Energy Behaviour – A Standards Outlook

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ABSTRACT

The electricity demand in Canada is estimated to rise by 1% each year from 2014 and 2040 due to several factors including a growing population and a greater reliance on electrical appliances and equipment (NRCan, 2020). This increase is further impacted by the electrification shift, which continues to uncover new challenges and requires utility companies to remain agile. Peak demand times are destabilizing the grid and require additional investments to complement the existing production capacity.

Many consumer-targeted programs are utility-driven by province and are designed to engage the end user through gamification, thereby contributing to global demand reduction. Gamification is one of many widely available tools that behavioural science offers in end user engagement programs, used for its ease of application and appeal to users. To promote broader uptake of these tools and ensure the sustainability of tomorrow's grids while meeting today's growing energy demands, the development of standards is one way to provide quality assurance for these programs and create a forum for policy discussions. To this end, an environmental scan, literature review, key informant interviews, and consultations with a range of Canadian energy program experts highlighted the need for standards-based solutions that provide a common definition of energy behaviour and key elements of an effective energy program.

Using this knowledge, we propose an efficient application of Behavioural Energy Programs (BEPs), best practice guides for design, real-time data collection and analysis, and project benchmarks for field practitioners. These recommendations mirror the widely applied ISO 50001 "plan, do, check, act" method for implementation.

Introduction

An increased dependence on the electrical grid and a growing population are contributing to a rising electricity demand in Canada (NRCan 2020). This projected increase can be attributed in part to an ongoing trend to electrify end user consumption to meet the nation's decarbonization targets, thereby creating more peak time demands. This is also compounded by a growing dependence on intermittent renewable energy sources, making demand and the availability of supply even less predictable. To respond to these abrupt shifts in demand, grid operators need to invest in expensive expansions that include production sources, cables, and other accessories. An alternate way to manage these shifts in demand include presenting consumers with the opportunity to support grid operators using grid (and hence demand) balancing by adopting behaviours to support demand shifting (Kacha 2024). Although recent reports by the International Energy Agency (IEA) indicate that the world can reach net-zero by 2050, a large proportion of this effort will require a change in end user behaviours and the adoption of more environmentally-friendly habits (Sussman 2021).

Utilities are considering additional demand management techniques as they look ahead into the future of the grid to sustainably manage demand changes. Demand management is frequently dealt with through: 1) grid expansion (i.e., an increase in energy production); and 2) Distributed Energy Resources (DER) integration (i.e., combining renewable technologies such as wind and solar PV with storage systems such as battery, thermal, and pumped storage). Users are prompted to play an active role in managing demand by adopting new behaviours or acquiring technology and adhering to automated demand response programs, where energy consumption reduction is managed using technology and bypassing human interactions. One demand management method gaining popularity is demand response programs (or more broadly behavioural energy programs) that apply user engagement strategies including gamification, a method for increasing engagement that simulates game features such as hurdles (e.g., presented at an expected peak event at a certain day and time of the day) and rewards (e.g., monetary rewards or rebates for a minimum number of completed events).

Behavioural Energy Programs (BEPs) are gaining momentum as one of the many tools used by utility companies and grid operators to decrease end user energy consumption. An estimated 20-30% of electricity savings can be attributed to behavioural change introduced by these programs (Jaffe and Stavins 1994; Gillingham and Palmer 2014; Schützenhofer 2021). However, the impact and success rate of BEPs is dependent on several factors such as the environment, the aim, and the context, all of which play a crucial role in program design and implementation, as well as the awareness of BEPs among end users. Some utility companies in Canada have reported notable success in program implementation and are looking to adopt a behavioural lens for all their programs. Other utility companies report that their BEPs were not as successful as anticipated and have either halted their work on behavioural energy programs or are in the process of redesigning these interventions due to the lack of behavioural persistence—the maintenance of a behaviour following participation in a behavioural program (Ashby et al. 2017). Furthermore, designing, implementing, and evaluating these programs is complex given their multi-disciplinary nature. This process is resource-intensive and relies heavily on both energy utilization technologies and human factors that influence end user energy use patterns.

