INCORPORATING BEHAVIOUR CHANGE CONCEPTS INTO FACILITY ENERGY MANAGEMENT TRAINING IN PROFESSIONAL AND POST-SECONDARY PROGRAMS

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Abstract: Improvement in energy efficiency is widely recognized as a critical element in sustainable development to meet economic and energy security goals, to reduce local air pollution, and to stabilize atmospheric CO₂ concentrations. Energy management involves the application of methods, tools, and techniques to improve energy efficiency. Energy management training (EMT) emerged following the energy crises of the 1970’s. This training has traditionally focused on engineering methods and technology. However, it has been argued for decades that traditional engineering-economic theories do not fully explain why cost-effective energy-saving measures are often not implemented – known as the “energy efficiency gap”. To explain this gap, experts commonly cite a variety of barriers and criticisms of energy management practices, usually with explicit criticisms of engineers and their methodologies. To reduce the energy efficiency gap, experts and policymakers are increasingly arguing for the adoption of behaviour change techniques. We argue that if behavioural interventions are to be effective in narrowing the gap, then professionals at the front lines of energy management, engineers in particular, must be trained to understand behaviour change concepts and apply proven techniques. Our survey of training professionals reveals broad agreement (92%) that behaviour should be included in EMT. However, our survey also reveals that many trainers have only a vague idea as to what concepts and techniques should be taught. Many participants equate behaviour with motivational arguments for saving energy (like environment), and also rely heavily on awareness techniques. While motivation and awareness are critical, there is ample research to demonstrate there are additional concepts, tools, and techniques that must be applied to achieve the potential for behavior change. This study helps advance the practice of EMT in engineering curricula by identifying five specific elements to include in future training: (1) limits of engineering-economic approaches, (2) fundamental cognitive biases, (3) energy-saving potential of behavioural actions, (4) proven behaviour change techniques, and (5) measurement and evaluation methods. This study draws heavily upon the interrelated disciplines of psychology, cognitive sciences, and behavioural economics.
1 INTRODUCTION

The purpose of this study is to examine the rationale for incorporating behaviour change concepts and techniques into energy management training (EMT) programs, and to make specific recommendations for behaviour change concepts and skills to be incorporated into such training.

Improvement in energy efficiency is widely recognized as a critical element in sustainable development (United Nations, 2007). Improved energy efficiency is seen as essential to meet economic and energy security goals, to reduce local air pollution, and to stabilize atmospheric CO₂ concentrations (National Action Plan for Energy Efficiency, 2008)(Edenhofer et al., 2014)(IEA, 2012).

Although energy efficiency is measured at multiple scales and across all economic sectors, the focus of this study is on energy efficiency in the residential, commercial, and industrial sectors. Energy management involves the application of methods, tools, and techniques to improve energy efficiency in facilities. We define energy management as “The efficient and effective use of energy to maximize profits (minimize costs) and enhance competitive positions” (Capehart, Turner, & Kennedy, 2012)¹.

EMT emerged following the energy crises of the 1970’s (Dias, Mattos, & Balestieri, 2004)(Geller, Harrington, Rosenfeld, Tanishima, & Unander, 2006). This training has traditionally focused on engineering methods and technology (e.g. energy efficiency improvements), augmented by: rational economic methods (e.g. life cycle cost), environmental health (e.g. indoor air quality), and organizational techniques (e.g. forming energy teams). In this study we focus on the role of engineers as energy managers. However, it must be recognized that energy management professionals come from a variety of disciplines. An engineering degree is a widely accepted qualification for energy management positions, but individuals trained in business, economics, management and trades often hold these positions as well.

While engineering methods have been the main emphasis of EMT, experts have argued for decades that traditional engineering and economic theories do not fully explain why cost-effective energy-saving measures are often not implemented – known as the “energy efficiency gap” (Lutzenhiser, 1993)(Jaffe & Stavins, 1994). To explain the energy efficiency gap, researchers commonly cite a variety of barriers and criticisms of energy management practices, usually with explicit criticisms of engineers and emphasis on the limitations of engineering methods (Geller & Attali, 2005). For decades behaviour change has been recognized as a critical element in energy management (Stern, 1992), and in more recent years, experts have increasingly argued for the adoption of behavioural actions to provide solutions to the energy efficiency gap (Dietz, 2010)(Gardner & Stern, 2008)(Westervelt, 2014)(Allcott & Mullainathan, 2010). Nonetheless, as will be shown, engineering methods still dominate EMT curricula.

