers (AEE), which provides the Certified Energy Manager (CEM) and Certified Energy Auditor (CEA) credentials
- The US Green Building Council (USGBC), which provides the certifications for LEED Green Associate and LEED AP

We attempted contacts by telephone and email to seek information on building operations best practices. The ASHRAE contact referred us to the page of the ASHRAE website for its Operations and Performance Management Professional Certification program (*https://www.ashrae.org/opmp*), which includes a related handbook. We were not able to reach contacts for the other two organizations but will continue to try to do so over the course of the evaluation.

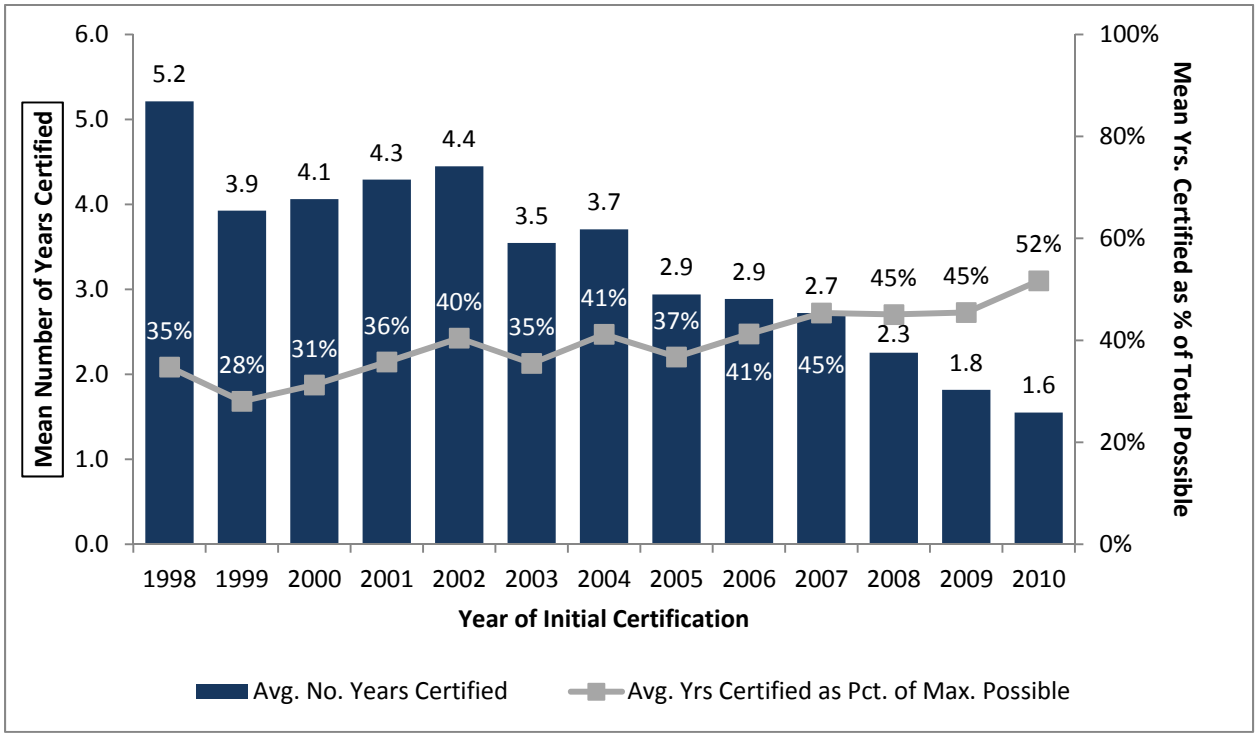
[41] *http://thewarrencentre.org.au/wp-content/uploads/2011/11/LEHR-Research-Survery-Report-Ver-5.2.pdf.*

Certification Renewal Rates

Of 1,329329 Northwest BOC certificants in the NEEC database who received their initial certification in 02010 or earlier (and so could have renewed in 2012), 537753 (57%) have renewed their registration at least once.[42] Certificants often maintain certification beyond a single renewal. Those that have renewed at least once have maintained certification a mean of 5.00 years. However, that figure includes recent certificants that are still certified, many of whom likely will continue certification for several more years.

Figure 7 shows, for each certificant cohort since 1998, the mean certification tenure, as well as the mean tenure as a percentage of the total possible tenure for that cohort. The first trend shows that mean tenures increase as the total possible tenure increases, up to about four years, on average. The second trend shows that the mean tenure typically is about one-third to two-fifths the total possible tenure.

Figure 7: Certification Tenure and Tenure as Percentage of Total Possible Tenure, by Cohort



[42] The NEEC database does not provide consistent and comprehensive information on renewal. However, the database indicates, for each operator, the original date of certification and the last year the operator was still certified. We assume that an operator renewed certification if the latest date of certification is at least two years after the original date of certification.

We sought information on typical renewal rates for comparable certifications. We requested information on renewal from the aforementioned certifying organizations. We received responses from one of the organizations (ASHRAE), reporting first-time renewal rates of 80% or greater (Table 25). It is important to note, however, that ASHRAE and the certifications it provides target professional engineers who may look on them as necessary work credentials. We will continue to attempt to collect data on renewal rates from other, perhaps more directly comparable, entities, such as IFMA.

Table 25: Professional Association Certification Programs

ASSOCIATION	RENEWAL FREQUENCY	RENEWAL RATE
BOC	1 year	51%
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)	3 years	80%
Association of Energy Engineers (AEE)	3 years	Unavailable
US Green Building Council (USGBC)	2 years	Unavailable

Snapshot of BOC Certificants

As part of our overall effort to provide feedback on the BOC-E initiative, we conducted a survey of BOC certificants. In addition to gathering information about certificants' O&M practices (needed to estimate BOC-related savings), the survey collected data on certificants and their workplace characteristics to inform our understanding of the building operator market. This memo includes survey results from 329 respondents who took the survey.

Results cover several topics:

- Facility characteristics (size and ownership)
- The organization of building operation staff
- The value of BOC training to employers and certificants
- Respondents' perceptions of existing barriers to BOC training and the possible impacts of course changes on attendance
- Respondents' knowledge of and interest in alternatives to BOC training

The following subsections summarize the interim survey results for each of the above topics. Not all of the survey respondents answered all survey questions. Therefore, sample sizes for the various analyses vary. For each analysis, we identify the survey question(s) that generated the data and the number of survey respondents that answered the question(s).

Facility Characteristics

The NEEC database of BOC certificants reports facility size for about 25% of the records. For those cases, we asked respondents to verify or correct the information in the database. We asked all other respondents to report the size of their facility (or facilities, if they were responsible for multiple facilities). For 157 of the 329 (48%) survey respondents, the database provided facility size, and 129 (82%) of those confirmed that information. Of the 28 who did not confirm the database value, 14 reported a greater value, 1 reported a lower value, and 11 did not know the value. In cases where the respondent did not know the value, we used the database value.

The 329 survey responses represented 240 separate facilities: three-quarters of the facilities had a sole respondent, and the remaining quarter had from two to nine respondents. Table 26 shows the distribution of respondents and of facilities across the facility size categories.[43] Nearly half the respondents and facilities were in the upper two size categories (more than 500,000 square feet).

Table 26: Distribution of Facility Size

	Respondents and Facilities in Each Size Category			
	Respondents (*n* = 329)		Facilities (*n* = 240)	
Facility Size (Square Feet)	Count	Percent	Count	Percent
Up to 50,000	18	5%	13	5%
More than 50,000 up to 100,000	31	9%	24	10%
More than 100,000 up to 250,000	55	17%	46	19%
More than 250,000 up to 500,000	57	17%	39	16%
More than 500,000 up to 1 million	48	15%	36	15%
More than 1 million	78	24%	61	25%
Don't know	42	13%	21	9%
Total	**329**	**100%**	**240**	**100%**

Survey Questions:
Program BOC records show that your facility has [input SF] square feet of space. Is this accurate?
How many square feet of space does your facility have?

We compared the distribution of facility size from surveyed respondents to the distribution found in the CBSA.[44] As Table 27 shows, the distribution of facility size among BOC certificants differs markedly from that in the CBSA: half of the BOC respondents' total facility area was in

[43] For facilities with multiple respondents, we took the mean reported facility size across the multiple respondents.

[44] To be consistent with the current NEEA ACE model, we excluded grocery and restaurant facilities, as they do not typically employ building operators.

facilities at least one-half million square feet in size, while half of the total building are in the CBSA is in facilities 50,000 square feet or smaller.

Table 27: Distribution of Total Facility Size in BOC Survey Sample and CBSA

Size Range	BOC Survey (n = 219)[1]	CBSA	
		Total Square Footage (MSF)	Percentage of Total
Up to 50,000	6%	1,066	50%
50,001 to 100,000	11%	327	15%
100,001 to 500,000	39%	640	30%
More than 500,000	44%	101	5%

1 The denominator for these percentages is the number of facilities for which we could compute facility size. Computing similar percentages for respondents rather than facilities gives the exact same values.

A large majority (86%) of respondents reported that their company either owns the entire facility they work in (83%) or owns part and leases part (3%).

Organization of O&M Staff

We asked survey respondents about the building operation staff employed at their facility. We first asked for the total count of "building operations and maintenance staff," including both line and supervisory staff. We then asked respondents to list all the titles of "building operators" at their facility, how many of each type of building operator there were, who they reported to, and whether any (for any given title) had BOC certification.

Respondents reported a mean of 28 building O&M staff, but the distribution was highly skewed, with more than half reporting 10 or fewer and three-quarters reporting no more than 25. However, two-thirds of all O&M staff are in facilities with more than 50 staff.

About one-third of respondents (n = 126) did not report specific operator titles. For those that did (n = 203), we coded the job titles into several categories. As Table 28 shows, most of the categories, and 91% of the staff, likely represented the BOC market. However, several categories, and about 9% of the staff, did not clearly represent the types of workers likely to be part of the BOC market. We included the former group of staff categories ("included" operators) in the counts of operators per facility and excluded the latter group. Thus, the following analyses and discussion focus on the "included" operators.

Table 28: Coded Job Title Categories

Job Title Category	Description	Percent of O&M Staff
Titles Likely Representing BOC Market – Included in Counts of Operators		
Technical / Mechanical	Includes the terms mechanic, maintenance, or technical or referring to specific energy-using systems, but do not indicate a management or custodial position.	34%
Custodial	Includes the term custodian or custodial but do not indicate a management position.	26%
Professional	Engineers, electricians, and similar high-skilled professional positions	16%
Manager (O&M)	Includes the terms manager, director, lead, or similar and also specifically indicated technical or mechanical responsibilities.	6%
Custodial Manager or Supervisor	Includes the terms manager, director, lead, supervisor, coordinator or similar, with respect to custodial staff or duties.	5%
Supervisor, Coordinator, Assistant Manager	Includes the terms supervisor, coordinator, assistant manager or similar and not otherwise classified	3%
Manager (General)	Includes the terms manager, director, lead, or similar and not otherwise classified	3%
Subtotal		*91%*
Titles Not Likely Representing BOC Market – Excluded from Counts of Operators		
Unskilled Labor	Refers to floor staff, grounds staff, labor, or similar	4%
Other Skilled Labor	Refers to skilled labor (painters, carpenters, etc.) that do not obviously operate or maintain energy-using equipment.	3%
Office	Refers to administrative, support, or bookkeeping.	1%
Other	Miscellaneous and not codeable.	1%
Subtotal		*9%*
Total		**100%**

Survey Question: "[P]lease list the kinds of building operators at your facility, starting with the most senior. For each type, please record a general job title …."

The two-thirds of the sample who did report such counts reported a mean of 14 building operators, compared to a mean of 25 total O&M staff. As Table 29 shows, most respondents (71%) were from facilities with 10 or fewer operators, but 76% of the total count of included operators were in facilities with more than 10 of them.

Table 29: Number of "Included" Building Operators (*n* = 203)

Number of Operators at Respondent's Facility	Respondents Reporting Each Number		Number of Operators at Facilities	
	Count	Percent	Sum	Percent
One or Two Operators	28	14%	48	2%
Three to Five Operators	68	33%	264	9%
Six to 10 Operators	49	24%	355	13%
11 to 25 Operators	38	19%	551	20%
26 to 50 Operators	12	6%	378	14%
51 to 100 Operators	4	2%	289	10%
101 to 500 Operators	4	2%	905	32%
Total	**203**	**100%**	**2,789**	**100%**

Survey Question: "[P]lease list the kinds of building operators at your facility, starting with the most senior. For each type, please record a general job title; tell us how many operators have that title…."

Both the reported total count of all O&M staff and of building operators correlated with the reported facility size (total O&M staff, $r = .47$, operators, $r = .22$; $p < .005$, both correlations). In other words, the larger the facility, the more O&M staff in general and the more type of staff that respondents identified by title.

However, as Table 30 shows, the relationship is not strictly linear. As facility size increases, the mean amount of facility space per O&M staff or per operator also increased. In other words, as facility size increases, the number of staff needed per amount of area decreases, suggesting possible efficiency gains.

Table 30: Relationship between Facility Size and Square Footage per Staff

Facility Size (Square Feet) [1]	All O&M Staff (*n* = 266) [2]		"Included" Operators (*n* = 179) [3]	
	Count	Mean Square Footage per	Count	Mean Square Footage per
Up to 100,000	47	26,992	30	18,560
More than 100,000 up to 250,000	52	45,250	36	48,838
More than 250,000 up to 500,000	55	86,947	37	92,300
More than 500,000 up to 1,000,000	46	72,657	34	104,674
More than 1,000,000	66	105,686	42	255,365

1 The size difference between tiers is not constant. The increase in square footage per operator, relative to the increase in facility size, appears to be relatively constant across tiers.

2 Survey Question: "About how many building operations and maintenance staff work at your facility in total, including both line and supervisory staff?"

3 Survey Question: "[P]lease list the kinds of building operators at your facility, starting with the most senior. For each type, please record a general job title; tell us how many operators have that title…."

Table 31 shows that, among the 203 respondents who provided details on staff by job title, technical/mechanical workers were the most common type of operators, followed by technical professionals and management and supervisory staff. Respondents were most likely to say that technical professionals and the custodial managers and supervisors included BOC-certified operators – two-thirds of the respondents who identified those types of job titles said that at least one person with that title had the BOC credential. At least half of the respondents who identified other types of managers and general technical/mechanical staff reported at least one BOC operator with those types of title.

Table 31: Reported Building Operator Categories (*n* = 203; Multiple Responses Allowed)

	Respondents Reporting Job Category		Respondents Reporting At Least One Has BOC	
Job Category	Count	Percent1	Count	Percent[2]
Technical / Mechanical	143	70%	80	56%
Professional	84	41%	56	67%
Manager (O&M)	66	33%	38	58%
Supervisor, Coordinator, Assistant Manager	57	28%	31	54%
Manager (General)	35	17%	15	43%
Custodial	32	16%	7	22%
Custodial Manager or Supervisor	12	6%	8	67%

Survey Question: "[P]lease list the kinds of building operators at your facility, starting with the most senior. For each type, please record a general job title, tell us how many operators have that title, … whether any of them have the BOC credential, …."

1 Percentage of all respondents (n = 329)

2 Percentage of respondents reporting the job title. For example, 144 respondents reported job titles that we categorized as 'Technical, Mechanical'; of those, 80 (56%) reported that at least one staff member with that title had BOC.

We also examined the mean and total number of operators by category (Table 32Table 32). The "technical/mechanical" and "professional" categories remain the most numerous. However, while only 10% of respondents reported staff with custodial titles, this was the third most numerous category in terms of total number of operators. That is because the mean number of custodial staff, among those who reported custodial titles, was much larger than for other types of staff identified (see Table 32, second data column).

Table 32: Mean and Total Number of O&M Staff in Reported Building Operator Categories[1]

Job Category	Number of Respondents Identifying Title (*n* = 203)	Mean Number Reported, Among those Identifying title[2]	Total Number of Staff with Title (*n* = 2,244)	Percent of All Staff Identified (*n* = 2,244)
Technical / Mechanical	143	5.4	770	34.3%
Professional	84	5.6	474	21.1%
Custodial	32	13.4	430	19.1%
Manager (O&M)	66	1.7	112	5.0%
Supervisor, Coord., Asst. Mgr.	57	1.4	82	3.6%
Manager (General)	35	2.2	76	3.4%
Custodial Mgr. or Supervisor	12	4.3	52	2.3%

Survey Question: "[P]lease list the kinds of building operators at your facility, starting with the most senior. For each type, please record a general job title; tell us how many operators have that title…."

1 We excluded two respondents who reported counts of O&M staff that were statistical outliers. Given the large study sample, we defined a statistical outlier as a value that exceeded the sample mean by at least 3.1 standard deviations, which would include 0.1% of the expected distribution.

2 The sample size for each mean is the total number of respondents identifying the title, shown in the column to the left.

To explore why those who identified custodial titles reported so many of them, we examined whether those respondents represented larger or different types of facilities than those that did not report custodial staff. On average, those that did and did not report custodial staff reported similar total counts of O&M staff (19 vs. 21) and reported similar facility sizes (924,427 vs. 866,838 square feet). However, we found that respondents from K-12 Schools accounted for a much larger percentage of the total reported custodial staff (86%) relative to their percentage of all O&M staff (35%).[45]

We followed up on this finding by exploring whether other operator types were more or less likely to be associated with some employer types than others. For each respondent, we calculated the number of each operator type as a percentage of the total count of operators identified. We then calculated the mean percentages for each employer type. We used bivariate regression to analyze the relationship between company type and operator type. This analysis showed, for each employer type, whether the percentage of each operator type was higher or lower than would be expected if operator type were not associated with employer type.

[45] We identified the employer type for each survey respondent from the BOC database.

Table 33 shows the mean percentages that deviated from the expected levels (at $p < .05$). Relative to expected percentages, colleges used more managers; health care and property management firms used more professional staff (engineers and electricians) and fewer general technical/mechanical staff; government and municipality facilities used more general technical/mechanical staff and municipalities used fewer professionals; and, as noted above, K-12 schools used more custodial staff but also used relatively fewer professional staff.

Table 33: Association of Operator Types with Employer Types

	PERCENTAGE OF ALL OPERATORS FOR EACH EMPLOYER TYPE[1] BY OPERATOR TYPE[2]					
EMPLOYER TYPE	Manager (O&M)	Manager (Gen'l.)	Profes-sional	Technical / Mechanical	Supervisor	Custodial
College	**21%**	**16%**				
Healthcare			**56%**	*27%*		
Property Mgmt.			**65%**	*21%*		
Municipality			*3%*	**63%**		
Government				**68%**		
K-12 School			*5%*			**37%**
Across All Types	5%	3%	21%	34%	4%	19%

Survey Question: "[P]lease list the kinds of building operators at your facility, starting with the most senior. For each type, please record a general job title; tell us how many operators have that title…."

1 Employer type is from the BOC database.

2 Percentages in bold font represent operator types that are more likely to be associated with a particular company type, relative to all other company types. Percentages in italic font represent operator types that are less likely to be associated with a particular company type, relative to all other company types. All values are significant at $p < .05$. We do not show percentages that do not depart from expected values. This table does not show the "custodial manager or supervisor" operator type, which showed minimal deviation from expected percentages.

The results of such analyses may provide information useful to BOC's planning and marketing activities. For example, they may allow BOC to tailor training modules to the types of expected attendees, based on the attendees' employer types.

Finally, for each job category described, we asked respondents the title of the person those persons reported to. As expected, respondents tended to give managerial or supervisory titles when identifying whom the operation staff reported to (Table 34). These responses are consistent with the descriptions that market informants gave of hierarchies among building operators.

Table 34: Supervisory Job Categories (*n* = 203; Multiple Responses Allowed)

Job Category	Count and Percent of Respondents Identifying Staff Reporting to Each Job Category	
	Count	Percent
Officer	38	19%
Director	65	32%
Manager	96	47%
Supervisor	112	55%
Technical	13	6%
Custodian	2	1%
Other	29	14%

Survey Question: "[P]lease list the kinds of building operators at your facility, starting with the most senior. For each type, please record a general job title; tell us …who they report to…."

Perceived Value of BOC Training

To get at the perceived value of BOC training, we asked a variety of questions concerning employer requirements and support for certification and certification renewal and whether the respondent would have pursued certification and renewal without such influences. Of the 329 respondents, 215 answered this section of the survey. Results show that employers generally do not require certification but provide important support, without which most respondents would not have gotten certification.

Of the 215 respondents who completed this section, more than three-quarters (78%) said their employer does not require BOC certification for any staff and 5% said they did not know their employer's policy. Of the 36 respondents who said their employer requires certification for at least some employees[46], 33 said the requirement applied to them. About two-thirds (21 of 33) of those respondents said they would have taken the training even if they had not been required to do so.

We also asked whether, and in what ways, the employer supports BOC certification and renewal, even if it does not require it. As Table 35 shows, 93% of respondents reported some type of certification support, most of whom said their employer covers at least some related expenses. In addition, almost three-fourths (72%) of respondents said their employer permits them to take the BOC training during paid work hours. Somewhat fewer respondents also reported support for renewal of certification: somewhat more than half reported that the employer covers some

[46] One of those respondents said the company requires either BOC or completion of TPC courses. TPC is a private organization that provides building/facility maintenance technician training. See: *http://www.tpctraining.com/c-476-facilitybuilding-maintenance-technician.aspx*.

renewal expenses, and just less than half reported that the employer permitted them to take renewal-related continuing education courses during paid work hours. These findings suggest that many employers may perceive less value to renewal than that of initial certification.