Behaviour can be defined as “a specific response of a certain organism to a specific stimulus or group of stimuli” (Collins Dictionary 2024). Building upon this general definition of behaviour, energy behaviour can be defined as “all human actions that affect the way that fuels (electricity, gas, petroleum, coal, etc.) are used to achieve desired services, including the acquisition or disposal of energy-related technologies and materials, the ways in which these are used, and the mental processes that relate to these actions” (Rotmann and Mourik 2013). These actions are impacted by many factors, including internal (individual) motivations and habits, outside (social) influences, and the context in which an action occurs. In a briefing note, the Canadian government identified “attitudes and behaviour towards energy use [as] major factors in shaping Canadian energy demand” (Canada Energy Regulator 2009). However, user behaviour in particular affects energy usage; this briefing note states that overlooking behaviour would “limit the accuracy of forecasts.” There is considerable compatibility between Demand Response and Demand Side Management programs and residential energy demand as both programs (of which BEPs are a subset) demonstrate the value in incentivizing customers to distribute high-demand activities across the day in support of overall grid stability (Anderson, 2016; Osman et al., 2023). Due to the complexity of energy behaviour, BEPs looking to change end user energy consumption patterns need to pinpoint the behaviour change that is being targeted, consider how this behaviour is influenced, and define the program's purpose of this targeted behavioural change.

The energy sector currently relies on standards to support design, maintenance, and operations. Standards are consensus-based technical documents generated by experts that provide guidance and outline best practices in each domain. Standards-based solutions can include resources that support the interpretation and/or implementation of standards. These resources may include training courses on using a given standard or tools that support their implementation. Since standards are already used by actors within the energy sector (i.e., regulators, utility companies, grid operators, distributors, consultants / contractors and all parties affected by the design, development, application, and monitoring of BEPs), they are well-positioned to guide the design and implementation of BEPs to promote sustainable energy behaviours. To achieve lasting energy savings through behavioural shifts, there is a need for context-specific interventions, collaboration across experts, and standards development.

Recently, CSA Group conducted a study that examined opportunities for standards-based solutions to support energy programs in Canada (Rotmann, Karlin, and Cowan 2024). This work included a review of existing literature, an evaluation of the standards landscape, and interviews with several subject matter experts to examine current challenges faced by BEPs and best practices for their development. We further developed the recommendations emerging from this work by engaging in several additional consultations with a range of experts, refining next steps, and initiate a new CSA standard. This paper presents an overview of this research, including specific ways that a new standard in energy behaviour can support the development and implementation of BEPs to help meet Canada's emission targets.

Landscape and Literature Review

Energy Usage and Behavioural Energy Programs

Residential energy usage encompasses a range of actions, each shaped by environmental factors and psychological drivers. For instance, considering energy-efficient lighting, distinct behaviours emerge, such as turning off lights when leaving a room, installing energy-efficient bulbs or sensors, and setting light timers or automation systems. Although these actions contribute to overall energy reduction, they vary in terms of timing, motivation, complexity, financial implications, savings, and how long behaviour changes persist. This is similarly applicable to space conditioning with additional options including the traditional practice of lowering the thermostat setting at night and increasing it again in the morning. Although this strategy does provide overall energy savings, it creates peak demands in the early mornings and places extra stress on the grid. By understanding interactions between energy technologies and individual behaviours, we can identify the true potential of energy efficiency solutions or demand management beyond purely technological factors.

Foundational features of BEPs include understanding how people make energy-related decisions, interact with technology, and utilize energy resources. By studying individual behaviours and evaluating program impacts, BEPs inform improvements to energy consumption patterns. Common metrics, such as Kilowatt hours (kWh) or greenhouse gas (GHG) reductions, allow us to quantify outcomes and align with measurable goals of energy efficiency interventions commonly found in roadmaps and targets. However, it is equally crucial to recognize non-energy impacts, such as enhanced comfort, health benefits, or reductions in energy bills (without perceived costs or risks). These qualitative motivators can influence energy user behaviours and may promote or inhibit program effectiveness.

Dimensions of Energy Behaviour

Since energy behaviours are variable, it is important to differentiate specific dimensions for better predicative accuracy and program effectiveness (Karlin et al. 2014). There are two broad behavioural dimensions that can describe energy behaviour: curtailment (daily or habitual changes in energy use) and efficiency restricting daily use and (one-time, long-term actions. However, these dimensions can be interconnected and oversimplify energy behaviour. As such, several researchers have proposed additional behavioural dimensions to consider when designing energy programs:

- Investment vs. Management of Efficient Equipment (Kempton 1986): This dimension contrasts a one-time investment in energy-efficient equipment (e.g., purchasing energy-efficient appliances) with ongoing management practices (e.g., ensuring proper maintenance).
- Weatherization, Equipment, Maintenance, Adjustments, and Daily (WEMAD) Behaviours (Dietz et al. 2009): This category encompasses a range of actions, including weatherization (e.g., insulating homes), equipment maintenance, and daily adjustments (e.g., turning off lights or adjusting thermostats).
- Maintenance and Management of Energy Devices, Advanced energy efficiency (Sanguinetti et al. 2022): A focus on maintaining and managing energy devices, including advanced technologies (e.g., smart thermostats). It also considers appliance efficiency.
- Family Style, Call an Expert, Household Management, and Weekend Projects (Boudet, Flora, and Armel 2016): This dimension includes diverse behaviours related to family habits, seeking professional advice, overall household management, and weekend energy-saving projects.