The connected ideas of an energy efficiency gap, limits of engineering-economic approaches, the importance of behaviour to overcome barriers, and energy management were captured by Backlund and colleagues as displayed in Figure 1 (Backlund, Thollander, Palm, & Ottosson, 2012). The premise of our study is that if behavioural interventions are to be effective in narrowing the efficiency gap, then professionals at the front lines of energy management must be trained to understand the concepts and apply proven behavioural techniques.

The scope of this study includes post-secondary training such as community college courses, undergraduate degrees, or graduate degrees. We also include certification training such as courses for building operators, energy managers, and auditors. We include programs in the U.S. and Canada.

We searched research databases and specific journals² for reviews, surveys, and recommendations for behaviour change concepts and tools in EMT. Some studies were found which are tangential to the

¹ (Backlund et al., 2012) Section 3.2 provides further discussion of the definition of “energy management.”

² Key words included combinations of “energy,” “energy management,” “energy efficiency,” and “training” or “education.” Research databases with the words “energy” were searched as well as Google Scholar. Specific journals
objectives of this study, such as a study providing recommendations for energy efficiency evaluation (Vine, Saxonis, Peters, Tannenbaum, & Wirtshafter, 2013), but no studies were found addressing our specific objectives. Hence, we believe this study offers a unique contribution.

![Energy efficiency gap and potential improvements via effective energy management](image)

Figure 1: Energy efficiency gap and potential improvements via effective energy management. Adapted from (Backlund et al., 2012)

To achieve our objectives, we begin by summarizing concepts traditionally taught in EMT. Next we define behaviour change, and review the energy efficiency literature that provides the rationale as to why behaviour is important in energy management. To develop recommendations for future training of energy management professionals, particularly engineers, we utilize expert elicitation via a survey of training professionals. Survey participants were invited from two general groups: post-secondary instructors, and instructors in professional certification programs. The main contribution of this paper is to provide a set of clear and practical recommendations for future training of energy management professionals to complement existing curriculum with behaviour-based content.

### 2 CONCEPTS TRADITIONALLY INCORPORATED IN EMT

#### 2.1 Who Delivers EMT Programs?

Databases of post-secondary energy management or efficiency degrees are maintained by multiple organizations. Examples include the U.S. federal government (U.S.Energy-Department, 2015) and the International Energy Program Evaluation Conference (IEPEC, 2015). In the U.S. and internationally, the Association of Energy Engineers (AEE) delivers a variety of training and certifications for skills such as energy auditing, measurement and verification, thermodynamics, and lighting (AEE, 2015). The leading program is the Certified Energy Manager (CEM), which has been offered since 1981 and has certified over 14,500 professionals. In Canada, the Canadian Institute for Energy Training offers multiple certification and training programs, including the CEM (CIET, 2015). Government agencies in both the U.S. and Canada both offer various types of training. Examples include federal offerings through the U.S. Department of Energy, Natural Resources Canada, the U.S. Federal Energy Management Program, and California Energy Standards certificates (CEC, 2015). Additionally, there are a myriad other specialized training and certifications offerings such as from the National Council on Qualifications for the Lighting Professions (NCQLP, 2015) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE, 2015). Universities and colleges offer degrees related to energy management.