Table 35: Employer Support for BOC Certification and Certification Renewal (*n* = 215)

	Count and Percent of Respondents Reporting Each Type of Company Support			
	Certification[1]		Renewal[2]	
Type of Support	Count	Percent	Count	Percent
Encourages BOC Certification/Renewal	201	93%	170	79%
Pays Associated Expenses	174	81%	132	61%
Pays Class or Continuing Education Fees	160	74%	106	49%
Pays Test/Certification/Renewal Fee	129	60%	118	55%
Pays Travel Expenses	101	47%	58	27%
Permits Training During Paid Working Hours	156	73%	104	48%

1 Survey Question: "Which of the following are true of your company? Your company (select all that apply): (1) encourages BOC certification for building O&M staff that do not have certification, (2) pays class fees for initial BOC certification, (3) pays the test/certification fee for initial BOC certification, (4) pays travel expenses associated with initial BOC certification pays other expenses associated with initial BOC certification (please specify), (5) allows you to attend BOC training during paid working hours."

2 Survey Question: "Which of the following are true of your company regarding RENEWAL of BOC certification? Your company (select all that apply): (1) encourages building O&M staff to renew BOC certification, (2) pays fees for continuing education classes for BOC renewal, (3) pays the BOC certification renewal fee, (4) pays travel expenses for continuing education for BOC renewal, (5) pays other expenses associated with BOC renewal (specify), (6) allows you to attend continuing education for BOC renewal during paid working hours."

Of the 174 respondents who said that their employer covered certification-related expenses, only 13% said they still would have gotten BOC certification if those costs had not been covered (66% said they would not have 22% did not know). Of those who reported that their employer gave them paid time off to take the training, just over about one-quarter (23%) said they would have gotten the certification even if they had to do it on their own time. Thus, both employer financial support and provision of paid time off for training are important for encouraging certification.

To further assess the effects of employer support, we examined differences in reported support between those who had and had not ever renewed certification. Certificants who had ever renewed were more likely to report that their employer pays the initial certification and renewal fees and continuing education class fees (Table 36). Thus, employer financial support appears to be associated with greater likelihood of renewal.

Table 36: Employer Financial Support for BOC Certification and Renewal, by Renewal History

Type of Support	Count and Percent of Respondents Reporting Each Type of Company Support, by Renewal History			
	Renewed at Some Point (*n* = 107)		Never Renewed (*n* = 108)	
	Count	Percent	Count	Percent
Pays Initial Test/Certification Fee[1]	73	68%	55	51%
Pays Certification Renewal Fee[2]	72	67%	46	43%
Pays Continuing Education Class Fees[1]	62	58%	44	41%

Note: Same survey questions as for Table 35.

1 Difference between "renewed" and "never renewed" groups is statistically significant at $p = .01$.

2 Difference between "renewed" and "never renewed" groups is statistically significant at $p < .001$.

We also analyzed levels of employer support by whether respondents first received certification within the past five years (2008 or later) or more than five years ago (2007 or earlier). The analyses suggest that general employer support for initial certification has increased over the last several years: more recently certified respondents were significantly more likely to agree that their employer "encourages BOC certification for uncertified O&M staff" (55% vs. 39%; $p = .01$). However, the two groups did not differ significantly in likelihood of reporting that employers provided financial support for certification.

Renewal Awareness

Almost half (49%) of the surveyed certificants had not renewed certification. We asked those respondents if they were aware that maintaining BOC certification requires annual renewal. Of those who provided a response ($n = 103$), most (89%) reported they were aware of the annual renewal requirement, while (11%) were not. Thus, awareness of the renewal requirement is high, but not complete.

Factors Affecting Participation in BOC Training

We asked respondents what they thought were the three largest barriers to getting building operators to participate in BOC training. Respondents could select from a list of options or record a barrier not on the list. About three-fifths of respondents cited employer-related barriers, such as inability to get approval or lack of supervisor support (Table 37). Other common barriers were cost and time or location-related issues, each endorsed by nearly half the respondents. These responses are consistent with the immediately preceding findings that employer support, in the forms of both encouragement and financial assistance, are important.

Table 37: Perceived Barriers to Participation in BOC Training
(*n* = 215; Multiple Responses Allowed)

Barrier	Count and Percent of Respondents Reporting Each Barrier	
	Count	Percent
Employer-Related Barriers	128	60%
Inability To Get Authorization/Approval	67	31%
Staffing Restrictions	64	30%
Lack Of Supervisor Support	51	24%
Time And Location-Related Barriers	98	45%
Not Enough Time	59	27%
Inconvenient Class Schedule	41	19%
Inconvenient Location	12	6%
Cost	93	43%
Lack Of Awareness	58	27%
Other[1]	17	8%
None	16	7%
Don't Know	6	3%

Survey Question: First, what do you think are the three largest barriers to getting building operators to participate in the BOC training?

1 Includes issues with instructors or instruction (4), lack of interest (3), renewal requirements (2), and miscellaneous response (8).

We also investigated whether the perceived barriers were related to when respondents received certification. Those certified in 2007 or earlier were twice as likely as those more recently certified to report inconvenient class schedule as a barrier (27% vs. 13%, $p = .01$), suggesting that class schedules have become less of a barrier over time.

Interestingly, we also observed a marginally significant trend for more recently certified respondents to report lack of awareness as a barrier (32% vs. 20%, $p = .06$). We observed a slight trend for more recent certificants to report cost as a barrier, but the difference did not achieve statistical significance (48% vs. 38%, $p > .10$).

As seen above, many respondents indicated that logistical barriers (inconvenient times and locations) keep building operators from participating in BOC training. To provide feedback on what BOC might do to overcome those barriers, we asked respondents what impact they thought certain changes to course format might have on course attendance. Specifically, we asked about the likely impact of providing online or webinar-based training, offering an intensive eight-day

course, changing the course from one-day-a-month to one-day-a-week, holding 14 to 16 evening or half-day sessions instead of eight full-day session, and holding training on weekends.

Two-thirds of respondents said that the online or webinar-based training would increase attendance (Table 38). Note, however, that the question did not specify whether all or only some sessions would be held online. It is possible that respondents assumed the question referred to a completely online course and would have responded differently to question about a mixed-mode course. Responses indicated that none of the other format changes would likely increase attendance, and in fact they would likely decrease attendance if they had any impact at all.

Table 38: Respondents' Predicted Impacts of Course Format Changes (*n* = 215)

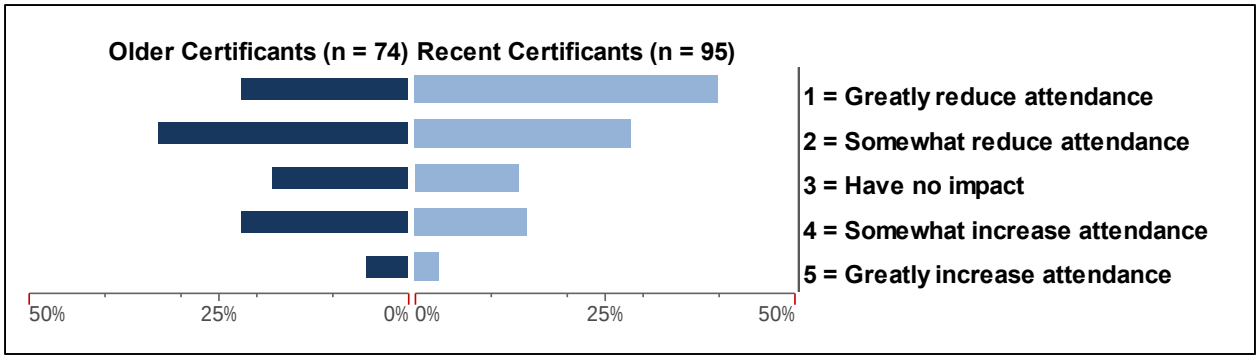
	Percentage Reporting Change Would Reduce, Have No Impact on, or Increase Attendance (1 = Greatly Reduce Attendance to 5 = Greatly Increase Attendance)			
Possible Change in Course Format	Reduce	No Impact	Increase	Don't Know[1]
Provide online or webinar training	12%	7%	67%	14%
Provide intensive Monday-to-Monday course	47%	6%	26%	21%
Change from monthly to weekly sessions	40%	18%	22%	20%
Split courses into 14 to 16 half days	41%	14%	20%	24%
Split the courses into 14 to 16 evening sessions	49%	13%	17%	21%
Have training only on weekends	63%	8%	8%	20%

Survey Question: We'd like your opinion on how some possible changes to the BOC course format might affect attendance. For each of the following possible changes, please select the option that best describes what impact you think it might have: greatly reduce attendance, somewhat reduce attendance, have no impact, somewhat increase attendance, greatly increase attendance.

1 Includes respondents that did not answer the question.

Again, we examined responses separately for respondents who received certification more than five years ago and within the past five years. We found a statistically significant difference for only one of the suggested course format changes. Recent certificants were more likely than other respondents to say that splitting courses into 14 to 16 evening sessions would reduce attendance (p = .015). No other comparisons showed statistically significant differences.

Figure 8: Perceived Impact of Splitting Courses into 14 to 16 Evening Sessions, among Older and Recent Certificants (*n* = 169)



Note: Same survey question as for Table 38.

Alternatives to BOC Training

An important part of knowing the building operator's market is knowing what alternatives exist to BOC training. We asked respondents if they were aware of any other place they could have gotten training that would have been equivalent to BOC training. Of the 215 respondents who answered the question, 31 (14%) reported they were aware of an alternative to BOC. Twelve of those cited professional associations, specifically: the Building Owners and Managers Association (BOMA) and the Building Owners and Managers Institute (BOMI), the Construction Industry Technical Council (CITC), the Refrigeration Service Engineers Society (RSES), the Association for Facilities Engineering (AFE), and the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE). Twelve mentioned trade or technical schools, community colleges, or the University of Wisconsin. Three respondents indicated they could have gotten equivalent training through an apprenticeship or on-the-job training. Two respondents cited utilities as a source of equivalent training. Finally, one person mentioned "trade unions" and another indicated "NEC" as comparable training sources.[47]

Additional analyses reveal that those certified in 2007 or earlier were nearly twice as likely to know of BOC alternatives than their recently certified counterparts (20% vs. 11%, $p = .06$). Furthermore, of those who knew of comparable trainings, older certificants were twice as likely as recent certificants to cite a trade association as a comparable BOC alternative.

We sought to determine how important BOC training – or its equivalent – was to the respondents. We asked the 31 respondents who had identified alternative training how likely they would have taken that training if BOC training were not available. We asked the rest of the

[47] It is possible that the reference to "NEC" is to NEC Corporation, an information technology and building maintenance and support service provider. We could not find any indication on the company's website (*http://www.nec.com/index.html*) that it provides training.

respondents how much effort they would have spent trying to find similar training if BOC training were not available.

The 31 respondents who identified alternative training generally indicated they likely would have taken that training if BOC were not offered. Specifically, 19 of the 31 (61%) gave a response of 4 or 5 on a scale from 1 (not at all likely) to 5 (highly likely). Four respondents indicated moderate likelihood ('3' on the 1-to-5 scale), and only two respondents said that it was not likely they would have taken alternative training. (Four respondents did not know the likelihood.)

The certificants who were not aware of any alternative to BOC provided less-uniform responses to the question of how much effort they would have spent trying to find similar training. On a scale of 1 (no effort) to 5 (great effort) 35% of respondents gave a response of 4 or 5, 27% gave a response of 3, and 27% responded with a 1 or 2. (Nine percent did not know how much effort they would have exerted.)

Taken together, the above results show that most respondents are not aware of alternatives to BOC training but value it sufficiently that they would likely take known equivalent training if BOC were not available or exert at least moderate effort to find equivalent training.

APPENDIX E: ACE MODEL REVIEW MEMO

MEMORANDUM

To: Rita Siong, NEEA

From: Ryan Bliss, Marjorie McRae, Research Into Action

Date: April 18, 2013

Re: 2012 BOC Program ACE Model Review

As part of our program evaluation activities, this memo provides a review of the input assumptions of the program ACE Model for the Building Operator Certification Expansion (BOC-E) Initiative. This review covers only input assumptions in the Excel workbook titled *BOC_2_ACE_Model* (Table 39), not the computational assumptions of the model.

Table 39: BOC-E ACE Model Current Key Input Assumptions

VAR. NO.	VARIABLE	DEFINITION	CURRENT INPUTS	SOURCE FOR REVIEW
1	kWh/ft^2/year	Electric consumption per sq foot.	16.7	BOC Survey
2	% savings	Percentage of savings for participating buildings.	2.50%	BOC Survey
3	kWh-saved/ft^2/year	Consumption * % of savings.	0.418	BOC Survey
4	Ft/operator	Researched square footage per operator.	286,000	BOC Survey
5	kWh/operator	Calculated savings per operator per market progress or LTMT reports.	119,405	BOC Survey
6	Number of operators	Number of building operators, currently used.	5,856	BOC Survey, other
7	% of market	Percentage of buildings <100K sq ft with building operators.	50%	Navigant Memo,[1] Market Informants
8	Years	Retirement rate.	5	Nexant Research
9	Dollars	Any additional costs associated with having a certified building operator. May include higher pay, incremental projects that wouldn't have been done, etc.	$1,129.29	ACE Model, NEEA and NEEC staff

1 *Memo: Projected market size for Building Operator Certification training in the Northwest*, Prepared by Navigant Consulting for Northwest Energy Efficiency Alliance, September 26, 2011.

SOURCES

This sections describes the methods the evaluators used to review and evaluate the key ACE Model input assumptions shown above in Table 39.

As shown in that table, the source for evaluating several of the assumptions is a survey of BOC operators we conducted from February 14 through March 21, 2013. This was a mixed-mode – online and telephone – survey of 329 BOC certificants to gather information about their operations and management practices, as well as workplace characteristics and certificants' own perceptions and attitudes. For this review of ACE Model input assumptions, we primarily use data on work practices and workplace characteristics; we report on respondent perceptions and attitudes elsewhere.

Other sources for reviewing ACE model assumptions are memos and reports from previous evaluations, sources cited in the ACE Model, interviews conducted with eight informants knowledgeable about the building operations market, and the Commercial Building Stock Assessment (CBSA)[48] and Commercial Buildings Energy Consumption Survey (CBECS)[49], as described in more detail below.

METHODS AND RESULTS

The following subsections describe how the evaluators used the above sources to address the ACE Model input assumptions and the results we obtained. The order does not strictly reflect the order in which the assumptions appear in the table, as the evaluation of some assumptions depend to some degree on the evaluation of assumptions later in the table.

Electric Consumption per Square Foot and Energy Savings (Table 39, Variables 1, 2, 3, and 5)

The Research Into Action team used a multi-faceted approach to estimate energy savings associated with the BOC Expansion Initiative. We evaluated current measure savings assumptions using secondary research, the Evaluation Team's extensive engineering experience with measure-specific data and program implementation, and survey research with BOC certificants.

We used a four-step, quantitative process to estimate the energy savings associated with the BOC Expansion Initiative. The first three steps dealt with the evaluation of data from the BOC

---

[48] *Northwest Commercial Building Stock Assessment: Final Report.* Prepared by The Cadmus Group, Inc. for the Northwest Energy Efficiency Alliance, December 21, 2009.

[49] Source: http://www.eia.gov/consumption/commercial/.

operator survey. Through this survey, we captured detailed data on facility system characteristics and operator activities across nine energy-using building systems: boilers, chilled-water systems, economizers and ventilation control, compressed air, fans and air distribution, domestic water heaters, lighting, pumps, and motors. We used these data to calculate: 1) electric consumption per square foot for each facility; and 2) energy savings (as a percentage of total energy use) from each operator's activities. Of the 329 survey respondents, 212 provided sufficiently complete responses to calculate energy usage and savings values.

We used survey responses to estimate savings on a per-respondent and per-square-foot basis to enable extrapolation to overall BOC operators.

The following provides further detail on our approach.

Establishing Baseline Energy Consumption

We classified each survey respondent building type into one of the Commercial Buildings Energy Consumption Survey (CBECS) building type categories. We based the assignment of the specific category to each respondent on the employer associated with each record in the BOC database (Table 40).

Table 40: Classification of Survey Respondents into Building Categories

CATEGORY	NUMBER OF SURVEY RESPONDENTS
Education	79
Health Care – Inpatient	27
Health Care – Outpatient	4
Lodging	7
Mercantile Retail	5
Office	72
Public Assembly	1
Warehouse and Storage	8
Other	9
Total	**212**

We sub-categorized respondents by Climate Zone using the zip code on file in the BOC database and the CBECS U.S. Climate Zone Map available on the U.S. Energy Information Administration website. We mapped each sampled zip code using *BatchGeo*, an interactive geocode mapping tool, and overlaid the zip code map onto the climate zone map (Table 41).

Table 41: Classification of Survey Respondents into Climate Zones

CLIMATE ZONE	NUMBER OF SURVEY RESPONDENTS
Climate Zone 1: Fewer than 2,000 CDD and More than 7,000 HDD[1]	22
Climate Zone 2: Fewer than 2,000 CDD and 5,500-7,000 HDD	16
Climate Zone 3: Fewer than 2,000 CDD and 4,000-5,499 HDD	174
Total	**212**

1 CDD = Cooling Degree Day, HDD = Heating Degree Day.

We determined annual baseline energy consumption using Energy Use Intensity (EUI) data by fuel type, principal building activity (category type), climate zone, and end use. Table 42 and Table 43 summarize the EUI values used for electric consumption (kWh/ft^2) and fossil fuel consumption (1,000 BTU/ft^2).

Table 42: Electric Energy Use Intensity (kWh/ft2) by Climate Zone, End-Use, and Building Type[1]

CLIMATE ZONE	ELECTRIC ENERGY USE INTENSITY (KWH/FT2) AND % ANNUAL ENERGY CONSUMPTION BY END-USE AND BUILDING TYPE					
	Total	Space Heating	Cooling	Ventilation	Water Heating	Lighting
EDUCATION						
% Annual Energy Consumption	81%	4.5%	20.0%	22.7%	2.7%	30.9%
Zone 1	8.2	0.37	1.64	1.86	0.22	2.53
Zone 2	8.0	0.36	1.60	1.82	0.22	2.47
Zone 3	11.1	0.50	2.22	2.52	0.30	3.43
HEALTH CARE – INPATIENT						
% Annual Energy Consumption	81%	1.8%	13.8%	21.5%	1.1%	42.5%
Zone 1	23.7	0.43	3.27	5.08	0.26	10.08
Zone 2	27.7	0.50	3.83	5.94	0.30	11.79
Zone 3	23.3	0.42	3.22	5.00	0.25	9.91
HEALTH CARE – OUTPATIENT						
% Annual Energy Consumption	65%	4.3%	13.0%	6.2%	0.6%	41.0%
Zone 1	16.7	0.73	2.18	1.04	0.10	6.85
Zone 2	17.4	0.76	2.27	1.08	0.11	7.13
Zone 3	13.7	0.60	1.79	0.85	0.09	5.62

Continued

Climate Zone	Electric Energy Use Intensity (kWh/ft2) and % Annual Energy Consumption by End-Use and Building Type					
	Total	Space Heating	Cooling	Ventilation	Water Heating	Lighting
Lodging						
% Annual Energy Consumption	80%	5.9%	10.4%	5.9%	5.2%	52.6%
Zone 1	10.1	0.60	1.05	0.60	0.52	5.31
Zone 2	15.9	0.94	1.65	0.94	0.82	8.36
Zone 3	13.5	0.80	1.40	0.80	0.70	7.11
Retail						
% Annual Energy Consumption	76%	2.8%	11.9%	7.7%	0.7%	52.4%
Zone 1	14.2	0.40	1.69	1.09	0.10	7.45
Zone 2	11.0	0.31	1.31	0.85	0.08	5.77
Zone 3	14.8	0.41	1.76	1.14	0.10	7.76
Office						
% Annual Energy Consumption	68%	4.6%	13.9%	8.7%	1.2%	39.3%
Zone 1	13.9	0.64	1.93	1.21	0.16	5.46
Zone 2	18.2	0.84	2.52	1.58	0.21	7.15
Zone 3	17.1	0.79	2.37	1.48	0.20	6.72
Public Assembly						
% Annual Energy Consumption	78%	3.2%	20.8%	37.6%	N/A	16.0%
Zone 1	9.1	0.29	1.89	3.42	0.00	1.46
Zone 2	9.5	0.30	1.98	3.57	0.00	1.52
Zone 3	9.3	0.30	1.93	3.50	0.00	1.49
Warehouse and Storage						
% Annual Energy Consumption	71%	2.6%	5.3%	7.9%	1.3%	53.9%
Zone 1	7.0	0.18	0.37	0.55	0.09	3.78
Zone 2	9.6	0.25	0.51	0.76	0.13	5.18
Zone 3	7.9	0.21	0.42	0.62	0.10	4.26

Continued

Climate Zone	Electric Energy Use Intensity (kWh/ft2) and % Annual Energy Consumption by End-Use and Building Type					
	Total	Space Heating	Cooling	Ventilation	Water Heating	Lighting
Other Building Type						
% Annual Energy Consumption	67%	1.8%	12.0%	8.0%	0.4%	44.9%
Zone 1	Q[2]	N/A	N/A	N/A	N/A	N/A
Zone 2	24.6	0.44	2.95	1.97	0.11	11.04
Zone 3	24.6	0.44	2.95	1.97	0.11	11.04

1 We determined Zone 3 values for Lodging, Public Assembly, and Other Building Type through interpolation due to an absence of information available from CBECS for that particular building type and climate zone.

