Education That Changes Behavior: The Impacts of the BOC Program

Marjorie R. McRae, Research Into Action, Inc., Portland, OR
Jane S. Peters, Research Into Action, Inc., Portland, OR
Elizabeth Titus, Northeast Energy Efficiency Partnership, Lexington, MA
Tom Rooney, GDS Associates, Manchester, NH

ABSTRACT

The Building Operators Training and Certification (BOC) Program is an educational course for commercial and industrial building operators and facility managers that is now offered in sixteen states. This paper discusses a methodology used to estimate energy impacts from the training program. A key component of the method—surveys of students and nonparticipating building operators about their operational activities—was used twice for BOC programs in two disparate locations and obtained similar impacts. Because of this congruence of findings, supported by results from other aspects of the methodology, the paper proposes that other entities in northerly climates that implement the program as designed can use these estimated savings as likely, providing a good approximation of the actual program savings. Electricity savings are estimated to be 0.5 kWh per square foot of facility affected; gas savings are 1.95 MBtu per square foot. Further research is underway to identify an upper limit to the square footage affected by a single student, under the assumption that there is a limit to the building systems that one operator can influence.

Introduction

The Building Operators Training and Certification (BOC) Program is an educational course for commercial and industrial building operators and facility managers. It teaches building personnel how to operate and maintain building systems for optimal performance, energy-efficiency, and occupant comfort. This paper discusses a methodology used to estimate energy impacts from the educational program. A key component of the method—surveys of students and nonparticipating building operators about their operational activities—was used twice for BOC programs in two disparate locations and obtained similar impacts. Because of this congruence of findings, supported by findings from other aspects of the methodology, we argue that savings from the program can be "deemed," that is, taken as given for the BOC program when it is implemented as designed.

Description of the BOC Program

The Building Operators Training and Certification program educates building operators and facility managers of nonresidential facilities. Building operations and maintenance activities have long been identified as critical components for the efficient operation of commercial and industrial buildings. Yet, building operations and maintenance staff are often among the least educated about energy issues and among the least valued of staff in a company. These conditions led professionals interested in increasing energy efficiency to wonder how operations and maintenance staff could receive training and education that would increase their capabilities, their estimation of the importance of their work and their valuation by the market.

The Northwest Energy Efficiency Council (NEEC), extending efforts initiated by the Washington State Energy Office and the Idaho Building Operators Association, developed a training and certification series for building operators. The first of the series is Level 1 training, which comprises nine days over a seven-month period. The seven day or two-day long courses are:

- Building Systems Overview
- Energy Conservation Techniques
- HVAC Systems and Controls
- Energy Efficient Lighting
- Building Maintenance Codes
- Indoor Air Quality
- Facility Electrical Systems

Level 2 courses and certification are available for students wishing to further their training.

The NEEC BOC course is now offered in sixteen states. Detailed impact evaluations have been conducted in two regions: the Pacific Northwest (for the Northwest Energy Efficiency Alliance, "the Alliance") and the Northeast (for the Northeast Energy Efficiency Partnership, "NEEP").

Estimating the Impact of Training Programs

Estimating the impact of educational programs is difficult at best. For starters, the evaluator is attempting to measure a change in behavior. A simple equipment replacement program can use engineering estimates of the energy consumption differential between the two types of equipment, and assume that behavior—use of the equipment—stays fairly constant before and after the equipment change.

The evaluator does not know exactly what behaviors will change as a result of education and training, or even how they will change. A program such as the BOC, with over 50 hours of class time, delivers a vast amount of information. In addition, while a portion of its content might be "cookbook" style—*do X, do Y*—most of the course material endeavors to give students an understanding of building equipment and teaches them how to think about the equipment and make good decisions.

Next in the list of difficult evaluation conditions is that each student enters with a different background. These differences can be seen to affect the potential upside gain of the training—that is, the course might generate more energy savings from students who previously did no efficiency actions than from students who did some. On the other hand, one's background affects one's current learning. Perhaps students already familiar with energy efficiency gain the most from the course because they better understand the presentation and already have a habit of taking some action.

Finally, all of us, including students, are hard-pressed to identify whether we take a specific action because of a specific information source. Advertisers know this and also know the limitations of a single source of information. Advertising professionals recommend that firms get their message out multiple times, using multiple media, and multiple expressions of the message. For educational programs, it is hard for students to identify whether their subsequent behavior is because they were taught something, or whether their educational experience simply became part of the many experiences out of which their actions arose. Effective training builds on a base of what the student already knows, hoping to expand their ability to work with that information, but rarely presenting something that is clearly "new" or unknown to the student prior to the course.