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were also searched including The International Journal of Sustainability in Higher Education, Energy Engineering, Energy Efficiency, and Energy Policy.
2.2 Common EMT Curricula

Based on the experience of the authors, and a review of program offerings such as those identified in Section 2.1, we find that EMT curricula most commonly cover concepts and skills in the following six areas (Capehart et al., 2012)(DOE, 2015):

1. The rationale for energy management: economic benefits for the facility stakeholders, energy security, and environmental constraints.
2. Engineering/Technical Design Concepts: thermal systems (HVAC, steam, hot water, insulation, and boilers), electrical systems and motors (particularly variable speed operation), lighting, and alternative supplies (renewables, distributed generation, combined heat and power)
3. Economic Concepts: engineering economics (life cycle costing, net present value), utility rates and energy procurement (basic charges, peak, energy, procurement strategies)
4. Operation and Maintenance: facility operation, maintenance (e.g. preventive and predictive approaches), and commissioning (e.g. continuous and retro-commissioning)
5. Facility energy monitoring and assessment: energy auditing, audit instrumentation, Monitoring, Targeting and Reporting (MT&R) methods, and building automation systems

3 WHAT IS BEHAVIOUR CHANGE, AND WHY IS IT RELEVANT IN THE PRACTICE OF ENERGY MANAGEMENT?

3.1 What is Behaviour Change?

Behaviour and behaviour change are concepts rooted in the discipline of psychology. According to the American Psychological Association (APA, 2015) “behaviour modification” (which we consider synonymous with behaviour change) is defined as “The systematic use of principles of learning to increase the frequency of desired behaviors and/or decrease the frequency of problem behaviors.” This general definition fits well in the practice of energy management. In energy management, the desired behaviours are to use energy more efficiently, reduce energy costs, and deliver satisfactory energy services. The problem behaviours include wasting energy, incurring unnecessary costs, or allowing the delivery of sub-optimal energy services such as poor thermal comfort conditions.

3.2 Three Reasons Why Behaviour Change is Relevant to Energy Management

In our assessment, there are three basic reasons why behaviour change is relevant to the practice of energy management. Below we concisely examine each of these three reasons.

3.2.1 Engineering-economic Factors Do Not Fully Explain Energy Consumption Patterns

The limitations of engineering and economic methods and theories in explaining energy consumption patterns are well known. Lutzenhiser summarized this issue over twenty years ago highlighting some of common findings (Lutzenhiser, 1993):

- Energy use can vary as much as 300% for same household type, which cannot be explained by engineering and economic calculations.
- Many people do not understand their energy consumption, the cost of it, or how to reduce it.
- Financial incentives alone have mixed impact in reducing energy.
- Energy pricing alone does not explain consumption.
- There is value in assessing energy consumption as a social process.
- Organizational behaviour influences energy consumption.

Researchers continue to confirm the limits of engineering-economic factors. For example, a study published by the U.S. National Academy of Sciences confirmed that people commonly misunderstand
both their own levels of end use energy consumption and the relative magnitude of energy-saving measures (Attari, Dekay, Davidson, Bruine, & Bruin, 2010).

3.2.2 Behaviour Plays a Role in the Barriers and Criticisms in Energy Management

Most of the major barriers and criticisms of demand-side energy management policies and practices directly or indirectly involve behaviour.

Barriers have been extensively reviewed by others, and here we list the most common set of barriers (Thollander, Palm, & Rohdin, 2010): imperfect information, adverse selection, principal-agent relationships, split incentives, hidden costs, access to capital, risk, heterogeneity, form of information, credibility, values, inertia, bounded rationality, power, and culture. In an attempt to better understand barriers, classification and grouping arrangements have been proposed such as the three classifications developed by Sorrell and colleagues: economic, behavioural, and organizational (Sorrell et al., 2000).

In addition to common barriers, there are two criticisms of energy efficiency improvements which are ubiquitous: rebound effects and free ridership. Rebound effects are generally defined as a behavioural response to improvements in energy efficiency, and are typically classified as direct and indirect (Sorrell, 2007) (Greening, Greene, & Difiglio, 2000). Some experts view rebound effects as a major problem that justifies reducing investments in energy management (Herring, 2006), while others find the effects are over-estimated and argue that some types of rebound provide positive welfare effects (Gillingham, 2013). Solutions to mitigate rebound effects have been proposed (van den Bergh, 2010). Free ridership is a consumer behaviour phenomenon specific to subsidy programs, whereby consumers accept a subsidy for an investment they would have made anyway. Some have argued that free ridership is a major problem (Loughran & Kulick, 2004) while others have countered that the effects are exaggerated (Auffhammer, Blumstein, & Fowlie, 2008).