2 Q = Data withheld because fewer than 20 buildings were sampled for any cell, or because the Relative Standard Error (RSE) was greater than 50 percent for a cell in the "Total" column.

Table 43: Fossil Fuel (1,000 BTU/ft2) Energy Use Intensity by Climate Zone, End-Use, and Building Type[1]

Climate Zone	Fossil Fuel Energy Use Intensity (1,000 BTU/ft2) by End-Use and Building Type		
	Total	Space Heating	Water Heating
Education			
Zone 1	54.6	42.3	7.5
Zone 2	50.9	39.4	6.9
Zone 3	27.2	21.1	3.7
Health Care – Inpatient			
Zone 1	117.5	59.0	40.9
Zone 2	140.4	70.4	48.9
Zone 3	102.9	51.6	35.8
Health Care – Outpatient			
Zone 1	N/A	N/A	N/A
Zone 2	50.9	44.8	3.4
Zone 3	40.17	35.4	2.7
Lodging			
Zone 1	57.2	17.0	33.1
Zone 2	75.0	22.3	43.4
Zone 3	51.5	15.3	29.8

Continued

Climate Zone	Fossil Fuel Energy Use Intensity (1,000 BTU/ft2) by End-Use and Building Type		
	Total	Space Heating	Water Heating
Retail			
Zone 1	47.5	43.6	1.5
Zone 2	47.2	43.3	1.5
Zone 3	37.2	34.2	1.2
Office			
Zone 1	49.4	42.4	2.4
Zone 2	42.2	36.2	2.1
Zone 3	31.0	26.6	1.5
Public Assembly			
Zone 1	51.2	46.1	1.2
Zone 2	56.7	51.1	1.4
Zone 3	47.38	48.4	1.2
Warehouse and Storage			
Zone 1	35.5	29.8	1.0
Zone 2	27.2	22.8	0.8
Zone 3	31.6	26.5	0.9
Other Building Type			
Zone 1	Q[2]	Q	Q
Zone 2	47.2	43.3	1.5
Zone 3	37.2	34.2	1.2

1 We determined Zone 3 values for Public Assembly through interpolation due to an absence of information available from CBECS for that particular building type and climate zone.

2 Q = Data withheld because fewer than 20 buildings were sampled for any cell, or because the Relative Standard Error (RSE) was greater than 50 percent for a cell in the "Total" column.

We determined building square footages from input provided by the respondents during the survey or from information available from the BOC database.

Total Savings Estimates

The survey instrument captured energy savings from operations and maintenance (O&M) behaviors and activities as well as equipment retrofits and replacements. Equipment replacement and retrofit measures included high efficiency boiler installations, lighting upgrades, replacing standard tank-type water heaters with tankless water heaters, replacing standard efficiency

motors with premium efficiency motors, and installing variable frequency drives for fans and pumps.

For each retrofit measure, the survey asked respondents about the degree to which the BOC training influenced implementation of the project. The survey also requested specific details regarding the installed equipment (e.g., rated heating input in Btu/hr and Annual Fuel Utilization Efficiency for baseline and new energy efficient boilers).

The survey asked about O&M behaviors that BOC training targets, including modifications to existing control systems and set-points, the adoption of new maintenance practices and activities, and/or more frequent execution of these O&M activities. The survey grouped O&M activities into similar-measure categories, summarized in Table 44.

Table 44: Targeted O&M Measures

System / Specific Measures
Boilers
Boiler Maintenance Best Practices
Regular Steam Trap Surveys and Repairs
Reset Cutout Control Strategies
Boiler Tune-ups
Air Distribution & Ventilation
Demand Controlled Ventilation
CO-Based Ventilation Controls
Optimum Start/Stop Control Strategies
Scheduling VAV's and Fan-Powered Boxes in Air Distribution Systems
Duct Static Pressure Controls
Installation/Repair/Optimization of Air-Side Economizers
Conversion of Dry-Air Economizer to Enthalpy Economizer
Supply Air Temperature Reset Strategies
Compressed Air Leak Surveys and Repairs
Refrigerant Coil Cleaning
Pump Scheduling
Lighting Controls
Occupancy Sensors
Central Energy Management Systems
Chilled Water Reset Controls
Condenser Water Reset Controls

We used a combination of primary and secondary resources to estimate energy and demand impacts for the various actions taken at the sample sites. Our analyses included both electric and natural gas savings, as appropriate.

We calculated end-use savings (kWh/ft^2 or % of EUI) based on either one or a combination of the following methods:

- Average energy savings for specific end-uses and other savings calculation factors (such as hours of operation), based on a review of ratios of energy savings to demand savings from the RTF UES Measure Protocols and the following Technical Reference Manuals:
  - State of Illinois Energy Efficiency Technical Reference Manual
  - State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
  - Pennsylvania Public Utility Commission Technical Reference Manual – State of Pennsylvania Act 129 Energy Efficiency and Conservation Program
  - Massachusetts Technical Reference Manual
  - New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs: Commercial/Industrial Measures
  - State of Ohio Energy Efficiency Technical Reference Manual prepared for the Public Utilities Commission of Ohio by Vermont Energy Investment Corporation
  - State of Arkansas Deemed Savings - Quick Start Program – Commercial Measures Final Report
- Engineering analysis to estimate energy savings from measures that lent themselves well to stipulated assumptions and for the equipment replacement and retrofit measures covered in the survey (e.g., motors, boilers, lighting).
- Actual program data from Nexant-implemented retro-commissioning, building tune-up, and O&M programs, which include project- and measure-specific data for 50 to 60 typical O&M measures.

Energy Calculations

The equations we used to calculate measure-specific energy savings generally included: the energy consumption EUI for the building category for electricity (kWh/ft2) and/or fossil fuels (therms/ft2) depending on whether the measure in question affects electricity use, gas use, or both; a savings ratio/factor or per-unit savings; and the total or conditioned square footage of the facility gathered from survey responses or extracted from the BOC database. We used conditioned square footage, from information provided by a portion of the survey respondents, to estimate savings for any weather-dependent measures. We used total building square footage in

instances where respondents did not provide conditioned square footage. We calculated energy savings using EUI (kWh/ft2) values or, in the case of measures suitable for stipulated calculation, based on engineering assumptions. For savings using EUI values, we used the following formula:

Energy Savings = EUI (kWh/ft2) x Measure Savings (% or kWh/ ft2) x square footage (ft2)

Where:

EUI = End-Use EUI based on CBECS

Measure Savings = Savings (% of annual kWh) or (kWh/ft2) based on secondary information, eQUEST modeling, or Nexant implementation measure libraries (details provided below)

Square footage = Survey response

For measures suitable for stipulated calculation, we used the following equation:

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 = Nexant estimate from secondary deemed savings sources

Loading = Nexant estimate

Savings ratio = Based on secondary deemed savings sources or Nexant implementation measure libraries (details provided below)

We provide detailed We provide detailed methodologies used to estimate baseline boiler energy consumption and savings for each measure included in the survey in the attachment to this memorandum.

Calculated Input Assumptions

Using the above methods, we updated the input assumptions for electric consumption per square foot (15.9 kWh/ft^2, compared to 16.7 in the current model), percentage of kWh savings (4.59% total, 2.06% BOC-influenced, compared to 2.5%), and additional inputs derived from these inputs.

We also computed comparable input assumptions for gas consumption and therm savings.

We provide details on the revised electric and new gas input assumptions in the *Recommended Assumptions* section, at the end of this memo.

Percentage of Buildings in Market with Building Operators (Table 39, Variable 7)

NEEA currently assumes that 100% of buildings above 100,000 square feet, and 50% of those below that size, have in-house building operators. The source for this is a memo from a prior evaluator, which states the assumption that, "about half of the building operators in this smaller building size tier [less than 100,000 square feet] would likely consider participating in BOC training," and therefore, that, "the >5,000-99,000 tier has *about half the number of building operators* of the larger tiers" (emphasis added).[50] The justification for this assumption is that "The economies of scale are not substantial enough in this smaller building tier to support certification for as many building operators."

Regardless of whether or not there is a strong economic argument to certify building operators for building smaller than 100,000 square feet, the assertion that the smaller tier has *half the number of building operators as the larger tier* does not imply that 50% of buildings smaller than 100,000 square feet have in-house building operators. Rather, it means that one-third of all operators are in the smaller tier and two-thirds are in the larger tier. However, because the smaller tier has vastly more buildings than the larger tier, the number of operators in the smaller tier is divided over a much larger number of buildings than the number of operators in the larger tier.

The following example illustrates this. The current NEEA ACE Model assumes that there are 5,856 operators in the market. If there are half as many in the smaller tier as in the larger tier, then one-third (1,952) are in the smaller tier and two-thirds (3,904) are in the larger tier. From CBSA, we calculate that there are about 3,300 buildings in the Northwest in the larger tier and about 48,000 in the smaller tier.[51] Dividing the number of operators in the larger tier (3,904) by the estimated number of buildings in that tier yields a mean of about 1.2 operators per building in the larger tier. Therefore, it is possible for all buildings in that tier to have at least one operator.

Similarly, dividing the number of operators in the smaller tier (1,952) by the estimated number of buildings in that tier yields a mean of about .04 operator per building. Assuming that any

---

[50] *Projected Market Size for Building Operator Certification Training in the Northwest*. Memorandum prepared for the Northwest Energy Efficiency Alliance by Navigant Consulting, September 26, 2011.

[51] Table C-GB1 of the CBSA shows the total floor area by building type, and Table C-GB2 shows percentage of floor space of each building type by size tier. From these two sets of figures, we could calculate the total floor space by size tier for each building type. To estimate the number of buildings in a given tier, we divided the total floor space for each tier by the presumed mean value values for that size tier. The presumed mean values were not the midpoint, nor were they the same for each tier; rather, we chose a different value for each tier to approximate the skewed distribution of building size across all tiers. In practice, the results of the above are relatively insensitive to the presumed mean value of each tier.

building in the smaller tier that has any operators has *only one* operator, then 4% of buildings in the smaller tier have operators, not 50%.

The idea that 4% of buildings smaller than 100,000 square feet have in-house operators is consistent with the opinions of the market experts we interviewed for this evaluation. Those who had an opinion about the proportion of commercial space with in-house O&M staff suggested lower percentages than the NEEA assumptions (100% of buildings at least 100,000 square feet and 50% of smaller buildings). The informant with the most explicit estimate suggested that one-quarter to one-third of buildings over 50,000 square feet and substantially fewer than 10% of smaller ones have internal operations staff.

Another source for examining this issue is the BOC Initiative's 2001 MPER #7.[52] For that MPER, Research into Action conducted a survey of building operator supervisors and estimated that there were 5,128 facilities with in-house O&M staff in the region. If we assume that the figure of 5,128 includes all of the 3,300 buildings 100,000 square feet or larger, that leaves 1,828 other facilities with in-house O&M staff. Again, that calculates to about 4% of the total number of buildings at least 5,000 but less than 100,000 square feet. Even if only 75% of the buildings in the larger tier have in-house operators, that would mean there are about 2,700 buildings with operators in the small tier – about 6% of the total.

Number of Operators in the Market (Table 39, Variable 6)

We relied on data from the BOC certificant survey to estimate mean square feet of facility area per facility operator, counting all operators, both those with and without the BOC credential. We used this figure to estimate total size of the building operator market in buildings of at least 100,000 square feet. As detailed below, we estimated the number of operators in smaller buildings based on an estimated percentage of buildings in that tier with operators.

We used data on facility size and number of operators from all respondents that provided this data, including currently active and non-active BOC operators.

Survey Data Used

The survey solicited data on facility size and the total number of building O&M staff employed there. If, for a given respondent, the BOC database included facility size, then the survey asked the respondent to confirm the square footage or provide an alternate figure; otherwise, the survey simply asked for the square footage.[53]

---

[52] *Market Progress Evaluation Report: Regional Building Operator Certification, No. 7.* (Report #E01-088). Prepared for the Northwest Energy Efficiency Alliance by Research Into Action, Inc. September 2001.

[53] The survey also asked respondents how much of the facility was conditioned, but respondents were not consistently able to provide information on this.

To assess number of building O&M staff, the survey first asked respondents, "About how many building O&M staff work at your facility in total, including both line and supervisory staff?" The survey then asked respondents to "list the kinds of building operators at your facility, starting with the most senior." For each job title, the survey asked respondents to indicate the number of operators with that title, whether *any* of those operators have the BOC credential, what their main responsibilities are, and what percentage of the facility's area their responsibilities cover.

Nearly two-fifths (38%) of the respondents did not answer the questions about specific job titles. On average, those respondents reported more staff overall (27 vs. 16) and greater facility square footage (1,234,940 vs. 670,082).[54] However, the mean ratio of square footage to total count of O&M staff was nearly identical for the two groups (70,317 and 70,507).

Respondents identified a wide variety of job titles. We coded those titles into 11 categories (Table 45). Most of the categories – and a large majority of the staff – likely represented the BOC market. However, several categories – and about 9% of the staff – did not clearly represent the types of workers likely to be part of the BOC market. We included the former group of staff categories in the counts of operators per facility and excluded the latter group.

Table 45: Categorized Job Titles

JOB TITLE CATEGORY	DESCRIPTION	PERCENT OF O&M STAFF
TITLES LIKELY REPRESENTING BOC MARKET – INCLUDED IN COUNTS OF OPERATORS		
Technical / Mechanical	Includes the terms mechanic, maintenance, or technical or referring to specific energy-using systems, but do not indicate a management or custodial position.	34%
Custodial	Includes the term custodian or custodial but do not indicate a management position.	26%
Professional	Engineers, electricians, and similar high-skilled professional positions	16%
Manager (O&M)	Includes the terms manager, director, lead, or similar and also specifically indicated technical or mechanical responsibilities.	6%
Custodial Manager or Supervisor	Includes the terms manager, director, lead, supervisor, coordinator or similar, with respect to custodial staff or duties.	5%
Supervisor, Coordinator, Assistant Manager	Includes the terms supervisor, coordinator, assistant manager or similar and not otherwise classified	3%
		Continued

[54] These means exclude six cases for which either the reported square footage or the reported number of operators represented a statistical outlier. Because of the large sample size, we defined statistical outlier as a case that exceeds the mean value by at least 3.1 standard deviations, which would include 0.1% of the expected distribution.

Job Title Category	Description	Percent of O&M Staff
Titles Likely Representing BOC Market – Included in Counts of Operators (Continued)		
Manager (General)	Includes the terms manager, director, lead, or similar and not otherwise classified	3%
Subtotal		*91%*
Titles Not Likely Representing BOC Market – Excluded from Counts of Operators		
Unskilled Labor	Refers to floor staff, grounds staff, labor, or similar	4%
Other Skilled Labor	Refers to skilled labor (painters, carpenters, etc.) that do not obviously operate or maintain energy-using equipment.	3%
Office	Refers to administrative, support, or bookkeeping.	1%
Other	Miscellaneous and not codeable.	1%
Subtotal		*9%*
Total		**100%**

Survey Question: "[P]lease list the kinds of building operators at your facility, starting with the most senior. For each type, please record a general job title …."

Calculation of Facility-Level Values

The purpose of calculating the mean number of square feet per operator was to produce a sample mean that we could extrapolate to the population of all applicable regional building space. Therefore, each facility in the sample should count as one data point in the sample mean.

However, as one of the goals of the survey was to examine the degree to which responsibilities and energy-savings actions overlap among multiple operators for the same facility, we did not exclude multiple BOC certificants from the same facility from taking the survey. The 329 survey responses represented 240 separate facilities. As Table 46 shows, three-quarters of the facilities had a sole respondent, while the remaining facilities had from two to nine respondents.

Table 46: Distribution of Facilities and Respondents by Number of Respondents per Facility

Number of Respondents per Facility	Number and Percent of Facilities		Number and Percent of Respondents	
	Count	Percent	Count	Percent
One	182	76%	182	55%
Two	41	17%	82	25%
Three to Five	16	7%	56	17%
Nine	1	0%	9	3%
Total	**240**	**100%**	**329**	**100%**

For each facility with multiple respondents, we calculated a single value each for facility size (square feet) and number of operators. We calculated each parameter as the mean of all the values that the respondents for that facility provided. (If only one respondent represented a given facility, then we used only that respondent's data.)

As noted above, about two-fifths of respondents did not provide details about specific job titles. Thus, this information was not available for about one-third of the facilities. Excluding those facilities from analysis would significantly reduce the sample size, especially for larger facilities. Therefore, we sought a way to replace the missing data for those cases.

Nearly all respondents reported total counts of O&M staff, which we assume generally included staff that are not part of the BOC market as well as those that are part of the market. By calculating the proportion of "included" operators among all reported maintenance and operations staff – among respondents who provided both – we could estimate the counts of "included" operators for the facilities that did not provide that data.[55]

Therefore, we divided the number of "included" operators by the total count of O&M staff, among respondents that reported operator job titles, and then applied the resulting proportion to the total staff counts for the other respondents. However, to ensure that we did not undercount the number of operators for any facilities, we also calculated the total number of BOC certified operators for each facility: if that total exceeded the estimated total of "included" operators, we used it instead of the estimated value.

Even after applying the above approach, 21 of the 240 facilities did not have any data for facility size, number of operators, or both. We calculated square footage per operator for each of the remaining 219 facilities (164 facilities with a single respondent and 55 with multiple respondents).

Despite the previous exclusion of outliers in square footage and operator counts, the calculated square footage per operator appeared unusually large for two facilities, and in fact those facilities were statistical outliers.[56] We examined those cases and found that both cases had a single respondent. Neither respondent reported the number of maintenance and outreach staff, and both of those respondents were the only BOC operator for their facility. This meant that in both cases, the calculation of square feet per operator had only one operator as the denominator. As both these cases were statistical outliers, we excluded them from the calculation of the mean square footage per operator.

---

[55] This approach obtains justification from the fact that respondents that did and did not report job titles reported nearly identical total staff counts per square foot of facility space.

[56] The values for the two outliers were, respectively, 9,300,000 and 10,000,000 square feet per operator and exceeded the mean for all cases by at least 3.1 standard deviations (SDs).

Extrapolation to the Population and Estimation of Number of Operators

Our sample represented a higher proportion of large facilities relative to the region as a whole (Table 47).[57] In particular, a relatively small percentage of the facilities in our sample – and a very small percentage of the total square footage represented – was in the size tier below 100,000 square feet, while that tier constitutes most of the regional facilities and square footage.

Table 47: Comparison of Sample to Regional Population

Facility Size (Square Feet)	Number of Facilities in Sample	Percentage of Facilities		Percentage of Total Area	
		Sample	Region (CBSA)*	Sample	Region (CBSA)[1]
< 100,000	34	16%	94%	1%	63%
100,000 to 500,000	81	37%	6%	8%	32%
≥ 500,000	102	47%	0%	91%	5%
Total (Excl. Outliers)	**206**	**100%**	**100%**	**100%**	**100%**

1 The denominators for the regional percentages are the total count and total square footage of buildings at least 20,000 square feet. We estimated number of regional buildings as described in *Percentage of Buildings in Market with Building Operators* (Table 39, Variable 7), above.

The large disparity between the sample and regional population in the under-100,000-square-feet tier made it unfeasible to include that tier in our extrapolation from the sample. In other words, we could only accurately estimate the mean square footage per operator – and, hence, the mean number of operators – for buildings of at least 100,000 square feet. Following the discussion in *Percentage of Buildings in Market with Building Operators* (Table 39, Variable 7), above, we estimated the number of operators in the smaller tier based on the assumption that 5% of the buildings in that tier have a mean of one operator.

Even in the above-100,000-square-foot tier, our sample had relatively larger buildings than the regional population. To extrapolate in that tier from the sample to the population, we applied data weights to the calculated square footage per operator for each facility in that tier. We calculated data weights for two sub-tiers: (1) 100,000 to 500,000 square feet; and (2) more than 500,000 square feet. We calculated each sub-tier weight as the percentage of regional buildings in that sub-tier (out of all buildings at least 100,000 square feet) divided by the percentage of the sample in that sub-tier. Table 48 shows the resulting weights.

[57] *Northwest Commercial Building Stock Assessment: Final Report.* Prepared by The Cadmus Group, Inc. for the Northwest Energy Efficiency Alliance, December 21, 2009. This excludes groceries and restaurants, which typically use different mechanisms than building operators for building operations savings. Source: ACE Model, *Market* tab.

Table 48: Calculation of Weights for Square Footage per Operator, Buildings At Least 100,000 Square Feet

Facility Size (Square Feet)	Number of Facilities in Sample	Percent of Facilities Sample	Percent of Buildings in Region (CBSA)	Weight
100,000 to 500,000	81	44%	97%	2.20
500,000	102	56%	3%	0.05
Total	**183**	**100%**	**100%**	**n/a**

The above methods produced a weighted mean value of 72,935 square feet per included operator in buildings of at least 100,000 square feet. To estimate the number of operators in buildings of at least 100,000 square feet, we divided that figure into the total square footage of buildings expected to have operators in that size tier. Following the discussion in *Percentage of Buildings in Market with Building Operators* (Table 39, Variable 7), above, we assumed that no more than 75% of buildings in the larger tier have in-house operators. This produced an estimate of 7,609 operators in that tier.