Another difficulty that besets all behavior research, not simply the evaluation of education and training programs, is the potential for social desirability bias and measurement error. Social desirability bias occurs when respondents portray themselves in a good light, responding in a way that conforms to the expectations of the group to which the respondent belongs or identifies (Dillman 1978). As Dillman (2000) points out, "even very ordinary questions that seem, on the surface, to have little social desirability" can generate inaccurate answers.

Social desirability bias can occur in data when the possible responses to a question vary in their connotations to the respondents. When some response options carry positive connotations and others carry either neutral or negative connotations, respondents may be inclined to give the response that they feel has positive connotations or that they assume has such connotations for the interviewer.

Related to education and training programs, the potential for social desirability bias can complicate evaluation approaches that might ask respondents questions such as: "Do you use what you learned in the training (McRae 2002)?"

Methodology Used in BOC Impact Assessment

We came at the problem of estimating BOC impact from different directions, using a "triangulation" approach. We estimated the impact and influence of the BOC program from five sources of information:

- A survey of Pacific Northwest BOC students and nonparticipants that explored the extent to which each group undertook specific building operation efficiency activities. We combined these behavior measurements with engineering estimates of the savings per square foot attributable to each activity.
- A similar survey of Northeast BOC students and nonparticipants that explored the extent to which an expanded set of efficiency actions were undertaken.
- Engineering estimates of the energy savings from building retrocommissioning.
- Engineering estimates of the energy savings of the BOC program developed by the Alliance when it made its decision to fund the program.
- Students' self-reports of whether and how the BOC training affected their building operations practices.

Estimates Obtained from Two Surveys of Operator Actions

In two separate projects in the Northwest and the Northeast, we surveyed BOC students and nonparticipating building operators from the same region. In all surveys, respondents were asked detailed questions about specific energy-efficiency practices. The student surveys also sought to assess student satisfaction with the training, and the nonparticipant surveys sought to develop estimates of the market potential for the program.

We performed the first of the two studies for the Northwest Energy Efficiency Alliance. Through surveys conducted in 2001, we talked with students who had received BOC training sometime from 1997 to 2000. We asked BOC students and nonparticipants whether they repaired the gaskets on air handler doors, checked the condition of damper seals, confirmed economizer operations by checking the mixed air temperature or by some other method, cleaned heating and cooling coils, and undertook lighting retrofit or modifications. For each of these activities, we had previously obtained, from a review of the efficiency literature, engineering estimates of the savings associated with the activity.

A greater proportion of BOC students than nonparticipants reported conducting these activities on a regular basis. By taking the proportion of students undertaking each activity in excess of the proportion of nonparticipants, and multiplying the rate by an engineering estimate of the savings that accrues to the activity, we estimated that BOC students, compared with nonparticipants, save 0.14 kWh per square foot of space from these five actions.

We conducted the second study in the Northeast in 2002 for NEEP. We talked with students who had taken the BOC series in 2000 or 2001. We refined the question phrasing we had used in the Northwest and added additional electricity-saving measures, as well as gas- and water-saving measures. All respondents were questioned if they had conducted one of the energy-saving activities within the last six months. We also asked the percentage of the equipment or floorspace that was affected by the activity. We estimated that BOC students, compared with nonparticipants, save 0.18 kWh per square foot of space from nine electricity-saving measures. We also estimated savings of 1.95 MBtu per square foot from two activities and 0.16 gallons of water per square foot from unspecified, self-reported activities.

Retrocommissioning and BOC Planning Impact Estimates

Commissioning a building is the process of fine-tuning all of the electro-mechanical systems in a newly constructed building so that their performance, including their influence on each of the other systems, is optimal. Retrocommissioning applies the process to existing buildings. As defined by the American Council for an Energy Efficient Economy (ACEEE), it is the practice of re-tuning and recalibrating major systems in existing commercial buildings.

Table 1 compares the scope and impact of retrocommissioning activities with the scope and impact of the efficiency actions the second (NEEP) BOC survey addressed. An ACEEE-published work (Suozzo & Nadel 1998) estimates that retrocommissioning generates about 1.2 kWh in savings per square foot. The efficiency measures that produce those savings are diverse, relating to every electrical end use involved in building operations. The estimate of BOC student savings from just nine electric efficiency actions is about 15% of the savings retrocommissioning generates. The situation for oil and gas savings is considerably different. The two gas and oil measures explored for the BOC program address the major gas- and oil-using equipment in a building, and correspond with a savings estimate that is 75% of that estimated for retrocommissioning.