3.2.3 Behaviour Change can Produce Substantial Savings in Energy

One of the most prominent studies of the potential for behaviour change to save energy is the study of “behavioural wedges” (Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009). This study estimates that behavioural actions could reduce U.S. household carbon emissions equal to 7.7% of all U.S. emissions. The study analyzed carbon reductions, however all the carbon reduction estimates were based on reduced energy consumption. There are many studies which have examined the quantity of energy savings from behavioural interventions, such as household interventions (Abrahamse, Steg, Vlek, & Rothengatter, 2005), and electricity end-uses (Tiedemann, Sulyma, & Mazzi, 2013).

4 SURVEY OF ENERGY MANAGEMENT TEACHERS AND TRAINERS

A convenience survey was conducted to elicit the views of energy management educators. Answers to two principal questions were sought: (1) what, if any, behavioural training is currently delivered in EMT? and (2) what behavioural training is recommended to be included in EMT?

Targeted survey participants were individuals teaching post-secondary EMT courses and programs including certificate programs, colleges and university degrees. AEE, CIET, and the Northwest Energy Efficiency Council assisted in soliciting qualified educators. Additionally, all college and universities listed in the IEPEC database were contacted. 26 educators responded to the survey, 4 anonymously. Respondents’ experience was split roughly equally between these categories: programs offered through AEE and CIET, colleges, university engineering and science, university business and arts, and government agencies. The average teaching experience reported was 21 years (range of 3 to 45). In terms of their students, 30% or more of respondents have taught students whose highest level of education fell into each of the following categories: high school diploma, trade ticket, technologist, and university degree (most respondents reported having students in multiple categories).

73% of respondents reported that behavioural training is already incorporated in EMT programs they have taught. 18 participants identified the type of behavioural training provided. 6 identified community-
based social marketing, 1 identified behavioural research, 2 identified government agency programs, and 9 were non-specific about the behavioural training provided.

80% of respondents stated that behaviour change should be taught in all types of EMT programs. 12% thought only some types of EMT, and 8% stated that that behaviour change should not be taught in EMT. Respondents were asked to identify leading behaviour change programs, experts, or providers. Amongst the 24 respondents who stated behaviour change should be taught in some or all EMT programs, only 10 identified a specific behaviour change training resource. CBSM, Natural Resources Canada, and ISO 50001 were each identified by multiple respondents. Some specific researchers were mentioned by a few respondents.

5 RECOMMENDATIONS FOR INCORPORATING BEHAVIOUR IN EMT

Based on the experience of the authors complemented by the survey results, here we provide recommendations for incorporating behavioural concepts and skills into EMT programs, particularly engineering curricula. There are five elements recommended for inclusion.

5.1 Limits of Engineering-Economic Approaches to Energy Management

We recommend that students in EMT programs should review and understand the evidence of the limits of engineering-economic approaches to energy management. Energy managers are often criticized for excessive reliance on engineering-economic analysis without recognizing limits. Training should include a review of the commonly-accepted barriers and criticisms, so that where possible, barriers can be avoided and criticisms can be addressed proactively. To list some examples, consider that building operators should be aware that occupants generally do not understand which measures could save the most energy and energy cost in their facility. As another example, energy managers will benefit from understanding that some people might choose to implement a project for which the economic case is modest, based on indirect environmental benefits and the environmental attitudes of decision-makers.

5.2 Cognitive Biases

Cognitive biases are the fundamental mechanisms that support the rationale for behaviour change as a key element of energy management. Understanding cognitive biases provides the foundational knowledge for practitioners to be more effective in implementing behaviour change programs. Without understanding the underlying cognitive biases, energy managers will have only a superficial level of knowledge to apply behaviour change tools and techniques. This would be analogous to a technician using engineering formulas, without understanding how the formulas were derived or what assumptions are necessary to validate use of specific formulas. We find that Klotz has captured and summarized the most important cognitive biases applicable to energy management, as shown in Table 2 of his study (Klotz, 2010). A detailed discussion of each bias is beyond the scope of our study.