Assuming that 5% *of buildings* at least 5,000 and less than 100,000 square feet in size have operators, with an average of one operator per building, and 48,217 buildings in that tier,[58] we estimated 2,411 operators the small tier. Together, these produced a total of 10,020 operators (Table 49).

Table 49: Calculation of Number of Operators in Market

Facility Size (Square Feet)	Total Square Footage in Tier	Estimated Number of Buildings in Tier	Method Used to Estimate Number of Operators in Tier	Number of Operators
5,000 to 99,999	1,196,328,500	48,217	5% of buildings, mean of one operator per building	2,411
≥ 100,000	740,478,400	3,289	72,935 square feet per operator, 75% of square footage has operators	7,609
Total	**1,936,806,900**	**51,505**	**n/a**	**10,020**

Note that the above estimated number of regional building operators may not capture all outsourced building operations staff. Fifteen of the operators in the NEEC BOC database identified their company type as "facility services." Assuming roughly the same proportion in the IBOA population, we might assume 20 BOC operators in that sector regionally. Market informants estimated BOC penetration to be less than 2% in the facility services sector.

[58] Again, we based this estimate on methods described above, in *Estimate of Percentage of Facilities with Operators*.

Extrapolating from those figures, we estimate about 1,000 building operators in the regional facility services sector.

Mean Square Feet per BOC Operator (Table 39, Variable 4)

We also used data from the BOC certificant survey to estimate mean square feet of facility area per *active* BOC-credentialed operator. This is the "Ft/operator" figure (Variable 4 in Table 39) used to calculate total BOC savings with the following formula:

Total Savings =	Number of active BOC operators	x
	Square footage per operator	x
	Mean energy usage intensity (EUI)	x
	Mean percentage savings from certification	

As when calculating the mean square footage for all "included" operators, each unique facility in the survey sample represented a single data point. For each facility with multiple survey respondents, we calculated the facility area as the mean of the square footage that all respondents for that facility supplied.

However, calculating the mean square feet of facility area per BOC-credentialed operator was more straightforward than calculating the comparable figure for all "included" operators. For each facility, we counted the number of *currently active* BOC operators in the BOC database that work at that facility. As noted above, the survey respondents included active as well as non-active BOC operators. Of the 240 unique facilities represented in the survey sample, 197 had at least one currently active BOC operator and facility square footage data. For those 197 facilities, we calculated the square footage per active BOC operator.

We then calculated the simple, unweighted mean of those 197 records. We did not consider it necessary to apply data weights in this case because we are extrapolating the sample results to the population of BOC operators and the survey sample was representative of the population on key parameters (Table 50).

Table 50: Comparison of Survey Sample with BOC Population on Company Type and Location

CHARACTERISTIC	% OF BOC POPULATION	% OF SURVEY RESPONDENTS
COMPANY TYPE		
Government	10%	10%
Hospital, Retail, Facility Services, Other	8%	10%
Manufacturing	7%	5%
Municipality	22%	16%
College	9%	11%

Continued

CHARACTERISTIC	% OF BOC POPULATION	% OF SURVEY RESPONDENTS
COMPANY TYPE (CONTINUED)		
Healthcare	11%	13%
K-12 School	21%	26%
Property Management	7%	8%
Missing	4%	2%
LOCATION (ZIP 3)		
97xxx	26%	29%
98xxx	59%	62%
99xxx	7%	9%
Other	8%	1%

The above methods produced a mean of 432,768 square feet per BOC operator.

Retirement Rate (Table 39, Variable 8)

Survey respondents included currently "active" BOC operators – that is, those that have received or renewed the BOC credential since 2007 – as well as operators who are no longer active.[59] This allowed us to examine whether and to what degree length of time since certification or since most recent renewal affected savings from operator practices.

Neither percentage kWh nor therm savings was correlated with either number of years since initial certification (r = -.05 and .00, respectively) or with number of years since last year certification was in effect (r = -.02 and -.07, respectively).

As noted, not all respondents provided sufficient data to calculate savings. The subsample used to calculate savings was about two-thirds of the full survey sample. It is conceivable that length of time since initial certification or since certification lapse could be related to the likelihood that respondents completed enough of the survey to be included in the savings analysis. That is, it is possible that operators who received certification or who allowed their certification to lapse longer ago answered fewer of the O&M questions and therefore were more likely to be excluded from the savings analysis.

If so, it one could argue that the above correlations do not accurately describe the relationship between number of years since certification or certification lapse and amount of savings

[59] One of the key ACE model assumptions is a 5-year measure life (Variable 8, "retirement rate," in Table 39) for certification.

achieved. In fact, such a finding could be considered *prima facie* evidence that longer intervals since certification or certification lapse are related to achievement of less savings.

Therefore, we examined whether respondents in the savings subsample differed from the respondents that were not included in the savings analyses on length of time since initial certification or since certification lapse (Table 51).

Table 51: Comparison of Subsample for Savings Calculations with Other Survey Respondents

Number Years Since Event	In Savings Subsample (*n* = 212)	Not in Savings Subsample (*n* = 117)
Since Initial Certification		
Newly Certified	20%	24%
1 to 2 Years	19%	21%
3 to 4 Years	15%	15%
5 or More Years	45%	41%
Since Certification Lapse		
Currently Certified	67%	69%
1 to 2 Years	10%	13%
3 to 4 Years	10%	9%
5 or More Years	13%	9%
Total	**100%**	**100%**

As the above table shows, the two subgroups were nearly identical – to the extent that there was any difference at all, the respondents that did not provide sufficient data to be included in the savings analyses were slightly more likely to be newly certified.

Therefore, there is no evidence in our dataset of a drop off in amount of savings over time. Based on that finding, we recommend maintaining the retirement criterion (BOC "measure life") at a minimum of five years.

Additional Costs Associated with Certification (Table 39, Variable 9)

Implementation staff provided documentation of the cost assumptions. Based on our review of that documentation, we believe the costs are reasonable. Therefore, we do not recommend any changes.

RECOMMENDED ASSUMPTIONS

Based on the considerations discussed in the previous sections, we summarize our recommended ACE Model input assumptions in Table 52.

Table 52: BOC-E ACE Model Current and Recommended Key Input Assumptions

			Input Assumptions		
				Recommended[1]	
Var. No.[2]	Variable	Definition	Current	Total	BOC-Influenced
		kWh Savings			
1a	kWh/ft^2/year	Electric consumption per square foot.	16.7	15.9	15.9
2a	% savings	Percentage of savings for participating buildings.	2.50%	4.27%	2.03%
3a	kWh-saved/ft^2/year	Consumption * % of savings.	0.418	0.662	0.315
5a	kWh/operator	Calculated savings per operator.	119,405	286,299	136,272
		Therm Savings			
1b	Therms/ft^2/year	Gas consumption per square foot.	1b	0.40	0.40
2b	% savings	Percentage of savings for participating buildings.	2b	6.16%	3.58%
3b	Therms-saved/ft^2/year	Consumption * % of savings.	3b	0.025	0.014
5b	Therms/operator	Calculated savings per operator.	5b	10,691	6,218
		BTU Savings (kWh and Therms Combined)			
1c	BTU/ft^2/year	Total consumption per square foot.	n/a	93,981	93,981
2c	% savings	Percentage of savings for participating buildings.	n/a	5.09%	2.70%
3c	BTU-saved/ft^2/year	Consumption * % of savings.	n/a	4,728	2,511
5c	BTU/operator	Calculated savings per operator.	n/a	2,046.0M	1,086.7M

Continued

Var. No.[2]	Variable	Definition	Input Assumptions		
				Recommended[1]	
			Current	Total	BOC-Influenced
		Other Parameters			
4	ft^2/operator	Researched square footage per operator.	286,000	432,768	
6	Number of operators	Number of building operators, currently used.	5,856	10,020	
7	% of market	Percentage of buildings <100K square feet with building operators.	50%	5%	
8	Years	Retirement rate.	5	No change	
9	Dollars	Any additional costs associated with having a certified building operator.	$1,129.29	No recommendation	

1 Total savings represent the combined savings of all reported O&M activities. BOC-influenced savings are the savings after applying the percentage influence of BOC training (see *Savings Estimates*, above). Total minus BOC-influenced savings represent savings from efficiency actions that would have occurred in this population without BOC training.

2 The variable numbers correspond to the numbering in Table 39 in *ACE MODEL ASSUMPTIONS*.

3 The 2.5% figure is a NEEA planning assumption based on a Northwest Power and Conservation Council estimate of electricity savings achievable through building operations. There was no similar source for gas savings.

4 This is the square footage per BOC operator, not the square footage per operator for all "included" operators, which we used to calculate number of operators in the market.

Our results based on CBECS EUI values – 15.9 kWh/ft^2/year and 40 therms/ft^2/year – are consistent with CBSA weighted mean EUIs. The CBSA reports a mean weighted electric EUI of 17 kWh/ft^2 across all building types. However, that includes groceries and restaurants, which and are not considered part of the BOC universe as they typically use different mechanisms than building operators for building operations savings. Those two building types have EUIs of more than 40, so a weighted mean EUI that excludes those two types would be lower. We calculated the mean EUIs for all other non-vacant building types, weighted by each type's relative contribution to the total square footage for those types. The resulting mean regional EUI for the BOC universe was 15.6 kWh/ft^2, which is nearly identical to our sample value based on CBECS. Our mean gas EUI of .40 is also consistent with a weighted regional mean of .42 similarly calculated from CBSA data.

Nevertheless, we recalculated all savings values, substituting CBSA EUI values for CBECS values. As noted above, we also calculated savings values including savings from non-incented capital improvements to assess their contribution to savings. Table 53 shows the results. The first

column (CBECS EUI Data, O&M Only) shows the same values as does the above table. As this table shows, neither using CBSA EUI values nor including savings from non-incented capital projects had much effect on the results, particularly for the estimates of BOC-influenced savings.

Table 53: Savings Estimates Calculated With Only O&M Measures and With Non-Incented Capital Improvements, Using CBECS and CBSA Data

	Using CBECS EUI Data		Using CBSA EUI Data	
	O&M Only	With Capital Improvements	O&M Only	With Capital Improvements
Mean kWh % Savings – Total	4.27%	4.59%	4.02%	4.32%
Mean kWh % Savings – BOC-influenced	2.03%	2.06%	2.04%	2.07%
Mean therm % Savings – Total	6.16%	6.18%	6.26%	6.28%
Mean therm % Savings – BOC-influenced	3.58%	3.59%	3.58%	3.59%

ATTACHMENT: BASELINE ENERGY CONSUMPTION AND MEASURE-LEVEL SAVINGS METHODS

Establishing Baseline Boiler Energy Consumption

The evaluators used two methods to determine the annual space heating consumption for each respondent. The first involved taking specific information provided during the survey and calculating annual consumption using the algorithm shown below. The survey asked for rated heating input in Btu/hr and the Annual Fuel Utilization Efficiency (AFUE). If the respondent provided this information, the evaluators used the following algorithm to determine annual space heating fuel consumption:

Total Therms/Year = 0.77 x 24 x HDD x Boiler Heating Capacity (Btu/hr) x ESF / (AFUE x ΔT) / 100,000

Where:

0.77 = Deemed Boiler Oversize Factor

24 = Hours per Day

HDD = Average Annual Heating Degree Days = Determined to be 4,760

ESF = Energy Savings Factor Based on Frequency of Surveys/Repairs (0%, 7.5% or 12.5%)

AFUE = Annual Fuel Utilization Efficiency = Deemed to be 80% if not provided

ΔT = Winter Design Temperature Difference = Determined to be 27.2°F

100,000 = Btu to therm Conversion Factor

Comments: The evaluators determined HDD and Winter Design Temperature Difference values based on the geographic distribution of the sampled respondents and corresponding design data obtained from the 2009 Version of ASHRAE Fundamentals.

When respondents did not provide heating capacity and efficiency, the evaluators determined annual boiler energy consumption from the building square footage, the facility-type or use, and fossil fuel energy utilization intensity in 1,000 BTU/ft2 determined from CBECS Data.

Measure-Level Savings

Boiler Maintenance

The evaluators applied a maximum deemed savings factor of 0.5% to total annual heating energy consumption to estimate annual energy savings resulting from boiler maintenance best practices.

The maximum deemed savings factor of 0.5% is a conservative estimate based on our engineering judgment and implementation experience.

For each respondent, we either applied the maximum deemed energy savings factor of 0.5% or discounted that factor based on each respondent's responses to a sequence of questions pertaining to the frequency of critical O&M practices as well as the types of instrumentation used when evaluating boiler operating conditions. The Evaluation Team developed a simple scoring system to determine the amount by which to discount savings for each respondent. The survey included the following O&M practices:

- Check boiler supply and return temperatures
- Check boiler stack temperature
- Check combustion efficiency
- Check for corrosion or scaling
- Clean fire tubes
- Check and clean heat exchangers
- Replace leaking tubes
- Inspect insulation on piping and boilers
- Clean/replace fuel oil burner tip
- Calibrate sensors

The average savings factor applied to the sample was approximately 0.24%.

Boiler Tune-Up

The evaluators used a maximum deemed savings value of 1.6% of total annual heating energy consumption to estimate annual energy savings resulting from annual boiler tune-ups. The deemed savings factor of 1.6% is an engineering estimate based on our experience and a review of the following two Technical Reference Manuals that include deemed savings methodologies and energy saving factors for boiler tune-up measures.

- ➡ State of Illinois Energy Efficiency Technical Reference Manual.
- ➡ State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0.

For each respondent, we either applied the maximum deemed energy savings factor of 1.6% or discounted that factor based on each respondent's responses to a sequence of questions pertaining to the frequency and scope of boiler tune-ups. The Evaluation Team developed a simple scoring system to determine the amount by which to discount savings for each respondent. The survey included following items:

- Measure flue gas oxygen content
- Measure flue gas carbon monoxide content

- Measure flue gas combustibles content
- Measure flue gas emissions contact (NOx)
- Measure fuel flow rate
- Measure flue gas temperature
- Measure steam flow rate (if steam boiler)
- Adjust combustion control positioning to achieve desired combustion characteristics
- Document pre- and post-tune-up conditions as well as any modifications/repairs made

The average savings factor applied to the sample, after applying the simple scoring system, was approximately 1.2%.

Boiler Replacement

The survey asked respondents whether they had replaced any boilers with energy efficient condensing boilers, and if so, what the quantity, heating capacity, and efficiencies (AFUE) were for the baseline and energy efficient equipment. In instances where the operator did not know, could not recall, or simply did not provide a boiler capacity or thermal efficiency, the evaluators used deemed values. The evaluators determined deemed heating capacities by applying the average boiler input intensity (Btu/ft^2) for each facility type and multiplying it by the building's conditioned space square footage.

In instances where respondents did not know the baseline heating efficiencies, the evaluators deemed values based upon the fuel source, product type (steam or hot water), and the requirements of the State Energy Codes for Washington, Oregon, Idaho, and Montana, which came from the 2009 Version of the International Energy Conservation Code (IECC), summarized in Table 54.

Table 54: IECC 2009 Minimum Annual Fuel Utilization Efficiency (AFUE) Ratings for Boilers by Fuel Type and Product

System Type	Minimum AFUE
Gas-fired, hot water	80% (<=2,500 MBH), 82% (>2,500 MBH)
Gas-fired, steam	75% (<=2,500 MBH), 77% (>2,500 MBH)
Oil-fired, hot water	80% (<300 MBH), 82% (>=300 MBH & <=2,500 MBH), 84% (>2,500 MBH)
Oil-fired, steam	81% (>2,500 MBH)
Electric	93% (Resistance), 97% Heat Pump

Where respondents did not provide an AFUE value for the new energy efficient equipment, the evaluators deemed values based upon a review of minimum efficiency requirements commonly required by incentive programs across the country and/or a review of multiple manufacturers' websites to determine what is currently available. Table 55 summarizes the deemed system efficiencies used for retrofit equipment.

Table 55: Deemed Annual Fuel Utilization Efficiency (AFUE) Ratings for Boilers by Fuel Type

SYSTEM TYPE	AFUE
Gas-fired, hot water	85%
Gas-fired, hot water, condensing	90%
Gas-fired, steam	80%
Oil-fired, hot water	85%
Oil-fired, steam	83%
Electric	98%

Energy savings for this measure resulted from the increase in operating efficiency. The evaluators calculated savings using the following equation:

Total Therms/Year = (0.77 x 24 x HDD x Boiler Heating Capacity (Btu/hr) / ΔT) x ($1/TE_b$ – $1/TE_{ee}$) x (1/100,000)

Where:

0.77 = Deemed Boiler Oversize Factor

24 = Hours per Day

HDD = Average Annual Heating Degree Days = Determined to be 4,760

ΔT = Winter Design Temperature Difference = Determined to be 27.2°F

TE_b = thermal efficiency of baseline unit

TE_{ee} = thermal efficiency of new energy efficient unit

100,000 = Btu to therm Conversion Factor

Comments: The evaluators determined HDD and Winter Design Temperature Difference values based on the geographic distribution of the sampled respondents and corresponding design data obtained from the 2009 Version of ASHRAE Fundamentals.

Boiler – Reset/Cutout Controls

Reset controls measures entail the installation of a controller that adjusts boiler control temperature in response to outdoor air temperature. As outdoor air temperature increases, the controller will automatically reset the boiler control temperature downward to save energy.

Boiler cutout controls automatically turn off a natural gas boiler and associated heating system when outside air reaches a preset temperature. The measure could also include a timer to de-energize the heating equipment based on time of day.

The evaluators estimated savings from the implementation of reset and cutout controls using energy factors of 3.8% and 1.7%, respectively. These energy factors come from the State of Arkansas Deemed Savings Quick Start Program - Commercial Measures: Final Report prepared by Nexant, Inc. dated November 16, 2007. We note that in most instances reset and cutout controls are implemented conjointly.

The survey asked respondents whether they had implemented boiler reset controls at any of their facilities. If respondents responded positively, then the survey asked a follow-up question regarding whether or not the respondent had also implemented cutout controls. The evaluators determined an energy savings factor based upon respondent responses and then multiplied that factor by the building square footage and annual space heating energy intensity (1,000 Btu/ft^2/yr) determined from CBECS Data for the specific facility type and climate zone. The savings algorithm used for this measure is:

Total Therms/Year = Space Heating EUI x Building Area x ESF / 100

Where:

Space Heating EUI = Determined based on facility type and climate zone from CBECS 2003

ESF = Energy Savings Factor (3.8% Reset Only, 1.7% Cutout Only, 5.5% Reset & Cutout)

100 = Conversion Factor (1,000 Btu's to therms)

Steam Trap Surveys & Repairs

The average useful life of a steam trap typically ranges from 4- to 8-years depending upon the trap type and quality of manufacture[60]. This translates to the potential failure of 12.5% to 25% of all steam traps in a given system on an annual basis. A pro-active steam trap survey and repair program can reduce energy losses associated with steam trap failures by up to 20% annually through systematic identification and repair or replacement. Operators should perform steam trap surveys on an annual basis.

The survey asked respondents whether steam trap surveys and repairs are part of their standard O&M procedures, and if so, how frequently they conduct these activities. The evaluators credited respondents with savings if they indicated they performed surveys "At least once a year" or "Less than once a year." If reported to be annually, the evaluators applied a savings factor of 12.5% to annual space heating fuel consumption. If "Less than once a year," the evaluators applied a savings factor of 7.5%. If "Only as needed," "Never have done," or "Don't Know," the evaluators credited no savings.

[60] Source: Risko, James. "Understanding Steam Traps." *Chemical Engineering Progress*. February 2011: pp. 21-26, American Institute of Chemical Engineers.

The evaluators determined these deemed savings factors from our experience in evaluating steam trap survey and repair incentive programs; in particular the Wisconsin Focus on Energy 2012 Business Incentive and Large Energy User Evaluation conducted by Nexant, Inc. The evaluators assumed steam traps to be in a space heating application as opposed to industrial process.

The evaluators estimated energy savings by multiplying the conditioned space square footage and annual space heating energy intensity (1,000 Btu/ft^2/yr) determined from CBECS Data for the specific facility type and climate zone. The savings algorithm used is:

Total Therms/Year = Space Heating EUI x Building Area x ESF / 100

Where:

Space Heating EUI = Determined based on facility type and climate zone from CBECS 2003

ESF = Energy Savings Factor (12.5% "At least once a year", 7.5% "Less than once a year")

100 = Conversion Factor (1,000 Btu's to therms)

Chilled Water Temperature Reset

Chilled water temperature reset controls allow a chiller system to operate at a higher chilled water temperature during periods of low cooling load. For this evaluation, we assumed a constant chilled water temperature of 45°F and an average offset of 5°F.

The survey asked respondents whether their responsibilities included the operation and maintenance of a central chilled water system. The survey asked those who responded positively whether they had had implemented chilled water temperature reset control strategies since achieving the becoming BOC credential. If the respondent satisfied both criteria, the survey then asked the respondent to provide the normal chilled water operating temperature during peak cooling season as well as the temperature offset. The evaluators used deemed values in cases where respondents did not provide this information. Deemed values consisted of a chilled water temperature of 45°F and an offset of 5°.