Table 1. Comparison of Retrocommissioning Scope and Impact with the Scope of the BOC Measurements and Their Associated Impact

Equipment Fuel Type	Scope of Retro-commissioning Measures	Estimated Impact of Retro-commissioning	Scope of Measured BOC Activities	BOC Activities As Proportion of Retro-commissioning Estimates
Electricity-Powered	Highly diverse, numerous	1.2 kWh/sf	9 measures	15%
Gas- and Oil-Powered	Primarily boilers and furnaces	2.6 MBtu/sf	Boilers and furnaces	75%

From the triangulation perspective, the MMBtu savings from the survey approach appears to provide a reasonable estimate of the gas and oil impacts from the BOC training, yet not for electricity. The survey estimate from nine efficiency measures understates the behavioral change from the nine-day BOC program, while the estimate from retrocommissioning is too high to use, as retrocommissioning is considerably more thorough than we would expect the actions of the average student to be. And retrocommissioning requires considerably more expertise than we would expect the average student to have.

For the electricity savings, a third perspective in the triangulation approach is available from the work done by the Alliance in its initial analysis of the BOC program's cost-effectiveness. When the Alliance considered funding the program, it reviewed engineering simulations and available data on maintenance activities to estimate the program's likely impact. Based on these simulations and expert opinion, the Alliance predicted a program impact of 0.5 kWh per square foot.

The value of 1.2 kWh/sq ft for savings related to retrocommissioning as reported by Suozzo and Nadel (1998) is well referenced and believed to be a conservative estimate as compared with other values reported. For example, results from Sacramento Utility District's (SMUD) retrocommissioning pilot program in May 1999, found that even with the installation of high-efficiency equipment during the construction process, retrocommissioning savings were readily available as soon as a few years after building occupancy. Savings associated with retrocommissioning were calculated using the DOE-2 building energy simulation tool. Resulting values from SMUD's program showed savings for four sample buildings ranged from 6.7 kWh/sq ft to 0.5 kWh/sq ft, with an average of 3.3 kWh/sq ft. Similarly, Texas A&M found average savings from retrocommissioning that exceeded 20% of total building energy use (Suozzo & Nadel 1998).

Students' Self-Reported Actions and Program Influence

The last information source in the triangulation approach is the students' own assessment of the program and its influence. In both the Pacific Northwest and the Northeast, students expressed high satisfaction with the program and its usefulness. Students' supervisors expressed similar views, as shown in Table 2.

Table 2. BOC Impact on Students' Job Performance, As Assessed by Students and Supervisor

Knowledge Gained From BOC Leads To:	Percent of Students*		Percent of Supervisors*	
	Northwest (n=107)	Northeast (n=49)	Northwest (N=50)	Northeast (n=12)
Improved Job Performance	87%	NA	70%	NA
Saved Money	78%	69%	72%	100%
Saved Energy	75%	78%	74%	90%
Improved Occupant Comfort	75%	76%	78%	83%
No Influence on Performance, Comfort, Money or Energy	8%	6%	8%	8%

* Respondents answering "don't know" were treated as "no" responses.

In the second study (in the Northeast) we refined our questions to students about if and how the BOC training changed their behavior. About 40% of students thought they both engaged in new activities and conducted other activities with greater frequency as a result of what they learned in the course (see Table 3).

Table 3. Application of Concepts Taught in BOC Classes

Application of BOC Training	Northeast Students (n=49)
Uses or Applies Methods and Concepts from BOC Classes	90%
Performs New Activities Not Performed Prior to Taking BOC Classes	57%
Does Some Activities More Regularly or Frequently Now Than Prior to Taking BOC Classes	57%
Does Both New Activities and Some Activities More Frequently	39%

Although the responses shown in both Tables 2 and 3 are potentially subject to social desirability bias, they strongly suggest that BOC students believe they engage in more efficiency actions subsequent to taking the course than they did previously. This, in turn, supports the findings from the detailed questions on efficiency actions that BOC students perform.

Finally, the first study survey (in the Northwest) asked about behaviors related to energy efficiency for which we did not have engineering estimates of savings available. First, we explored whether they had undertaken nine specific actions. For each of these nine, a greater proportion of BOC students than nonparticipants conducted the behaviors on a regular basis. These activities are in addition to the five activities for which savings estimates were available. Second, we asked the BOC students open-ended questions about lighting and other efficiency actions they had taken since completing the BOC training, and which they credited with saving energy or money or improving comfort. The majority of students named one or more actions they had taken in addition to those explored in the closed-ended questions.

Estimated Program Impact Based on Triangulation of Findings

To recap the findings in the reverse order from which we presented them: most BOC students and their supervisors believe the BOC training resulted in them saving energy. Most BOC students stated they perform new activities or conduct previously undertaken activities more frequently as a result of the training.