5.3 Common Behavioural Actions which are Proven to Save Energy

In Section 3.2.3 we cited some key findings of behavioural actions proven to save energy. We recommend that EMT curricula review the relevant behavioural actions and summarize research findings of the typical magnitude of energy savings achievable. We find it is useful to observe that behavioural actions typically fall into the following four categories, listed here along with illustrative examples:

1. **Operation**: laundry temperature setback; turning off lights.
2. **Maintenance**: change HVAC filters; tune up home air conditioners.
3. **Purchasing**: low flow showerheads; condensing water heater versus conventional.
4. **Activity Substitution**: line dry clothes versus machine dry; wear sweater versus turn up thermostat; broom sweep sawdust instead of using compressed air.

We believe these categories offer a useful framework for grouping behavioural actions to save energy. One reason is that in facilities it is often different actors who are responsible for each of the first three categories. This is true in households, commercial buildings, as well as industrial facilities where different
individuals or organizational groups have responsibility for operation, maintenance and purchasing energy-consuming equipment. We emphasize the importance of activity substitution because this category, by definition, involves a substantial change in the quantity or quality of energy services. Whenever substantial changes in service are involved, the barriers to implementation are typically exacerbated. These are the "hidden cost" and "risk" barriers referred to in Section 3.2.2, and energy managers need to be aware of these imperfect substitutions which might hinder their efforts.

5.4 Introduction to Behavioural Change Techniques

EMT programs should include an introduction to proven behaviour change techniques that can be applied in facilities, typically described using social marketing approaches. We illustrate what is feasible based on the behavioural training that was delivered to four cohorts of master's degree engineering students (104 students) at the University of British Columbia from 2011-2014 (Rogak & Mazzi, 2013). Students were required to demonstrate an understanding of Community Based Social Marketing (CBSM) (McKenzie-Mohr, 2011) through examination, a real-world course assignment, and a Learning-Through-Service energy audit project. The training emphasized eight strategies which are commonly employed and proven to save energy: commitment, prompts, norms, social diffusion, goods/services, communication, financial incentives, and convenience (McKenzie-Mohr, Lee, Shultz, & Kotler, 2012).

5.5 Measurement and Evaluation of Behavioural Change Interventions

Measurement and evaluation of behavioural change interventions are important to assess the value of resources utilized to develop and deliver behavioural interventions (i.e. staff time and financial investments). As such, EMT programs are recommended to address this important step. While there are methods proposed to measure and evaluate behavioural interventions (Sweeney, 2009)(McKenzie-Mohr et al., 2012), we find that effective evaluation of these interventions are challenging. We emphasize the importance monitoring systems and techniques such as MT&R in EMT programs.

6 LIMITATIONS

This study has two key limitations. First, due to the broad and interdisciplinary nature of the study, many concepts and findings are supported by others' research and illustrative examples. There has been a necessary trade-off between depth and breadth. Second, our survey was a convenience sample with a modest sample size (25), which must be acknowledged in attempts to generalize the results.

7 CONCLUSIONS

Our review of the literature demonstrates that behavioural interventions have a key role in the practice of energy management, specifically to help reduce the energy efficiency gap. Often policymakers and researchers assess this gap (or "wedge") at a high level, examining a specific economic sector or even an entire economy aggregated for a specified jurisdiction (e.g. municipality, state, or nation). We argue that if behavioural interventions are to be effective in narrowing the efficiency gap, then professionals at the front lines of energy management, engineers in particular, must be trained to understand the concepts and apply proven behavioural techniques. Our survey of training professionals reveals broad agreement (92% surveyed) that behaviour should be included in EMT. However, our survey also reveals that many trainers have only a vague idea as to what concepts and techniques should be taught. Many participants equate behaviour with motivational arguments for saving energy (like environment), and also rely heavily on awareness techniques. While motivation and awareness are critical, there is ample research to demonstrate there are more concepts, tools, and techniques that must be applied to achieve the potential for behavior change. This paper helps advance the practice of EMT by identifying five specific elements to include in future EMT: (1) limits of engineering-economic approaches, (2) fundamental cognitive biases, (3) energy-saving potential of behavioural actions, (4) proven behaviour change techniques, and (5) measurement and evaluation methods.
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