The evaluators estimated energy savings using an energy savings intensity factor of 0.04 kWh/ft^2, which the evaluators based upon measure libraries from recommissioning (RCx), building tune-up, and O&M program implementation conducted by Nexant in Illinois for the Commonwealth Edison Company Commercial Recommissioning Program.

The evaluators estimated energy savings by multiplying the conditioned space square footage by an energy savings intensity factor of 0.04 kWh/ft^2. The savings algorithm is:

Total Energy Savings (kWh) = Conditioned Space x 0.04 kWh/ft^2

We note that the actual average chilled water system operating temperature and temperature offset reported by respondents were 45.6°F and 5.8°F, respectively.

Condenser Water Temperature Reset

This measure applies to central chilled water plants featuring a water-cooled chiller and cooling tower (condenser) used to reject heat. The measure involves resetting (lowering) the condenser water operating temperature set-point thereby decreasing the temperature lift between the evaporator and the condenser in a chilled water distribution system, which results in a reduced chiller load and increased operating efficiency.

The survey asked respondents whether their responsibilities included the operation and maintenance of a cooling tower. The survey asked those who responded positively whether they had implemented condenser water temperature reset control strategies at any of their facilities. The evaluators estimated energy savings using an energy savings intensity factor of 0.08 kWh/ft^2, which the evaluators determined from Nexant's measure libraries from recommissioning (RCx), building tune-up, and O&M program implementation work conducted by Nexant in Illinois for the Commonwealth Edison Company Commercial Recommissioning Program.

The evaluators determined energy savings by multiplying the conditioned space square footage by the energy savings intensity factor of 0.08 kWh/ft^2. The savings algorithm is shown below:

Total Energy Savings (kWh) = Conditioned Space x 0.08 kWh/ft^2

We note that the survey did not gather actual condenser water temperature setpoints and offsets due to survey duration time constraints.

Demand-Controlled Ventilation (DCV)

Demand-controlled ventilation is a strategy that controls the amount of outside ventilation air brought into a facility in order to satisfy minimum fresh air requirements, but reduce over-ventilating and unnecessary heating and cooling costs. Operators typically achieve this measure through the installation of CO2 sensors and controls.

The survey asked respondents whether their responsibilities included the operation and maintenance of economizers or ventilation controls. The survey asked those who responded positively whether demand-controlled ventilation systems were in use at any of their facilities. The evaluators then credited savings based on respondent response.

The evaluators deemed electric energy savings from the implementation of DCV-controls using an energy savings intensity factor of 0.22 kWh/ft^2, which the evaluators determined from Nexant's measure libraries from recommissioning (RCx), building tune-up, and O&M program

implementation work conducted by Nexant in Illinois for the Commonwealth Edison Company Commercial Recommissioning Program.

The evaluators calculated savings using the following savings algorithm:

Total Energy Savings (kWh) = Conditioned Space x 0.22 kWh/ft^2

The evaluators deemed fossil fuel savings using an energy savings factor of 10% applied to annual space heating consumption in therms/year. The algorithm is:

Total Fossil Fuel Savings (therms) = Space Heating EUI x ESF x Conditioned Space / 100

Where:

Space Heating EUI = Determined based on facility type and climate zone from CBECS 2003

ESF = Energy Savings Factor deemed at 10%

100 = Conversion Factor (1,000 Btu's to therms)

Add/Repair/Optimize Air-side Economizer

Air-side economizers provide free cooling when outdoor air temperatures are below the required HVAC system supply air temperature. Economizers typically consist of an air damper that modulates from minimum position, when it is possible to meet the full cooling load by the minimum outside air volume, to the 100% outdoor air position as the outdoor air temperature approaches the required supply air temperature. When outdoor air temperature is greater than the return air temperature, the outdoor air damper will revert back to the minimum setting for ventilation.

The survey asked respondents whether their responsibilities included the operation and maintenance of supply air distribution systems equipped with air-side economizers. The survey asked those responding positively whether they had retroactively installed, repaired, or optimized an air-side, dry-bulb economizer at any of their facilities. The evaluators then credited savings based on the respondent's response.

The evaluators determined electric energy savings from the installation, repair, or optimization of a dry-bulb economizer using a savings factor of 0.24 kWh/ft^2, which the evaluators determined from Nexant's measure libraries from recommissioning (RCx), building tune-up, and O&M program implementation work conducted by Nexant in Illinois for the Commonwealth Edison Company Commercial Recommissioning Program.

The evaluators calculated savings using the following savings algorithm:

Total Energy Savings (kWh) = Conditioned Space x 0.24 kWh/ft^2

Supply Air Temperature Reset

Supply air temperature involves a strategy where supply air temperature is adjusted based on outside air temperature, return air temperature, or zone level information in VAV system applications featuring zone level reheat capabilities.

The survey asked respondents whether they had implemented supply air temperature reset control strategies at any of their facilities. If "Yes", The evaluators estimated energy savings using a savings factor of 0.12 kWh/ft^2 for cooling and 3,075.81 BTU/ft^2 for heating, which the evaluators determined from Nexant's measure libraries from recommissioning (RCx), building tune-up, and O&M program implementation work conducted by Nexant in Illinois for the Commonwealth Edison Company Commercial Recommissioning Program.

The evaluators calculated electric savings using the following savings algorithm:

Total Energy Savings (kWh) = Conditioned Space x 0.12 kWh/ft^2

The evaluators calculated fossil fuel savings using the following savings algorithm:

Total Fossil Fuel Savings (therms) = Conditioned Space x 3,075.81 BTU/ft^2 / 100,000

Air Distribution System – Optimum Start/Stop

This operating practice is a refinement of scheduled operation. Under scheduled operations timers activated air handlers at pre-established hours of the day in order to achieve desired indoor air conditions prior to occupancy. Optimum start-stop operations allow start times to be modified based on actual weather conditions. Most systems monitor outside air temperature, outside air humidity, and indoor air temperature.

The survey asked respondents whether they had implemented optimum start-stop control strategies at any of their facilities. If implemented, the evaluators deemed energy savings using a savings factor of 0.10 kWh/ft^2 for cooling and 648.5 BTU/ft^2 for heating. These factors the evaluators determined from Nexant's measure libraries from recommissioning (RCx), building tune-up, and O&M program implementation work conducted by Nexant in Illinois for the Commonwealth Edison Company Commercial Recommissioning Program.

The evaluators calculated electric savings using the following savings algorithm:

Total Energy Savings (kWh) = Conditioned Space x 0.10 kWh/ft^2

The evaluators calculated fossil fuel savings using the following savings algorithm:

Total Fossil Fuel Savings (therms) = Conditioned Space x 648.5 BTU/ft^2 / 100,000

Air Distribution System – Enthalpy Economizer Conversion

Operators implement this measure to upgrade an outside air dry-bulb economizer to a dual enthalpy controlled economizer. Dual enthalpy economizers regulate the amount of outside air introduced into a ventilation system based on the relative temperature and humidity of the outside and return air. If the enthalpy (latent and sensible heat) of the outside air is less than that of the return air when space cooling is required, then the system allows outside air in to reduce or eliminate the cooling requirement of the air conditioning equipment.

The survey asked respondents whether they had upgraded a pre-existing dry-bulb economizer to a dual-enthalpy economizer at any of their facilities. If implemented, the evaluators deemed energy savings using a savings factor of 0.14 kWh/ft^2. The evaluators deemed this factor from Nexant's measure libraries from recommissioning (RCx), building tune-up, and O&M program implementation work conducted by Nexant in Illinois for the Commonwealth Edison Company Commercial Recommissioning Program.

The evaluators calculated electric savings using the following savings algorithm:

Total Energy Savings (kWh) = Conditioned Space x 0.14 kWh/ft^2

Air Distribution System – Schedule VAV's & Fan-Powered Boxes

This measure consists of implementing start/stop operations for Variable Air Volume (VAV) boxes and fan-powered boxes in a central air distribution system. Energy savings result from a decrease in supply air demand when the system closes dampers on VAV boxes or moves them to the minimum open position during unoccupied periods of the day. Savings also result when the system shuts down fan motors and electric heating elements in fan-powered boxes at pre-established times when the building is unoccupied. Proper implementation of this measure results in cooling and heating energy savings.

The survey asked respondents whether they had implemented scheduling of VAV's or fan-powered boxes at any of their facilities. In instances where they had, the evaluators deemed energy savings using a savings factor of 0.05 kWh/ft^2 for electric cooling savings and 224.7 BTU/ft^2 for fossil fuel heating savings. The factors the evaluators determined from Nexant's measure libraries from recommissioning (RCx), building tune-up, and O&M program implementation work conducted by Nexant in Illinois for the Commonwealth Edison Company Commercial Recommissioning Program.

Electric The evaluators calculated savings using the following savings algorithm:

Total Energy Savings (kWh) = Conditioned Space x 0.05 kWh/ft^2

Fossil Fuel The evaluators calculated savings using the following savings algorithm:

Total Fossil Fuel Savings (therms) = Conditioned Space x 224.7 BTU/ft^2 / 100,000

Air Distribution System – Duct Static Pressure Control

Control strategies that allow a variable air volume system to reduce duct static pressure at part-load conditions can result in lower supply fan speeds and energy savings.

The survey asked respondents whether they had implemented duct static pressure reset controls at any of their facilities. In instances where they had, the evaluators deemed energy savings using a savings factor of 0.20 kWh/ft^2 for electric cooling savings and 944 BTU/ft^2 for fossil fuel heating savings. The factors the evaluators determined from Nexant's measure libraries from recommissioning (RCx), building tune-up, and O&M program implementation work conducted by Nexant in Illinois for the Commonwealth Edison Company Commercial Recommissioning Program.

The evaluators calculated electric savings using the following savings algorithm:

Total Energy Savings (kWh) = Conditioned Space x 0.20 kWh/ft^2

The evaluators calculated fossil fuel savings using the following savings algorithm:

Total Fossil Fuel Savings (therms) = Conditioned Space x 944 BTU/ft^2 / 100,000

VFD for HVAC Fans & Pumps

The survey asked operators to provide the quantity of VFDs installed as well as the combined CFM (cubic feet per minute) of the retrofitted supply fans. The evaluators estimated total fan brake-horsepower (BHP) using the CFM capacities that the respondent provided and manufacturer's data taken from *Greenheck* product literature for centrifugal fans (*Models SFD/SFB/SWB*) and vaneaxial fans (*Model AX*). For this evaluation, the evaluators stipulated fans indicated to be 25,000 CFM or less to be centrifugal. The evaluators stipulated fans with maximum volumetric flow rates exceeding 25,000 CFM to be vane axial. The evaluators used manufacturer's data to develop CFM-to-BHP trends and algorithms used to estimate fan BHP based on the fan CFM provided by the respondent during the survey. The evaluators then estimated energy savings using the following algorithm below:

Total kWh/Year = ESF x BHP x Hours / η_{motor}

Where:

ESF = Deemed VFD Energy Savings Factor = 0.15 [61]

[61] Deemed savings factor for VFD for HVAC Fans measure determined based on Nexant's implementation experience and recommendations from the State of Ohio Energy Efficiency Technical Reference Manual

BHP = Fan Brakehorsepower

Hours = Stipulated Hours of Use for Motors in Commercial Buildings [62]
- Office = 4,400 hours
- Health Care - Inpatient = 7,250 hours
- Education = 5,000 hours
- Retail = 5,550 hours
- Other = 5,250 hours

η_{motor} = Fan Motor Efficiency = Deemed at 90%

The evaluators used an energy savings factor of 0.15 to estimate savings for VFD on HVAC fan measures. The evaluators used several TRMs to develop the deemed savings factor. The 2010 Ohio TRM recommends savings factors ranging from .092 to 0.535 and the 2012 Pennsylvania Utility Commission TRM and Mid-Atlantic TRM recommend savings factors ranging from 0.123 to 0.717 depending upon the pre-existing fan operating conditions and air volume modulation capabilities. Higher savings factors apply to constant volume fan systems. Lower savings factors apply to systems previously equipped with forward curved or air foil inlet guide vanes. Due to time constraints, the survey not gather all fan system characteristics; therefore evaluators used a conservative estimate for savings.

Approximately two-thirds of the survey respondents reporting to have installed VFDs on HVAC fans did not provide a total fan CFM capacity. In those instances the evaluators used the sample average, which was approximately 10 BHP.

The survey asked operators whether they had installed VFDs on any pumps they are responsible for maintaining. The evaluators credited those responding positively with a lump sum of 33,534 kWh/year in annual energy savings. The evaluators had to use a lump sum approach because of the survey's limited ability to gather information on quantities and pump horsepower ratings. The evaluators stipulated a lump sum value for this evaluation based upon the findings of past evaluation work; specifically the findings from Nexant's 2012 Evaluation of VFD - Pump Measures for the Wisconsin Focus on Energy Business Incentive and Large Energy User Programs, which encompassed a total of 53 projects.

Compressed Air Leak Survey & Repair

Air leaks in a compressed air system can be a significant source of wasted energy (up to 20-30% of total compressed air production capacity[63]). It is possible to minimize energy losses through

(August 6, 2010) , the Pennsylvania Public Utility Commission Technical Reference Manual (June 2012), and the 2011 Mid-Atlantic TRM.

62 Source: 2012 Pennsylvania Utility Commission TRM, page 172, Table C-14: Stipulated Hours of Use for Motors in Commercial Buildings.

the performance of routine leak surveys and repairs. There are several methods for detecting air leaks in a compressed air system. The most effective way to identify leaks is to use ultrasonic acoustic detecting technology. Other methods include infrared thermography, audible sound, and the application of soapy water over areas where there may be leaks.

The survey asked respondents whether they had incorporated compressed air leak surveys and repairs into their standard O&M procedures. The survey also asked those responding positively to provide the frequency of these surveys, the number of leaks typically identified and repaired, and the instrumentation/method used to identify leaks. The evaluators determined energy savings for each respondent based on the number of leaks reportedly identified and repaired on an annual basis. The evaluators discounted savings based upon the frequency of surveys and the type of instrumentation used to identify leaks.

The algorithm used to estimate savings for this measure is:

Total kWh/Year = Qty x Frequency Factor x Instrumentation Factor x Savings Factor x 8,760

Where:

Qty = Quantity of Leaks Repaired

Frequency Factor = 1 if "At least annually", 0.5 if "Less than annually", 0 if "Never", "Other", or "As needed"

Instrumentation Factor = 1 if "Ultrasonic leak detectors", 0.75 if "Infrared camera", 0.5 if "Audible Sound" or "Other"

Savings Factor = 0.75 kW per leak repaired [64]

8,760 = Deemed Annual Hours of Operation

Replace Tank-Type Water Heater with Tankless

The survey asked respondents whether they had replaced standard tank-type water heaters with tankless water heaters at any of their facilities. The survey also asked respondents to provide the quantity, tank capacity, and fuel source (gas or electric) for any that they replaced. A significant number of the respondents did not provide tank capacities; therefore, the evaluators stipulated

---

[63] Source: Marshall, Ron. "Finding and Fixing Leaks." Available at: http://www.airbestpractices.com/system-assessments/leaks/finding-and-fixing-leaks.

[64] Average savings per leak repaired based on findings of 2012 Wisconsin Focus On Energy Business Incentive and Large Energy User Evaluation performed by Nexant. Sample size of 31 compressed air survey and repair projects.

savings for this measure assuming a 50-gallon tank capacity and energy factor of 0.62 for the baseline water heating system. The evaluators assumed replacement tankless water heaters to have an energy factor of 0.82.

For natural gas-fired water heaters the evaluators stipulated energy savings at 9,700,000 BTU/year per unit based on technical reference manuals[65]. For electric water heaters energy the evaluators stipulated savings at 461 kWh/year per unit, based on data collected and reported by the Regional Technical Forum[66].

Cooling Coil Cleaning

The evaluators used a maximum deemed savings factor of 2% of total annual space cooling energy consumption to estimate annual energy savings resulting from annual cooling (evaporator) coil cleaning. We determined the annual space cooling consumption for each respondent by multiplying the building square footage by the appropriate electric EUI (kWh/ft^2) value based on facility type and climate zone determined by zip code. The evaluators credited respondents who report cleaning evaporator coils on an annual basis with the full 2% savings factor and those indicating "Less than once a year" with a discounted savings factor of 1%. The evaluators based the deemed savings factor of 2% upon the findings of a work paper on "Commercial Evaporator Coil Cleaning" published by San Diego Gas & Electric Energy Efficiency Engineering Department dated June 4, 2012[67]. The evaluators used the following algorithm to determine savings:

Savings for those who claim to perform coil cleaning "At Least Once a Year"

kWh Saved/year = 2% x Conditioned Space (ft2) x EUI Space Cooling (kWh/ft2)

Savings for those who claim to perform coil cleaning "Less than once a year"

kWh Saved/year = 1% x Conditioned Space (ft2) x EUI Space Cooling (kWh/ft2)

Replace Standard Efficiency Motor with Premium Efficiency Motor

The survey asked respondents whether they had replaced standard efficiency motors with premium efficiency motors at any of their facilities since becoming BOC-credentialed. The survey asked those who reported having done so to provide quantities, ages, and rated

[65] Source: Rhode Island Technical Reference Manual for Estimating Savings from Energy Efficiency Measures 2012 Program Year

[66] Regional Technical Forum Electric Savings Assumptions for Tankless Water Heaters

[67] Harmstead, Charles. "Commercial Evaporator Coil Cleaning"

horsepower values for each motor. The evaluators calculated energy savings using the following algorithm:

kWh/Year Savings = DSF x Motor Horsepower x Qty x Operating Hours

Where:

Operating Hours = Stipulated Hours of Use for HVAC Fan Motor = 4,000 hours

DSF = Deemed Savings Factor determined based upon motor horsepower and the following table extracted from the *Wisconsin Focus on Energy Evaluation: Business Programs: Deemed Savings Manual V1.0 published March 22, 2010.* (See Table 56.)

Table 56: Deemed kW Savings Factor for Replacing Standard Efficiency Motors with NEMA Premium Efficiency Motors

Motor HP	Deemed Savings Factor (kW)	Motor HP	Deemed Savings Factor (kW)
1	0.0177	30	0.2025
1.5	0.0221	40	0.2202
2	0.0291	50	0.347
3	0.0381	60	0.3817
5	0.0546	75	0.4056
7.5	0.0863	100	0.4874
10	0.1075	125	0.5385
15	0.1214	150	0.5784
20	0.1926	200	0.9505
25	0.1769		

Schedule Pumps

This measure consists of turning off pumps when they are unnecessary through the use of central control strategies or timers.

The survey asked respondents whether they had implemented pump scheduling at any of their facilities. The evaluators credited those who responded positively with energy savings estimated by multiplying conditioned space (ft2) by an energy savings intensity factor of 0.11 kWh/ft^2, which the evaluators determined from Nexant's measure libraries from recommissioning (RCx), building tune-up, and O&M program implementation work conducted by Nexant in Illinois for the Commonwealth Edison Company Commercial Recommissioning Program.

The savings algorithm is:

Total Energy Savings (kWh) = Conditioned Space x 0.11 kWh/ft^2

Lighting Retrofit

The survey asked respondents whether they had completed lighting retrofit projects at any of the facilities they are responsible for maintaining and to identify only those retrofits they had not received incentives for. The survey asked respondents to provide specific project information including the quantity of fixtures replaced, the type of fixtures removed and installed, fixture or lamp wattages for the baseline and retrofit fixtures, and the overall project savings (if known). Approximately 44% of the respondents reported completing lighting retrofits at one of their facilities, but only 24% of the projects did not receive an incentive or rebate.

The majority of respondents were unable to provide all of the information requested; particularly when it came to lamp or fixture wattages and overall project savings. In instances where respondents could not provide this information, the evaluators stipulated baseline and retrofit fixture wattages using the fixture and lamp descriptions provided by the building operator and Nexant's comprehensive database of lighting practices. The basic algorithm used for all lighting retrofits is shown below:

Annual Savings kWh/yr = ($LtgWatts_{old}$ – $LtgWatts_{new}$) x Qty / 1,000 * Operating Hours

Where:

$LtgWatts_{old}$ = Baseline Fixture Watts

$LtgWatts_{new}$ = Retrofit Fixture Watts

Qty = Quantity of Fixtures Replaced

1,000 = Watts per Kilowatt

Operating Hours = Deemed Based on Occupancy/Facility Type [68]

- Education = 2,300
- Health Care - Inpatient = 5,000
- Health Care - Outpatient = 3,600
- Lodging = 3,000
- Mercantile Retail = 4,800
- Office = 3,200
- Other = 2,500
- Warehouse and Storage = 3,000

[68] Source: 'RTF Lighting Operating Hours and Controls Priority.xlsx' available on Regional Technical Forum website: http://rtf.nwcouncil.org/subcommittees/comlighting/.

Lighting Controls

The survey asked respondents whether they had installed lighting controls or occupancy sensors at any of the facilities they are responsible for maintaining. The evaluator credited savings to NEEA only for projects that respondents implemented without the aid of a rebate or incentive. If a respondent had completed a project without incentives, the survey asked the respondent to provide specific details such as:

- Control technology (occupancy sensors, timers, photocells, or central Energy Management System)
- Year of Upgrade
- Whether they installed new controls or if project just involved set-point modifications
- Controlled load (combined kW of all affected light fixtures)
- Baseline (pre-retrofit) lighting control operations
- Estimated project savings (kWh/year) or reduction in daily or annual lighting system operating hours

Most respondents could not provide all requested information. Therefore, the method that the evaluators used to determine energy savings depended upon the amount of information the each respondent provided. The evaluators used custom calculations to estimate savings when respondents provided sufficient information. The evaluators used a deemed approach in instances where the respondent was unable to provide sufficient information to support custom calculations.