Detailed questioning of students in the Northwest resulted in an estimate of 0.14 kWh savings per square foot from five activities taught in the BOC; students undertook an additional nine energy-related activities more frequently than nonparticipants, yet savings estimates were not available for these activities. A revised line of questioning for students in the Northeast resulted in an estimate of 0.18 kWh savings per square foot from nine activities—and 1.95 MBtu savings from two activities—taught in the BOC. At the same time, the reader must also recognize that the BOC savings exceed those we were able to estimate from a handful of activities.

Retrocommissioning, with estimated savings in excess of six times the savings estimated for the surveyed activities, provides an upper limit to the impact of the BOC program. It involves many of the activities and principles of the BOC, but is conducted by someone who has:

- Greater expertise than the typical BOC student,
- Time dedicated solely to the task (in contrast to students' primary task of operating the building),

- Purview of the whole building (as opposed to, perhaps, one or two systems or areas of the building operated by a single individual), and
- Full management support to implement whatever adjustments are needed.

The electricity savings estimate developed for the Alliance at the outset of the program—0.5 kWh per square foot—appears to best fit the available evidence: that some effect is occurring that we know is likely to be at least two times higher than we have estimated from survey questions, but unlikely to be six times higher.

We conclude that the BOC program results in electricity savings of roughly 0.5 kWh per square foot affected by the participating building operator.

Reliability of BOC Impact Assessment

We believe the values presented in this paper provide a good approximation of the impact that other northerly utilities and agencies will obtain from the program operated in a manner consistent with NEEC's program design.

In very rough terms, the two impact evaluations described in this paper each cost an amount equivalent to the tuition of approximately 50 BOC students. We suggest that the electricity and Btu impacts of this program are known with sufficient reliability that further refinements to the estimate are not warranted by the cost of such research.

We suggest that utilities might consider assuming the electricity savings from the BOC training to be 0.5 kWh per square foot affected by the student. We make this judgment based on the findings from two BOC programs operating at different times, with different instructors. The building stock and weather conditions also vary between the regions where the program was offered, although both climates are northerly. We also make this judgment through a triangulation process that looked at the problem from different perspectives. While only one of the two studies produce a Btu savings estimate, that estimate—of 1.95 MBtu per square foot affected by the student—is also supported by the triangulation process.

Future Research

One important area of further research into the impact of the BOC program remains. How large of an area—in square feet—can one trained building operator be reasonably assumed to affect? The studies conducted in the Northwest and Northeast both sought to understand the square footage for which the average student was responsible, but the results were unsatisfactory. We asked the students the size of their facilities and the proportion of the facility they worked on. For the latter question, the response was typically "all of it." While that may be true in some sense, the average facility sending students to the two BOC programs was huge—over 600,000 square feet. It seems highly improbable that one trained building operator can uniformly improve building efficiency by 0.5 kWh per square foot throughout the facility. If so, that would amount to 300,000 kWh in annual savings.

And what are we to assume when two or more building operators come from a single facility, each claiming to work on the whole facility?

The estimates of 0.5 kWh and 1.95 MBtu per square foot represent an achievable potential for the entire facility were the entire building operations staff to take the BOC. However, the savings accruing to a single operator needs to be capped, or so it appears from the research to date.

A close scrutiny of the data suggests that a cap of 50,000 square feet might be reasonable, however the supporting data are weak. This figure will serve as our initial hypothesis in research being initiated on the BOC program in another part of the country. In addition, one of the sponsors of the Northeast study is conducting a small-sample follow-up investigation of this topic.

This issue of the reach of a single student remains to be settled before the BOC savings estimates can confidently be applied on a deemed basis.

References

Dillman, Don A. 1978. Mail and telephone surveys: *The Total Design Method*. New York, N.Y.: John Wiley & Sons.

Dillman, Don A. 2000. Mail and Internet surveys: *The Tailored Design Method*. New York, N.Y.: John Wiley & Sons.

McRae, Marjorie R. 2002. "Sure You Do. Uh-huh: Improving the Accuracy of Self-Reported Efficiency Actions." In *Proceedings of the ACEEE 2002 Summer Study on Energy Efficiency in Buildings*. 10:189-196. Washington, D.C.: American Council for an Energy Efficient Economy.

Peters, Jane S., Marjorie R. McRae, and Dave Robison. 2001. *Regional Building Operator Certification Venture: Final Market Progress Evaluation Report.* Portland, Oreg.: Northwest Energy Efficiency Alliance.

Peters, Jane S., Marjorie R. McRae, Jessica B. Letteney, and Tom Rooney. 2002. *Evaluation of the Building Operator Training and Certification (BOC) Program in the Northeast.* Lexington, Mass.: Northeast Energy Efficiency Partnership.

Suozzo, Margaret and Steve Nadel. 1998. *Selecting Targets for Market Transformation Programs: A National Analysis.* Washington, D.C.: American Council for an Energy Efficient Economy.