The deemed savings approach consisted of applying energy savings factors (kWh/ft^2) to building square footage. The evaluators developed the deemed energy savings factor based on the calculated average of lighting control measures from Nexant's 2012 Evaluation of the Wisconsin Focus on Energy Business Incentive and Large Energy User Programs. The deemed savings algorithm is shown below:

The savings algorithm is:

Total Energy Savings (kWh) = Conditioned Space x 0.005957 kWh/ft^2

F APPENDIX F: DATA COLLECTION INSTRUMENTS

STAFF INTERVIEW GUIDE

Draft 10/11/12, Revised 10/17/12

Interview Objectives

The objective is to understand:

- ➡ Background and Initiative Progress
  - Document initiative progress toward the 2012 objectives, including perceptions about which areas of the initiative are most successful and why; which are less successful and why not.
  - Identify barriers and opportunities to expanding BOC training and achieving greater penetration among building operators.
- ➡ New BOC Product
  - Gather details about the new BOC "blended learning" course, set to pilot in November, 2012.
  - Learn about ANSI accreditation for BOC learning course and the expected impact on achieving expanded training and penetration goals.
  - Learn about the program's experience to date with new sub-groups (IUOE members, veterans, Federal employees)
- ➡ Market Transformation Strategy [primarily Kim Hughes and Cynthia Putnam]
  - Per Karen Horkitz' suggestion at the 9/27 team meeting, prompt key initiative staff to articulate the MT strategy, including exit strategy (e.g., how will we know when the market has been transformed?)

Interview Respondents

Organization	Contact Name	Contact Position
NEEA	Kim Hughes	Operations Manager, Commercial Sector
NEEC	Cynthia Putnam	BOC Program Director (Program and curriculum development)
Lane Community College	Erik Westerholm	Oregon BOC Delivery
NEEC	Karen Schraven	BOC Marketing and Course Logistics

Interview Approach

We will conduct phone interviews with program staff in October 2012. Interviews should last 30 to 60 minutes.

Interview Guide

Name _____

Title _____

Phone _____

Email _____

Introduction

My firm, Research Into Action, is conducting an evaluation of the BOC-E initiative. The purpose of the interview today is to better understand (a) how the program is currently implemented and marketed, (b) progress toward its 2012 goals, (c) how initiative activities are expected to address market barriers, (d) the ways in which coordination with other organizations occurs, and (e) staff articulation of the market transformation theory. Your responses will also help us refine our certificant survey questions.

Role

1. Please describe your role with the BOC-E initiative and how long you have been working in this position.

Initiative Progress

2. The initiative was approved in March 2012. Please briefly outline the key activities the initiative has been focusing on since then.

3. **[If not addressed already]** Can you give me an update on progress in recruiting veterans, IUOE members, and Federal employees?

4. So far, for the initiative overall what has been working particularly well?

5. What has been particularly challenging?

6. The online portion of the "blended learning course" for BOC certification is scheduled to pilot next month, in November. Is this on track?

Initiative Design/Expanded BOC Product

7. Please describe how you expect the blended learning course to function.

8. How many students do you expect to take the course?

9. The initiative's Quarterly Progress Toward Business Objectives document lists "develop ANSI standard recommendation" as an objective for December 2012. Please describe this process and what barrier or barriers you expect it to address in the market.
[If needed: In the logic model, the barrier is listed as "Product performance standard (ANSI)"]

    a) Process description:

    b) Barriers it will address:

    c) How it will address barrier/s

10. How will the ANSI accreditation boost BOC participation by Federal employees?

11. In July 2012, the IUOE partnership was formalized. Please describe this partnership and what barrier or barriers you expect it to address.
[If needed: The logic model indicates it should address the "lack of awareness" market barrier.]

    a) Description of partnership:

    b) Barrier/s it will address:

    c) How it will address barrier/s:

12. Please describe the BOC Renewal Implementation Plan.

13. Is the Renewal Implementation Plan on track to be implemented in this month, per the Quarterly Progress Report?

14. How will the design of this (BOC Renewal) plan ensure that employers and operators value maintenance and certification?
[Note: The logic model identifies "Maintenance and certification is valued by employers and operators " as an outcome, which will be measured by MPI #9 (Maintenance of certification is valued by employers and operators)]

15. Aside from the above, is there anything you can tell me about how the program may have departed from the program logic model?

16. Are there any elements of the logic model that you think may need to be revised?

Marketing and Outreach Campaigns/Processes

17. Please describe the key marketing activities for the expanded BOC initiative.

18. How, if at all, has integration with the NEEA's marketing and Education & Training teams affected the initiative's ability to conduct marketing and outreach?

19. How would you describe the initiative's key marketing strategies?

20. What marketing activities have taken place thus far?

21. How do you expect these activities to boost participation in BOC course offerings, particularly in underserved markets?

22. Please describe the marketing and outreach activities that will target unemployed operators and returning Veterans.

MT Strategy

23. Please describe the initiative's overall Market Transformation strategy, including its exit strategy.
[Probe for additional strategies to expand BOC beyond utility role in supporting BOC +." Karen Horkitz did not see an articulation of how the strategy builds demand – the demand side strategy. Probe for any additional support of a demand side strategy]

Final Thoughts

24. **[If not addressed before the interview]** We plan to interview up to 15 market informants outside of NEEA and NEEC to inform our review of the ACE model assumptions. We anticipate interviewing contacts from BOMA, BOMI, IUOE, community colleges, and federal-sector operators. Can you identify any individuals you think would be good contacts to interview?
[Ask for full name and contact information]

25. Do you have any additional thoughts about the BOC-E initiative that you think will be valuable for the evaluation that we did not already touch on?

MARKET INFORMANT INTERVIEW GUIDE

Final December 3, 2012

Interview Objectives

- Learn about the building operator market (e.g. operator qualifications, trends, square footage, supervisor/multiple staff issues, existence of studies on state-of-the-art practices)
- Gain market informant perspective on barriers to BOC training
- Gather informant perspectives on best ways to address market barriers and achieve the initiative's desired outcomes.

In advance of the interview, we will email the informants to arrange a time to talk.

Interviewer to Note: Operation and maintenance activities are different but equally important. Maintenance activities ensure that equipment and systems have the capacity to run effectively. For example, dirty condenser coils reduce the capacity of the air conditioning system by not allowing sufficient heat transfer to occur. Operational activities ensure that equipment and systems perform optimally. If operators set up poorly staged air conditioning compressors or if compressors operate when free cooling could be used, the compressors are wasting energy and sometimes affecting comfort by overcooling spaces.

Introduction

I'm calling on behalf of the Northwest Energy Efficiency Alliance to talk with you about its Building Operator Certification Expansion initiative (BOC-E). As a key person in the BOC marketplace, I'd like to hear your perspective on a range of topics related to NEEA (in partnership with NEEC)'s efforts to increase participation in BOC training, in hopes of boosting BOC certifications, across the northwest.

I'm estimating this survey will take about 20 minutes. Is now a good time to talk? If not, could we schedule another time at your convenience?

Understanding the Market

Who Are Building Operators

First, I'd like to learn a little bit about who building operators are, and what motivates them. I'd also like to note that throughout our interview, any reference to buildings will mean commercial buildings.

1. What are the typical responsibilities of a building operator? What are the typical qualifications or backgrounds of a building operator?

2. Thinking about the population of building operators, who among them typically seeks out BOC certification?

3. What motivates a building operator to become BOC certified?

4. Conversely, what types of things stand in the way of building operators becoming BOC certified?

Trends in Building Operations

Now I'd like to talk a little about any recent trends you see in building operations.

5. Thinking back to 10 years ago, what key trends and changes in the field of building operations have you seen since then?

   [**Probe**]

   Is there a change in how buildings are managed and maintained?

   Is there a change in the skill sets of the people (i.e. minimum qualifications) who do this work?

Current State of Energy Efficiency in Commercial Buildings

6. How familiar are you with the types of energy efficiency measures that BOC training addresses?

   [Probe]

   About what measures, etc.

7. What do you think is the overall state of energy efficiency in commercial buildings with respect to those types of measures?

   [Probe]

   Does it vary by public/private sector?

   Does it vary by building type?

8. Are you aware of any studies, sources, or reference guides on current, "state-of-the-art" or “best practices” for building operation and maintenance activities?

BOC Expansion Potential

The next topic I’d like to explore is how much of the commercial space in the Northwest has potential for employing in-house, BOC-certified operators.

9. What is your estimate of the portion of commercial space that has *internal* operations staff vs. *outsourced* building operations staff (e.g. to Johnson Controls, etc.)?

    a. Is there a typical building size threshold below which facilities are unlikely to have a building operator on staff? **(Note to interviewer: NEEA currently assumes all buildings above 100,000 SF have operators, and half of those below 100,000 SF)**

    b. Of the internal operations staff, what is your estimate of the portion that is BOC certified vs. non-certified?

    c. What is your estimate of the portion of building operations *companies*, like Johnson Controls, that have any BOC-certified staff?

    d. And what’s your estimate of the proportion of these contract *staff* that are BOC-certified?

10. How do owner-occupied buildings compare to tenant-occupied buildings in terms of interest in BOC certification?

11. How should BOC administrators approach outreach to these two occupant types to build awareness of BOC?

How Building Operations Staff Apply BOC Knowledge

Now I’d like to ask you to explain how building operations staff are organized.

10. Could you please describe common ways in which the job responsibilities of building operations staff are organized? For example, if one is BOC-certified, are they responsible for some portion of square footage, or a single piece of equipment, etc.?

    [Probe]

    Is there some sort of a "standard?" Or is it idiosyncratic?

11. Do building owners or managers typically send only supervisors, or multiple operations staff for BOC training?

    [Probe]

    What would be the advantage to sending multiple staff vs. having a BOC-trained supervisor disseminate information to internal building operations staff?

12. What are the common ways that trained staff disseminate BOC knowledge among building staff?

    [Probe]

    Operations manuals, updates to manuals, etc.

    Supervisor gets trained, supervisor comes back and trains his/her staff?

    Supervisor gets trained AND sends his/her staff for training?

    Supervisor gets trained, then directs his/her staff on specific activities?

    Other?

Attributing Energy Savings to BOC

The program needs to count energy savings impacts. Currently, this is calculated using a series of inputs such as number of operators trained, square footage per operator, how long the training produces savings (i.e. "measure life"). I'd like to get your input on the key variables associated with energy savings that result from BOC training and certification.

13. In thinking about how BOC training results in energy savings, can you provide any insight into the important variables the program should consider when determining energy savings?

Market Value of BOC

14. How valuable an asset is BOC certification to employers of building operators?

15. How valuable an asset is BOC certification to the building operators themselves?

16 Is there any evidence of market value for BOC certification?

    [Probe]

What evidence is there? Job postings?

17. What will it take to increase employer perceptions of the value of BOC certification?

18. What will it take to increase building operator perceptions of the value of BOC certification?

Market Awareness of, and Barriers to, BOC Training

Now I'd like to shift gears from understanding how the market works to understanding specific factors affecting the prevalence of BOC certification in the market.

19. One of the barriers the BOC-Expansion initiative is trying to address is "lack of awareness" about BOC training and certification opportunities. Do you have any insights to share on how aware building operators are of BOC in the northwest?

    [Probe]

    Is lack of awareness a widespread problem?

    Are there regional differences in awareness about BOC?

20. What are your thoughts on the most effective strategies and methods to inform building operators about BOC training opportunities?

21. Do you anticipate that it would be effective for the initiative to partner with the International Union of Operating Engineers (IUOE) as a means of increasing awareness?

Underserved Markets

"Underserved markets or communities" are defined as markets that BOC serves on an infrequent basis (i.e. ranging from once every three to seven years), and generally only with the active engagement of a utility sponsor or larger employer. The trainings have experienced some difficulty reaching operators in "underserved markets" because the market population is small and enrollment is not sufficient to cover training delivery costs.

22. What markets do you think might be underserved?

    [Probe]

    Do what extent do you think the following are underserved markets: rural locations, individuals with atypical needs (such as returning veterans and unemployed operators), and business types with atypical needs?

23. Do you think the outreach and promotional strategies need to differ for underserved markets?

    [Probe]

    What should those strategies look like? Do they vary by specific underserved submarket?

    Do these groups need assistance to afford the training?

24. What do you think are the key barriers to building operators obtaining BOC certification in underserved markets?

25. How might BOC content, structure, or delivery need to change to increase its uptake among firms in underserved markets?

26. Soon, BOC training will occur via a "blended learning course," which offers 20-25% of the curriculum online, with the rest being classroom-delivered. How will the blending learning course help mitigate these barriers?

    [Probe]

    Is offering 20-25% of the curriculum online enough, or should all, or perhaps some larger portion of the curriculum be available online to better mitigate the barriers?

Federal Sector

27. What do you think are the key barriers to building operators obtaining BOC certification in the Federal Sector?

28. What are some methods that you think would be effective at increasing federal sector participation?

Authorized provider under ANSI Standard 17024

29. For BOC training, how would becoming an ANSI authorized provider help build interest in the federal sector?

    [Probe]

    Would that be an effective strategy for BOC to pursue in further reaching this sector?

Outreach

Final Thoughts

30. Is there anything else you'd like to add regarding expanding BOC certification in building operations market?

Thank you very much for taking the time to speak with me today.

BOC CERTIFICANT SURVEY

[The following variables were piped into the survey from the NEEC BOC database:

- CERTYEAR: Year of initial certification
- RENEWYEAR: Year of most recent renewal
- SIZE: Facility size

Thank you for agreeing to take this survey! Please read each question carefully and select the response that best represents your experience. If you are not sure about any answer, please provide your best guess - that is much better than having no information!

In multiple choice questions, please try to choose one of the options we have provided. However, we realize that often the responses we provided are not sufficient, so we have included "other" options where you can provide a brief explanation if you wish.

S1: First, we'd like to confirm that you received building operator certification from BOC – is that correct?

- ☐ Yes (1)
- ☐ No (2)

If S1 = No, Thank and Terminate

S2: Do you conduct or direct operations and maintenance activities at your facility?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I am not currently employed (4)

If S2 ≠ Yes, Thank and Terminate

S3: The BOC database shows that you initially received your certification in [CERTYEAR]. Does that seem right to you?

- ☐ Yes (85)
- ☐ No (86)
- ☐ I'm not sure (88)

Answer S4 If S3 = No or I'm not sure

S4: When did you receive certification?

Answer S5 If RENEWYEAR Is Not Empty

S5: The BOC database also shows that you most recently renewed your certification in [RENEWYEAR]. Does that seem right to you?

- ☐ Yes (81)
- ☐ No (82)
- ☐ I have not renewed my certification (83)
- ☐ I'm not sure (84)

Answer S6 If S5 ≠ No

S6: When did you most recently renew your certification?

Let's continue with some details about your job and your workplace.

1. What is your current job title?

- ☐ Operations manager (1)
- ☐ Maintenance manager (2)
- ☐ HVAC supervisor or technician (3)
- ☐ Engineering manager (4)
- ☐ Facilities manager (5)
- ☐ Engineer (6)
- ☐ General contractor (8)
- ☐ Building management specialist (9)
- ☐ Other engineering position (10)
- ☐ Other manager, team leader, supervisor position (11)
- ☐ Other – please specify: (12) _____

2. How many years have you worked in this role? (Please either check the "Number of years" button and record the number of years or, if there is some reason you cannot do that, check the other button and feel free to provide a brief explanation.)

   ☐ Number of years (1) _____

   ☐ Other response: (2) _____

Answer 3 If SIZE Is Not Empty

3. Program BOC records show that your facility has [SIZE] square feet of space. Is this accurate?

   ☐ Yes (1)

   ☐ No, we have about this many square feet: (2) _____

   ☐ Other response (3) _____

Answer 3 [alt version] If SIZE Is Empty

3. How many square feet of space does your facility have? (Again, either check 'Number of square feet' and record the number of select one of the other responses. Do not include outdoor areas like parking lots.)

   ☐ Number of square feet (1) _____

   ☐ I'm not sure (2)

   ☐ Other response (3) _____

3a. How much of your facility's space is conditioned? You can give me either the number of square feet or the percentage of the total space. (By 'conditioned' we mean that the space is reached by the facility's heating or air conditioning methods.)

   ☐ Conditioned square feet: (1) _____

   ☐ Percentage that IS conditioned (do not enter the % sign): (2)
   _____

   ☐ Other response (3) _____

   ☐ I'm not sure (4)

4. About how many building operations and maintenance staff work at your facility in total, including both line and supervisory staff?

☐ One (me) (1)

☐ More than one: how many? (2) _____

☐ Other response (3) _____

If 4 = One (me), Then Skip To 5.

4a. We would like to understand how facilities organize their building operations staffs. In the following table, please list the kinds of building operators at your facility, starting with the most senior. For each type, please record a general job title, tell us how many operators have that title, who they report to, whether any of them have the BOC credential, very briefly what their main responsibilities, and what percentage of the facility's area their responsibilities cover. [Record up to seven titles]

	Title	How many?	Who do they report to?	Any with BOC?	Main responsibilities	Percentage of the facility responsible for
1	Text	Numeric	Text	Yes (1) No (2)	Text	Numeric or Text
2	Text	Numeric	Text	Yes (1) No (2)	Text	Numeric or Text
3	Text	Numeric	Text	Yes (1) No (2)	Text	Numeric or Text
4	Text	Numeric	Text	Yes (1) No (2)	Text	Numeric or Text
5	Text	Numeric	Text	Yes (1) No (2)	Text	Numeric or Text
6	Text	Numeric	Text	Yes (1) No (2)	Text	Numeric or Text
7	Text	Numeric	Text	Yes (1) No (2)	Text	Numeric or Text

5. Were you employed at the time that you registered for your first BOC class?

☐ Yes (1)

☐ No (2)

☐ Other response (3) _____

Answer 5a If 5 ≠Yes

5a. Were you employed by the time you completed the BOC class?

☐ Yes (1)

☐ No (2)

☐ Other response (3) _____

6. Are you a returning veteran of the Iraq/Afghanistan war?

☐ Yes (4)

☐ No (5)

☐ Other response (6) _____

Now we would like to learn about your O&M practices, including practices of those working under your supervision. We'll also have a few questions about equipment retrofits or upgrades. Unless otherwise specified, please focus on your practices over the past year or since you received the BOC credential, if less than a year ago.

7. Do your responsibilities include the operation of a boiler system?

☐ Yes (1)

☐ No (2)

☐ Other response (4) _____

If Yes Is Not Selected, Then Skip To End of Block

8. Please provide some information about the boiler: (Please provide your best guess if you are not sure)

Fuel Efficiency (%)	Boiler Product	Other Boiler Product	Rated Heating Input	Fuel Type	Other Fuel Type
0-100	Hot water (1) Steam (2) Other (3) Don't know (4)	Text	Numeric	Natural Gas (1) Oil (2) Propane (3) Electricity (4) Other (5) Don't know (6)	Text

9. How frequently do you or someone working under your supervision perform the following maintenance activities?

	Frequency
(1) Check boiler supply and return temperatures (2) Check boiler stack temperature	1=At least once a day (1) 2=At least once a week (2) 3=At least once a month (3) 4=Less than once a month (4) 5=Only as needed (5) 6=Never have done (6) Don't Know (7)

And how about...?

	1=At least once a quarter (1)	2=2-3 times a year (2)	3=About once a year (3)	4=Less than once a year (4)	5=Only as needed (5)	6=Never have done (6)	Don't Know (7)
Check combustion efficiency (1)							

And the following...?

	1=At least once a year (1)	4=Less than once a year (2)	5=Only as needed (3)	6=Never have done (4)	Don't Know (5)
Check for corrosion or scaling (1)					
Clean fire tubes (2)					
Check and clean heat exchangers (3)					
Replace leaking tubes (4)					
Inspect insulation on piping and boilers (5)					
Clean/replace fuel oil burner tip (6)					
Calibrate sensors (7)					

	1=At least once a year (1)	4=Less than once a year (2)	5=Only as needed (3)	6=Never have done (4)	Don't Know (5)
Inspect steam traps (8)					

10. Have you replaced any of the boilers at your facilities with energy efficient condensing boilers? If so, how many?

☐ No - have not replaced any (1)

☐ Yes - number replaced (best guess) (2) _____

Answer If 10... Yes - number replaced (best guess) Is Selected

10a. Did your organization receive an incentive or rebate from a utility or other funding agency for any such boiler replacement(s)? If so, for how many replacements did you receive a rebate or incentive?

☐ No - did not receive any rebates or incentives (1)

☐ Yes - received rebate or incentive for this many boilers (best guess) (2) _____

☐ Yes - received rebate or incentive for ALL boilers replaced (4)

Answer If 10.... Yes - number replaced (best guess) Is Selected And 10a... Yes - received rebate or incentive for ALL boilers replaced Is Not Selected

10b. We'd like some details about those replacements that your organization did WITHOUT receiving an incentive or rebate. For each replacement, please tell us the year you did the replacement and the RATED input capacities, in BTU/hr, and the efficiencies of both the old and new boilers.

	OLD BOILER Input Capacity (BTU/hr) (1)	OLD BOILER Efficiency (2)	YEAR of Replacement (3)	NEW BOILER Input Capacity (BTU/hr) (4)	NEW BOILER Efficiency Rating (5)
Boiler 1 (1)					
Boiler 2 (2)					
Boiler 3 (3)					
Boiler 4 (4)					
Boiler 5 (5)					

11. Have you implemented hot water reset or cutout controls for any of the boilers at your facilities?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

If Yes Is Not Selected, Then Skip To 12.

11a. Is the hot water temperature reset based on outdoor air temperature?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

If Yes Is Not Selected, Then Skip To 12.

11b. What are the high and low hot water temperature set points, in degrees Fahrenheit (°F)?

High Temp Set Point (°F) (1)

Low Temp Set Point (°F) (2)

Other response (3)

11c. At what OUTDOOR air temperatures (°F) do hot water temperatures change and does the system shut down?

Other response (2)

OUTDOOR air temperatures (°F) at which hot water temperatures change (3)

OUTDOOR air temperature (°F) at which the system shuts down (4)

12. How often do you perform boiler tune-ups?

- ☐ At least once per year (1)
- ☐ Less than once per year (2)
- ☐ Never (3)

- ☐ Other response (4) _____
- ☐ As needed (5)

13. What do you typically do as part of a boiler tune-up? (Check all that apply)

- ☐ Measure flue gas oxygen content (1)
- ☐ Measure flue gas carbon monoxide content (2)
- ☐ Measure flue gas combustibles content (3)
- ☐ Measure flue gas emissions content (NOx) (4)
- ☐ Measure fuel flow rate (5)
- ☐ Measure flue gas temperature (6)
- ☐ Measure steam flow rate (if steam boiler) (7)
- ☐ Adjust combustion control positioning to achieve desired combustion characteristics (targets will generally be in accordance with Manufacturer's Specifications) (8)
- ☐ Document pre- and post-tune-up conditions as well as any modifications/repairs made (9)
- ☐ Other – specify: (10) _____

14. What instrumentation do you use in evaluating boiler operating conditions? (Check all that apply)

- ☐ Portable combustion analyzer (1)
- ☐ Infrared thermometer (temperature gun) (2)
- ☐ Thermocouple Probe (3)
- ☐ Other – specify: (4) _____

15. How often do you calibrate boiler controls?

- ☐ At least annually (1)
- ☐ Every one to two years (2)

- ☐ Less frequently than every two years (3)
- ☐ Never (4)
- ☐ Other response (5) _____
- ☐ As needed (6)

16. Have you implemented any energy-saving modifications to boiler equipment scheduling? If so, what were they?

- ☐ Yes (please describe) (1) _____
- ☐ No (2)
- ☐ Other response (4) _____

17. Have you implemented any other boiler or steam-system-related O&M measures that we have not asked about yet? If so what were they?

- ☐ Yes (please describe) (1) _____
- ☐ No (2)
- ☐ Other response (4) _____

18. Do your responsibilities include the operation of a chilled-water system?

- ☐ Yes (1)
- ☐ No (2)

If Yes Is Not Selected, Then Skip To End of Block

19. What is the nominal cooling capacity of the chiller(s), EITHER in tons OR BTU/hr of input? (Please record one or the other)

- ☐ BTU/hr (1) _____
- ☐ Other response (2) _____
- ☐ I don't know (3)
- ☐ Tons (5) _____

20. What is the chiller system's rated operating efficiency? (Provide as many of these as you easily can)

Design efficiency % (1)

Coefficient of Performance (CoP) % (2)

Integrated part-load value (IPLV) % (3)

Non-standard part-load value (NPLV) % (4)

Other response (5)

Again, the following questions relate to your activities in the past year, or since you received certification if less than one year ago. And they apply to persons working under your supervision as well as to yourself. 21. What O&M practices have you implemented to optimize chiller performance?

22. Have you implemented chilled-water reset controls at any of your facilities?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (4)

If Yes Is Not Selected, Then Skip To 23.

22a. What is the normal chilled-water operating temperature (°F) during peak cooling season?

- ☐ Temperature (°F) (1) _____
- ☐ Other response (2) _____
- ☐ I don't know (3)

22b. By how many degrees (°F) is temperature offset?

- ☐ Other response (1) _____
- ☐ Degrees (°F) (2) _____
- ☐ I don't know (3)

23. Do any of your facilities feature cooling towers?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

Answer If 23… Yes Is Selected

23a. Have you implemented condenser water supply temperature reset controls at any of these facilities?

- ☐ Yes (1)
- ☐ No (2)
- ☐ Other response (3) _____

24. Have you implemented any other chilled-water system-related O&M measures that we have not asked about yet? If so, what were they?

- ☐ Yes (please describe) (1) _____
- ☐ No (2)
- ☐ Other response (3) _____

25. Do your responsibilities include the operation of economizers and ventilation control?

- ☐ Yes (1)
- ☐ No (2)

If Yes Is Not Selected, Then Skip To End of Block

Again, all questions refer to the things that you or anyone working under your supervision do.

26. Have you installed carbon monoxide (CO) based ventilation controls at any of your facilities?

- ☐ Yes (1)
- ☐ No (2)
- ☐ Other response (3) _____

27. Have you evaluated the amount of outside air supplied by the central HVAC system at any of your facilities?

- ☐ Yes (1)
- ☐ No (2)
- ☐ Other response (3) _____

28. Do any of your facilities have HVAC systems equipped with air-side economizers?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

If Yes Is Not Selected, Then Skip To 29.

28a. Have you added air-side economizers to any of the HVAC systems at your facilities?

- ☐ Yes (1)
- ☐ No (2)
- ☐ Other response (3) _____

28b. Have you repaired inoperable pre-existing air-side economizers? If so, how did you do it?

- ☐ Yes - please briefly describe how (1) _____
- ☐ No (2)
- ☐ Other response (3) _____

28c. Have you done anything to optimize pre-existing air-side economizers? If so, what did you do?

- ☐ Yes (please briefly describe) (1) _____
- ☐ No (2)
- ☐ Other response (3) _____

28d. Have you upgraded pre-existing outside-air dry-bulb economizers to dual-enthalpy economizers?

- ☐ Yes (1)
- ☐ No (2)
- ☐ Other response (3) _____

29. Have you implemented supply air temperature reset strategies at any of your facilities? (For example, using free cooling provided by an economizer to increase supply air temperature set points and decrease cooling system operating hours)

- ☐ Yes (1)
- ☐ No (2)
- ☐ Other response (3) _____

30. Have you incorporated optimal start algorithms into any of the central HVAC control systems serving the facilities you operate or manage?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

If Yes Is Not Selected, Then Skip To 31.

30a. Is optimal start being used during heating and cooling seasons?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

30b. Were nighttime setbacks in place before you implemented optimal start logic?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

31. Have you implemented any other economizer-related O&M measures that we have not asked about? If so, what were they?

- ☐ Yes (please describe) (1) _____
- ☐ No (2)
- ☐ Other response (3) _____

32. Do your responsibilities include the operation of compressed air systems?

- ☐ Yes (1)
- ☐ No (2)

If Yes Is Not Selected, Then Skip To End of Block

33. Have you incorporated regular compressed air leak surveys into standard O&M procedures at any of these facilities?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

If Yes Is Not Selected, Then Skip To 34.

33a. How often do you perform leak surveys?

- ☐ At least annually (1)
- ☐ Less than annually (2)
- ☐ Never (3)
- ☐ Other response (4) _____
- ☐ As needed (5)

33b. What instrumentation do you use to identify leaks?

- ☐ Ultrasonic leak detectors (1)
- ☐ Infrared camera (2)
- ☐ Audible sound (human ear) (3)
- ☐ Other - specify: (4) _____

33c. Has this program been successful?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

33d. How many leaks have you identified and repaired within the past 12 months?

- ☐ Number of leaks (1) _____
- ☐ I don't know (2)
- ☐ Other response (3) _____

34. Have you implemented any other compressed air O&M measures that we have not asked about yet? If yes, what were they?

- ☐ Yes (please describe) (1) _____
- ☐ No (2)
- ☐ Other response (3) _____

35. Do your responsibilities include the operation of fans and air distribution systems?

- ☐ Yes (1)
- ☐ No (2)

If Yes Is Not Selected, Then Skip To End of Block

36. How frequently do you clean heat exchangers and/or cooling coils?

- ☐ At least once a year (1)
- ☐ Less than once a year (2)
- ☐ Never (3)
- ☐ Other response (4) _____
- ☐ As needed (5)

37. Do you inspect motor bearings and drive belts at least once a year?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

38. What methods do you use to evaluate motor conditions?

- ☐ Load measurements (1)
- ☐ Vibration analysis (2)
- ☐ Other - specify: (3) _____
- ☐ None (4)
- ☐ I don't know (5)

39. What types of instrumentation do you use to evaluate motor conditions?

- ☐ Multi-meter (1)
- ☐ Power meter (2)
- ☐ Amprobe (3)
- ☐ Vibration analysis (4)
- ☐ Other - specify: (5) _____
- ☐ None (6)
- ☐ I don't know (7)

40. Do you or those you supervise perform temperature or vibration analyses as part of normal motor maintenance?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

41. Have you implemented Demand Controlled Ventilation controls at any of your facilities?

- ☐ Yes (1)

☐ No (2)

☐ I don't know (3)

42. Have you evaluated duct static pressure or reduced/reset duct static pressure at any of your facilities?

☐ Yes (1)

☐ No (2)

☐ I don't know (3)

43. Have you installed variable frequency drives (VFDs) on any fan systems at your facilities? If so, how many?(Again, please provide your best guess)

☐ Yes - number of VFDs (best guess) (1) _____

☐ No (2)

Answer If 43.... Yes - number of VFDs Is Selected

43a. What is the approximate total CFM (or cubic feet per minute) of the supply fans?

☐ Total CFM (best guess) (1) _____

☐ Other response (2) _____

☐ I don't know (3)

44. Have you implemented any energy saving modifications to main air handling units (AHUs)? If so, what were they?

☐ Yes (please describe) (1) _____

☐ No (2)

☐ Other response (3) _____

45. Have you implemented any energy saving modifications to fan-powered box or variable air volume (VAV) box scheduling? If so, what were they?

☐ Yes (please describe) (1) _____

☐ No (2)

☐ Other response (3) _____

46. Have you implemented any other fan optimization/air distribution system related O&M measures that we have not asked about yet? If so, what were they?

☐ Yes (please describe) (1) _____

☐ No (2)

☐ Other response (3) _____

47. Do your responsibilities include domestic water heaters?

☐ Yes (1)

☐ No (2)

If Yes Is Not Selected, Then Skip To End of Block

48. Have you replaced a standard tank-type water heater with a tankless water heater at any of your facilities? If so, how many?(Again, if you are not certain of the number replaced, please provide your best guess)

☐ Yes - number replaced (best guess) (1) _____

☐ No (2)

If Yes - number replaced (best guess)... Is Not Selected, Then Skip To 49.

48a. Please provide some information about the tank replacements, starting with the most recent:(Provide information for up to three)

	Baseline Fuel Source	Other Fuel Source	Retrofit Fuel Source	Other Fuel Source	Average Tank Volume of Baseline	Other Tank Volume
Specify for up to three replacements:	Electric (1) Gas (2) Both types (3) Other (4) Don't know (5)	Specify Other Source (1)	Electric (1) Gas (2) Both (3) Other (4) Don't know (5)	Specify Other Source (1)	40 (1) 50 (2) 60 (3) 75 (4) 100 (5) Other (6) Don't Know (7)	Specify Other (1)

48b. Did your company (or organization) receive an incentive or rebate from a utility or other funding agency for any such tankless replacements? If so, how many?

- ☐ Yes - all of them (1)
- ☐ No (2)
- ☐ I don't know (3)
- ☐ Yes - received rebate or incentive for this many (best guess) (4) _____

49. Have you implemented any other hot water O&M measures that we have not asked about yet? If so, what were they?

- ☐ Yes (please describe) (1) _____
- ☐ No (2)
- ☐ Other response (3) _____

50. Do your responsibilities include lighting?

- ☐ Yes (1)
- ☐ No (2)

If Yes Is Not Selected, Then Skip To End of Block

51. Have you conducted a lighting system survey and savings opportunity assessment at any of your facilities since receiving BOC certification? If so, in what year?(Your best guess is fine)

- ☐ Yes - what year? (best guess) (1) _____
- ☐ No (2)
- ☐ I don't know (3)

52. Have you implemented any upgrades to lighting controls since receiving BOC certification?

- ☐ Yes (1)
- ☐ No (2)
- ☐ Don't know (3)

If Yes Is Not Selected, Then Skip To 53.

52a. We'd like to get some detail on those upgrades. For each one, please record the type of system upgraded, the year it was done, whether it involved installing new controls or making changes to setpoints or existing systems, and the load (kW) controlled.

	Type of system (use drop-down list).	When upgrade was done	Install new controls?	Rebate?	Change setpoints or existing systems?	Controlled load
Specify up to five	Occupancy Sensors (1) Timers (2) Photo Cells (3) Central EMS (4) Other (5)	Year (1)	Click if "Yes" (1)	Yes (1) No (2)	Click if "Yes" (1)	KILOWATTS (1)

52b. How was lighting controlled prior to the earliest of these changes?

52c. Considering all the changes you just described, approximately how much did those changes reduce energy use in kWh or reduce operating hours?(You may provide either or both information. If you don't know either, please select 'Other' and provide any information that may help estimate energy savings)

- ☐ Energy use reduced by (1) _____
- ☐ Operating hours reduced by (2) _____
- ☐ Other (3) _____

53. Does your facility include a central energy management system, or EMS?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

If Yes Is Not Selected, Then Skip To 54.

53a. Does your facility's EMS automatically turn lights on or off based on time of day?

- ☐ Yes (1)
- ☐ No (2)

- ☐ I don't know (3)
- ☐ Other basis - specify (4) _____

If Yes Is Not Selected, Then Skip To 53b.

53a1. At what hours does the system turn the lights on and off?

53a2. Are these settings modified throughout the year, as days become longer or shorter?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

53b. How often are set points changed within the Energy Management System?

- ☐ More than four times a year (1)
- ☐ About four times a year (2)
- ☐ About three times a year (3)
- ☐ About twice a year (4)
- ☐ About once a year (5)
- ☐ Less than once a year (6)
- ☐ Never (7)
- ☐ I don't know (8)
- ☐ As needed (9)

53c. Does the system control all interior and exterior lighting at the facility?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

54. Is lighting at your facility controlled by occupancy sensors?

- ☐ Yes (1)
- ☐ No (2)
- ☐ Don't know (3)

Answer If 54.... Yes Is Selected

54a. What space types are occupancy sensors being used in?

- ☐ Warehouse (1)
- ☐ Conference room (2)
- ☐ Restroom, bathroom (3)
- ☐ Hallway (4)
- ☐ Other – specify: (5) _____
- ☐ I don't know (6)

55. Have you completed any lighting retrofits involving lamps, fixtures, or ballasts? If yes, about how many?

- ☐ No (2)
- ☐ I don't know (3)
- ☐ Yes - number of retrofits (best guess) (4) _____

Answer If 55.... Yes - number of retrofits (best guess) Is Selected

55a. Did your organization receive an incentive or rebate from a utility or other funding agency for any such retrofits? If so, for how many did it receive an incentive or rebate?

- ☐ Yes - not all (please specify number) (1) _____
- ☐ None (2)
- ☐ I don't know (3)
- ☐ Yes - all of them (4)

Answer If 55.... Yes - number of retrofits (best guess) Is Selected And 55a.... Yes - all of them Is Not Selected

55b. We'd like some details about those lighting retrofits that you did WITHOUT receiving an incentive or rebate. Let's start with the most recent one you did. Please record the year, the type and wattage of the original and new lamps, the number of fixtures retrofitted and delamped, and the project savings.

Year (1)

Type of lamps removed (3)

Wattage of lamps removed (4)

Type of lamps installed (5)

Wattage of lamps installed (6)

Number of fixtures retrofitted (7)

Number of fixtures delamped (8)

Total kW savings (10)

Total first year kWh savings (11)

What was the building used for? (Please select from drop-down menu)

- ☐ Office (1)
- ☐ Retail (2)
- ☐ Grocery (3)
- ☐ School / University (4)
- ☐ Restaurant (5)
- ☐ Hospital / Medical (6)
- ☐ Warehouse (7)
- ☐ Industrial / Process (8)
- ☐ Hotel / Motel (9)
- ☐ Residential / Apartment (10)
- ☐ Government (11)

- ☐ Mixed Use (12)
- ☐ Other (13)

If this was a fluorescent retrofit, what type was it - relamp only, lamp & ballast, or full fixture? (Please select from drop-down menu)

- ☐ Not a fluorescent retrofit (1)
- ☐ Relamp only (2)
- ☐ Lamp & ballast (3)
- ☐ Full fixture (4)
- ☐ Combination of types (5)

Did you do any other lighting retrofits that you DID NOT receive an incentive or rebate for?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

If Yes Is Not Selected, Then Skip To 61.

55c. For that retrofit, please record the same information.

Year (1)

Type of lamps removed (3)

Wattage of lamps removed (4)

Type of lamps installed (5)

Wattage of lamps installed (6)

Number of fixtures retrofitted (7)

Number of fixtures delamped (8)

Total kW savings (10)

Total first year kWh savings (11)

What was the building used for? (Please select from drop-down menu)

- ☐ Office (1)
- ☐ Retail (2)
- ☐ Grocery (3)
- ☐ School / University (4)
- ☐ Restaurant (5)
- ☐ Hospital / Medical (6)
- ☐ Warehouse (7)
- ☐ Industrial / Process (8)
- ☐ Hotel / Motel (9)
- ☐ Residential / Apartment (10)
- ☐ Government (11)
- ☐ Mixed Use (12)
- ☐ Other (13)

If this was a fluorescent retrofit, what type was it - relamp only, lamp & ballast, or full fixture? (Please select from drop-down menu)

- ☐ Not a fluorescent retrofit (1)
- ☐ Relamp only (2)
- ☐ Lamp & ballast (3)
- ☐ Full fixture (4)
- ☐ Combination of types (5)

Did you do any other lighting retrofits that you DID NOT receive an incentive or rebate for?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

If Yes Is Not Selected, Then Skip To 56.

55d. And please record the same information for that retrofit.

Year (1)

Type of lamps removed (3)

Wattage of lamps removed (4)

Type of lamps installed (5)

Wattage of lamps installed (6)

Number of fixtures retrofitted (7)

Number of fixtures delamped (8)

Total kW savings (10)

Total first year kWh savings (11)

What was the building used for? (Please select from drop-down menu)

- ☐ Office (1)
- ☐ Retail (2)
- ☐ Grocery (3)
- ☐ School / University (4)
- ☐ Restaurant (5)
- ☐ Hospital / Medical (6)
- ☐ Warehouse (7)
- ☐ Industrial / Process (8)

- ☐ Hotel / Motel (9)
- ☐ Residential / Apartment (10)
- ☐ Government (11)
- ☐ Mixed Use (12)
- ☐ Other (13)

If this was a fluorescent retrofit, what type was it - relamp only, lamp & ballast, or full fixture? (Please select from drop-down menu)

- ☐ Not a fluorescent retrofit (1)
- ☐ Relamp only (2)
- ☐ Lamp & ballast (3)
- ☐ Full fixture (4)
- ☐ Combination of types (5)

56. Have you made any other modifications to standard O&M procedures at the facility that would have resulted in a reduction in lighting operating hours and/or energy consumption? If so, what were they?

- ☐ Yes (please specify) (1) _____
- ☐ No (2)
- ☐ I don't know (3)

57. Do your responsibilities include the operation of pumps?

- ☐ Yes (1)
- ☐ No (2)

If Yes Is Not Selected, Then Skip To End of Block

58. Have you installed a VFD on any of the pumps you are responsible for maintaining?

- ☐ Yes (1)
- ☐ No (2)

☐ I don't know (3)

If Yes Is Not Selected, Then Skip To 59.

58a. Did your organization receive an incentive or rebate from a utility or other funding agency for this installation?

☐ Yes (1)

☐ No (2)

☐ I don't know (3)

59. Have you implemented any energy saving modifications to pump scheduling? If so, what were they?

☐ Yes (please describe) (1) _____

☐ No (2)

☐ I don't know (3)

60. Do your responsibilities include the operation of motors?

☐ Yes (1)

☐ No (2)

If Yes Is Not Selected, Then Skip To 62.

61. Have you replaced any standard efficiency motors with high-efficiency motors at any of your facilities?

☐ Yes (1)

☐ No (2)

☐ I don't know (3)

If Yes Is Not Selected, Then Skip To 62.

61a. How many motors have you replaced? (Please give your best guess)

☐ One (1)

☐ More than one - specify (2) _____

☐ I don't know (4)

Answer If 61a.... One Is Selected Or 61a.... More than one - specify Is Selected

61b. Did your organization receive an incentive or rebate from a utility or other funding agency for any such replacement(s)? If so, how many did it receive an incentive or rebate for?

☐ Yes - all of the replacements (1)

☐ No (2)

☐ I don't know (3)

☐ Yes - fewer than all (specify the number) (4) _____

61c. Please provide some details about those motor replacements that you did WITHOUT receiving an incentive or rebate. What is the horsepower and efficiency level of each motor replaced? (If you don't know the efficiency level, please record how old (in years) the replaced motors were)

	The horsepower of the replaced motor	The efficiency level of the replaced motor	The age of the replaced motor (Ii you don't know the efficiency)
	HP of Motor (1)	Efficiency Level (1)	AGE of Motor (1)
1 (1)			
2 (2)			
3 (3)			
4 (4)			
5 (5)			

62. Have you implemented any other scheduling-related O&M measures that we have not asked about yet?

☐ Yes (1)

☐ No (2)

☐ Don't know (3)

Answer If 62.... Yes Is Selected

62a. What other scheduling-related O&M measures have you implemented? (Please provide a very brief description in the appropriate space - for example, describe any boiler-related O&M measures you haven't already told us about in the box next to 'Boilers')

Boilers (2)

Chilled-water system (3)

Economizers and ventilation control (4)

Compressed air (5)

Fan optimization / air distribution (6)

Hot water (7)

Lighting (8)

Pumps (9)

Motors (10)

Other - please describe (11)

Thank you for your time so far. We'd like to understand how much your BOC training influenced your O&M activities and equipment installation decisions. For each system you are responsible for, we will ask how much your BOC training affected your O&M activities and, if relevant, your decision to install any equipment that you didn't get a rebate or incentive for. Each time, please rate how much BOC training affected your decisions on a scale of 0 to 10, where 0 means "not at all" and 10 means "very much."

Answer If 27.... Yes Is Selected Or 62a.... Boilers Is Not Empty

63. How much did your BOC training affect the types and frequency of O&M activities you carried out on boilers?

- ☐ 0 - Not at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)

- ☐ 5 (6)
- ☐ 6 (7)
- ☐ 7 (8)
- ☐ 8 (9)
- ☐ 9 (10)
- ☐ 10 - Very Much (11)
- ☐ Don't know (12)

Answer If 10.... Yes - number replaced (best guess) Is Selected And 10a.... No - did not receive any rebates or incentives Is Not Selected

64. You said you had replaced one or more boilers with energy efficient condensing boilers. How much did your BOC training affect your decision to do that?

- ☐ 0 - Not at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 (6)
- ☐ 6 (7)
- ☐ 7 (8)
- ☐ 8 (9)
- ☐ 9 (10)
- ☐ 10 - Very much (11)
- ☐ Don't know (12)

Answer If 18.... Yes Is Selected Or 62a.... Chilled-water system Is Not Empty

65. How much did your BOC training affect the types and frequency of O&M activities you carried out on the chilled-water system?

- ☐ 0 - Not at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 (6)
- ☐ 6 (7)
- ☐ 7 (8)
- ☐ 8 (9)
- ☐ 9 (10)
- ☐ 10 - Very much (11)
- ☐ Don't know (12)

Answer If 25.... Yes Is Selected Or 62a.... Economizers and ventilation control Is Not Empty

66. How much did your BOC training affect the types and frequency of O&M activities you carried out on economizers and ventilation controls?

- ☐ 0 - Not at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 (6)
- ☐ 6 (7)

- ☐ 7 (8)
- ☐ 8 (9)
- ☐ 9 (10)
- ☐ 10 - Very much (11)
- ☐ Don't know (12)

Answer If 32. ... Yes Is Selected Or 62a.... Compressed air Is Not Empty

67. How much did your BOC training affect the types and frequency of O&M activities you carried out on compressed air systems?

- ☐ 0 - Not at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 (6)
- ☐ 6 (7)
- ☐ 7 (8)
- ☐ 8 (9)
- ☐ 9 (10)
- ☐ 10 - Very much (11)
- ☐ Don't know (12)

Answer If 35.... Yes Is Selected Or 62a.... Fan optimization / air distribution Is Not Empty

68. How much did your BOC training affect the types and frequency of O&M activities you carried out on fans and air distribution systems?

- ☐ 0 - Not at all (1)

- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 (6)
- ☐ 6 (7)
- ☐ 7 (8)
- ☐ 8 (9)
- ☐ 9 (10)
- ☐ 10 - Very much (11)
- ☐ Don't know (12)

Answer If 47.…Yes Is Selected Or 62a.... Hot water Is Not Empty

69. How much did your BOC training affect the types and frequency of O&M activities you carried out on hot water heaters?

- ☐ 0 - Not at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 (6)
- ☐ 6 (7)
- ☐ 7 (8)
- ☐ 8 (9)
- ☐ 9 (10)

- ☐ 10 - Very much (11)
- ☐ Don't know (12)

Answer If 48.... Yes - number replaced (best guess) Is Selected And 48b.... Yes - all of them Is Not Selected

70. You said you had replaced one or more a standard tank-type water heater with a tankless water heater. How much did your BOC training affect your decision to do that?

- ☐ 0 - Not at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 (6)
- ☐ 6 (7)
- ☐ 7 (8)
- ☐ 8 (9)
- ☐ 9 (10)
- ☐ 10 - Very much (11)
- ☐ Don't know (12)

Answer If 50.…Yes Is Selected Or 62a.... Lighting Is Not Empty

71. How much did your BOC training affect the types and frequency of O&M activities you carried out on lighting systems?

- ☐ 0 - Not at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)

- ☐ 4 (5)
- ☐ 5 (6)
- ☐ 6 (7)
- ☐ 7 (8)
- ☐ 8 (9)
- ☐ 9 (10)
- ☐ 10 - Very much (11)
- ☐ Don't know (12)

Answer If 55.... Yes - number of retrofits (best guess) Is Selected And 55a.... Yes - all of them Is Not Selected

72. You said you had carried out lighting retrofits. How much did your BOC training affect your decision to do that?

- ☐ 0 - Not at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 (6)
- ☐ 6 (7)
- ☐ 7 (8)
- ☐ 8 (9)
- ☐ 9 (10)
- ☐ 10 - Very much (11)
- ☐ Don't know (12)

Answer If 57…. Yes Is Selected Or 62a.... Pumps Is Not Empty

73. How much did your BOC training affect the types and frequency of O&M activities you carried out on pumps?

- ☐ 0 - Not at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 (6)
- ☐ 6 (7)
- ☐ 7 (8)
- ☐ 8 (9)
- ☐ 9 (10)
- ☐ 10 - Very much (11)
- ☐ Don't know (12)

Answer If 58.... Yes Is Selected And 58a.... Yes Is Not Selected

74. You said you had installed a VFD on pumps. How much did your BOC training affect your decision to do that?

- ☐ 0 - Not at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 (6)

- ☐ 6 (7)
- ☐ 7 (8)
- ☐ 8 (9)
- ☐ 9 (10)
- ☐ 10 - Very much (11)
- ☐ Don't know (12)

Answer If 60.... Yes Is Selected Or 62a.... Motors Is Not Empty

75. How much did your BOC training affect the types and frequency of O&M activities you carried out on motors?

- ☐ 0 - Not at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 (6)
- ☐ 6 (7)
- ☐ 7 (8)
- ☐ 8 (9)
- ☐ 9 (10)
- ☐ 10 - Very much (11)
- ☐ Don't know (12)

Answer If 61.... Yes Is Selected And 61b.... Yes - all of the replacements Is Not Selected

76. You said you had replaced standard efficiency motors with high-efficiency motors. How much did your BOC training affect your decision to do that?

- ☐ 0 - Not at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 (6)
- ☐ 6 (7)
- ☐ 7 (8)
- ☐ 8 (9)
- ☐ 9 (10)
- ☐ 10 - Very much (11)
- ☐ Don't know (12)

Thank you for your patience. We are nearly done. We'd just like to ask you a few questions about things that might affect the success of BOC training.

77. First, what do you think are the three largest barriers to getting building operators to participate in the BOC training? (Please select up to three items from the following list or select "other" and tell us what you think the largest barriers are)

- ☐ Cost (1)
- ☐ The class schedule is inconvenient (2)
- ☐ Not aware of it (3)
- ☐ Getting authorization/approval (4)
- ☐ Not enough time (5)
- ☐ Supervisor support (6)
- ☐ Staffing restrictions (7)
- ☐ None (8)

☐ Other, specify (9) _____

☐ Don't know (10)

78. We'd like your opinion on how some possible changes to the BOC course format might affect attendance. For each of the following possible changes, please select the option that best describes what impact you think it might have.

	Greatly reduce attendance (1)	Somewhat reduce attendance (2)	Have no impact (3)	Somewhat increase attendance (4)	Greatly increase attendance (5)	Don't know (6)
Condense the schedule from one day of training per month to one day every week (1)						
Provide online or webinar training (2)						
Split the courses into 14 to 16 half-day sessions, held during the day (3)						
Provide an intensive 8 days of training Monday through Monday (4)						
Have training only on the weekend (5)						
Other, specify: (6)						
Split the courses into 14 to 16 evening sessions (7)						

As we begin to wrap up, we'd like to ask you some questions about the value of the BOC credential.

79. Which of the following is most accurate? Your company...

☐ ...requires BOC certification for ALL building O&M staff (1)

☐ ...requires BOC certification for SOME building O&M staff, BUT NOT YOU (2)

☐ ...requires BOC certification for SOME building O&M staff, INCLUDING YOU (3)

☐ ...does not require BOC certification for ANY building O&M staff (4)

☐ I don't know (5)

☐ Other - please explain (6) _____

Answer If 79. ...requires BOC certification for ALL building O&M staff Is Selected Or...requires BOC certification for SOME building O&M staff, Including You Is Selected

79a. Would you still have gotten BOC certification if it weren't required?

☐ Yes (1)

☐ No (2)

☐ I don't know (3)

80. Which of the following are true of your company? Your company... (Select all that apply)

☐ ...encourages BOC certification for building O&M staff that do not have certification (1)

☐ ...pays class fees for initial BOC certification (2)

☐ ...pays the test/certification fee for initial BOC certification (3)

☐ ...pays travel expenses associated with initial BOC certification (4)

☐ ...pays other expenses associated with initial BOC certification - please specify (5) _____

☐ ...allows you to attend BOC training during paid working hours (6)

Answer If 80. ...pays class fees for initial BOC certification Is Selected Or ...pays the test/certification fee for initial BOC certification Is Selected Or ...pays travel expenses associated with initial BOC certification Is Selected Or ...pays other expenses associated with initial BOC certification - please specify Is Selected

80a. Would you still have gotten BOC certification if those costs weren't covered?

☐ Yes (1)

☐ No (2)

☐ I don't know (3)

Answer If 80....allows you to attend BOC training during paid working hours Is Selected

80b. Would you still have gotten BOC certification if your company did not allow you to attend BOC training during paid working hours?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

Answer If RENEWED Is Not Equal to Yes

81. Are you aware that maintaining BOC certification requires annual renewal?

- ☐ Yes (1)
- ☐ No (2)
- ☐ I don't know (3)

82. Which of the following are true of your company regarding RENEWAL of BOC certification? Your company... (Select all that apply)

- ☐ ...encourages building O&M staff to renew BOC certification (1)
- ☐ ...pays fees for continuing education classes for BOC renewal (2)
- ☐ ...pays the BOC certification renewal fee (3)
- ☐ ...pays travel expenses for continuing education for BOC renewal (4)
- ☐ ...pays other expenses associated with BOC renewal - please specify (5)
  _____
- ☐ ...allows you to attend continuing education for BOC renewal during paid working hours (6)

Answer If 82....pays fees for continuing education classes for BOC renewal Is Selected Or ...pays the BOC certification renewal fee Is Selected Or ...pays travel expenses for continuing education for BOC renewal Is Selected Or ...pays other expenses associated with BOC renewal - please specify Is Selected

82a. Would you still have renewed BOC certification if those costs weren't covered?

- ☐ Yes (1)

☐ No (2)

☐ I don't know (3)

Answer If 87. ...allows you to attend continuing education for BOC renewal during paid working hours Is Selected And RENEWED Is Equal to Yes

82b. Would you still have renewed BOC certification if your company did not allow you to attend continuing education courses during paid working hours?

☐ Yes (1)

☐ No (2)

☐ I don't know (3)

Thank you for your time. We would like to wrap up with a few questions about you.

83. Do you know any other place you could have gotten equivalent training if BOC training and certification were not offered? If yes, where?

☐ Yes (please specify where) (1) _____

☐ No (2)

☐ I don't know (3)

Answer If 88. ... Yes (please specify where) Is Selected

83a. How likely is it you would have taken that equivalent training if BOC training and certification were not offered? (Please select one of the responses from the following 1-5 scale)

☐ 1 - Not at all likely (1)

☐ 2 (2)

☐ 3 (3)

☐ 4 (4)

☐ 5 - Highly likely (5)

☐ Don't know (6)

Answer If 91.... Yes Is Not Selected

83b. Using a scale of 1 to 5, How much effort would you have spent trying to find similar training if BOC training and certification were not offered?

- ☐ 1 - No effort (1)
- ☐ 2 (2)
- ☐ 3 (3)
- ☐ 4 (4)
- ☐ 5 - Great effort (5)
- ☐ Don't know (6)

84. Do you speak a language other than English at home? If so, what language?

- ☐ Yes - what language? (1) _____
- ☐ No (2)
- ☐ Other response: (3) _____

Answer If 84. Do you speak a language other than English at home? Yes Is Selected Or 84. Do you speak a language other than English at home? Other –- specify: Is Selected

84a. Which language would you prefer the BOC instructor to use in class:

- ☐ English (1)
- ☐ Other language (specify): (2) _____
- ☐ I don't know (3)

85. One last question: does your company own the facility that you work in, or lease it?

- ☐ Own (1)
- ☐ Lease (2)
- ☐ Other - – specify: (3) _____
- ☐ I don't know (4)

Thank you very much for all of your valuable time. We know it was a significant investment, and we appreciate it.

CLICK "SUBMIT" IF YOU ARE FINISHED WITH YOUR SURVEY QUESTIONS.
THANKS AGAIN!

APPENDIX G: EVALUATION SOURCES

This appendix lists sources used in this MPER and the associated memoranda. We first list general sources, used throughout the MPER and memoranda, followed by sources specific to the market characterization and the ACE Model review.

GENERAL SOURCES

NEEC BOC Program Database

Excel files showing IBOA trainings in 2012

BOC certificant survey

Market informant interviews

MARKET CHARACTERIZATION

For the market characterization, in addition to relying on the above-mentioned general sources, we relied on a variety of NEEA reports and memoranda, data from the U.S. Census American Community Survey, the websites of various building-industry-related organizations, and personal communication with representatives of some of those organizations.

NEEA Reports and Memoranda

Market Progress Evaluation Report: Building Operator Certification, No. 3 (5/00) (Report #E01-52052). Prepared by Research Into Action, Inc., with Stellar Process, Inc. for Northwest Energy Efficiency Alliance. May, 2000.

Market Progress Evaluation Report: Regional Building Operator Certification, No. 7 (Report #E01-088). Prepared by Research Into Action, Inc. for Northwest Energy Efficiency Alliance. September, 2001.

Projected Market Size for Building Operator Certification Training in the Northwest. Memorandum prepared for the Northwest Energy Efficiency Alliance by Navigant Consulting, September 26, 2011.

Northwest Commercial Stock Building Assessment: Final Report. Prepared for Northwest Energy Efficiency Alliance by The Cadmus Group Inc. December 21, 2009.

Long-Term Monitoring and Tracking Report on 2011 Activities (Report #E12-239). Prepared for Northwest Energy Efficiency Alliance by Navigant Consulting, Inc., July 23, 2012. Available at: http://neea.org/docs/reports/long-term-monitoring-and-tracking-report-on-2011-activities.pdf?sfvrsn=16. Last accessed Jan. 14, 2013.

Long-Term Monitoring and Tracking Report on 2008 Activities (Report #E09-207). Prepared for Northwest Energy Efficiency Alliance by Summit Blue Consulting. LLC, July 8, 2008.

"Energy and Commerce Departments Announce New Centers for Building Operations Excellence." U.S. Department of Energy Press Release. Accessed March 12, 2013 at: http://energy.gov/articles/energy-and-commerce-departments-announce-new-centers-building-operations-excellence.

Census data

U.S. Census Bureau, 2006-2010 American Community Survey. Table EEO-ALL01R. Detailed Census Occupation by Sex and Race/Ethnicity by Oregon, Washington, Idaho, Montana. Accessed March 7, 2012 at http://factfinder2.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t

Websites

The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE): https://www.ashrae.org/

The Building Owners and Managers Association (BOMA): http://www.boma.org/Pages/default.aspx

APPA (formerly the Association of Physical Plant Administrators, now focusing on educational facilities management): http://www.appa.org/

The Project Managers Institute (PMI): http://www.pmi.org/

The International Facility Management Association (IFMA): http://ifma.org/

The IFMA "World Workplace" conference: http://www.worldworkplace.org/

The U.S. Department of Energy (DOE): http://energy.gov/

Personal communication

ASHRAE certification renewal: Joyce Abrams, ASHRAE representative, on February 25, 2013.

Information on U.S. Department of Energy and U.S. Department of Commerce Centers for Building Operations: Kevin O'Brien, a consultant working with the Corporation for Manufacturing Excellence, March 29, 2013.

ACE MODEL REVIEW

For the ACE model review, in addition to relying on the above-mentioned general sources and market size estimates from our market characterization, we relied on data from online energy-related sources, a variety of program technical reference manuals, and program data from Nexant-implemented retro-commissioning, building tune-up, and O&M programs, which include project- and measure-specific data for 50 to 60 typical O&M measures.

Online Sources

Commercial Buildings Energy Consumption Survey (CBECS): http://www.eia.gov/consumption/commercial/

The Regional Technical Forum Unit Energy Savings (UES) Measures and Standard Protocols: http://rtf.nwcouncil.org/measures/

Technical Reference Manuals

State of Illinois Energy Efficiency Technical Reference Manual

State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0

Pennsylvania Public Utility Commission Technical Reference Manual – State of Pennsylvania Act 129 Energy Efficiency and Conservation Program

Massachusetts Technical Reference Manual

New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs: Commercial/Industrial Measures

State of Ohio Energy Efficiency Technical Reference Manual prepared for the Public Utilities Commission of Ohio by Vermont Energy Investment Corporation

State of Arkansas Deemed Savings - Quick Start Program – Commercial Measures Final Report

research into action inc

Research Into Action, Inc.
PO Box 12312
Portland, OR 97212

www.researchintoaction.com

503 287 9136 (main)
503 281 7375 (fax)
888 492 9100 (toll free)

Memorandum

To: Amy Webb, Project Manager, NEEA

From: Ryan Bliss, Managing Director, Research Into Action

Date: September 9, 2015

Re: BOC Savings Estimate for Washington and Oregon Recalculated From 2014 CBSA EUIs

As part of the first Market Progress Evaluation Report (MPER) of the Northwest Energy Efficiency Alliance (NEEA) Building Operator Certification Expansion (BOC-E) Initiative[1], Research Into Action, in association with Nexant Inc., estimated the energy savings that result from BOC training. The methodology for calculating the savings, explained in MPER #1, relied on energy usage intensity (EUI) values published in the 2009 *Commercial Building Stock Inventory* (CBSA).[2] At NEEA's request, Research Into Action and Nexant have recalculated the energy savings estimates for the states of Washington and Oregon (the initiative did not include Idaho and Montana during MPER #1), using EUI values published in the 2014 CBSA.[3] Table 1 shows the published and recalculated savings estimates.

Table 1: Published and Recalculated MPER #1 Savings

Parameter	Published MPER #1 Savings		Recalculated MPER #1 Savings	
	Total	BOC-Influenced	Total	BOC-Influenced
Baseline Energy Consumption:				
Baseline kWh/Square Foot	15.5	15.5	13.20	13.20
Baseline Therms/Square Foot	0.40	0.40	0.30	0.30
Square Feet per Operator	432,768	432,768	432,768	432,768
Annual Savings: kWh/Square Foot	0.662	0.315	0.662	0.315
Annual % kWh Savings per Operator	4.27%	2.03%	5.01%	2.38%
Annual Savings: Therms/Square Foot	0.025	0.014	0.025	0.014
Annual % Therm Savings per Operator	6.16%	3.58%	8.41%	4.80%

1 *BOC-Expansion Initiative Market Progress Evaluation Report #1 (Report #E14-277).* Prepared by Research Into Action Inc. and Nexant Inc. for the Northwest Energy Efficiency Alliance, April 24, 2014 (updated February 12, 2015). Available at: http://neea.org/docs/default-source/reports/boc-expansion-initiative-market-progress-evaluation.pdf?sfvrsn=6

2 *Northwest Commercial Building Stock Assessment: Final Report. Prepared by The Cadmus Group, Inc. for the Northwest Energy Efficiency Alliance, December 21, 2009.*

3 *2014 Northwest Commercial Building Stock Assessment: Final Report.* Prepared by Navigant Consulting for the Northwest Energy Efficiency Alliance, December 16, 2014.

The table shows that the baseline energy consumption (kWh and therms) and annual percent kWh and therm savings changed, while the calculated kWh and therm savings per square foot did not change. This is because the kWh and therm savings per building are not dependent on the baseline energy consumption of the building. Rather, they are calculated from the maintenance activity conducted by the operator and are, for most measures, a function of the building conditioned square footage, which did not change with the updated baseline EUIs. By contrast, the percent savings per operator is calculated as the total energy saved per operator divided by the baseline building energy consumption. Since the estimates of baseline consumption changed with the updated EUIs, so did the estimated percent savings.