Additionally, the growing emphasis on renewable energy and increases in electrification and grid constraints introduce new considerations related to:

- Demand Response (DR): Shifting energy use based on demand signals.
- Demand Flexibility (DF): Adapting energy consumption patterns to optimize grid stability.
- Demand-Side Management (DSM): Coordinating energy use to balance supply and demand.

As the energy sector shifts its focus from overall energy reductions to load-shifting and time-of-use behaviours, it becomes critical to precisely define and target behaviours of interest when designing BEPs.

Behavioural Energy Programs and Strategies

Categorizing behavioural approaches can become challenging due to the complexity of different combinations. However, some researchers have attempted to group program types based on targeted motivations and delivery:

- Information-based programs: These deliver information directly to customers. Examples include Home Energy Reports (HERs) and home labels.
- Social interaction programs: These rely on interpersonal interactions. An example includes gamification that encourages certain behaviours in exchange for rewards.
- Education and training programs: These involve educating customers. Coaching and training fall into this category.
- Monetary incentive programs: These use financial rewards to motivate behavioural change. Examples include rebates and time-of-use rates.

Although these program types vary in their design and evaluation, programs that combine multiple behavioural strategies tend to be more effective as they can target several individual motivators. For instance, complex behavioural programs, including Home Energy Reports (HERs), competitions, and low-income audits, often utilize multiple behaviour change strategies to promote energy efficiency. By analyzing these programs and the strategies they implement, this allows us to pinpoint effective techniques for behavioural change.

Behavioural science identifies many techniques and strategies that can influence or modify behaviour, including targeting specific motivations, social influences, and environmental context (Michie et al. 2008). Bergquist et al. (2023) outlines six specific behavioural strategies that promote pro-environmental behaviours:

- Appeals: Encourage sustainable actions by targeting values or responsibilities.
- Commitment: Motivate people to commit to sustainable behaviours.
- Education: Increase knowledge by providing factual information.
- Feedback: Provide individuals/households with information about their own behaviour.
- Financial incentives: Use monetary rewards to incentivize sustainability.
- Social comparison: Highlight peer behaviours to encourage target behaviour changes.

Programs that integrated social comparison and financial incentive behavioural strategies into a BEP were most impactful in encouraging pro-environmental actions. Financial incentives tend to have a larger impact on energy conservation compared to other strategies. For example, savings from Time of Use (TOU) rates by "shifting only the appliance load to off-peak hours" amount to 6.5% (Syed 2009). Three Canadian provinces have tested TOU programs: British Columbia, Ontario, and Quebec. In Ontario, the implementation of TOU helped to shift energy consumption to off-peak times, where savings during the roll out of smart meters and the introduction of the TOU rate in Ontario (a summer energy peaking province) between 2009-2014 registered a 3.3% reduction in usage over the summer of 2012 (Faruqui and Bourbonnais 2020).

Evaluating Behaviour-Based Energy Interventions

As governments and utilities increasingly focus on behaviour-based energy interventions, there is a pressing need to rigorously evaluate the impact of these programs. However, one common challenge is establishing direct causal relationships between the intervention and desired outcomes (such as reduced energy consumption or greenhouse gas emissions). For example, even if electricity billing decreases after a program like Home Energy Reports (HERs) has been implemented, it is extremely difficult to pinpoint the use behaviours that were impacted without advanced technology capable of disaggregating home appliance usage. Additionally, the reasons that underlie changes to behaviour can only be identified from qualitative insights gathered directly from end users. Furthermore, since programs do not have a common structure with specific parameters or data collection methods, drawing comparisons around the effectiveness across programs is challenging.

A comprehensive report examined methodologies and evaluation of BEPs implemented in residential settings (Todd et al. 2012). This work outlines important recommendations for evaluating energy programs, including:

- Independent Evaluators: Use third-party evaluators to define and implement analyses, assess impacts, assign households to conditions, and report results to avoid conflicts of interest.
- Well-Designed Studies: Whenever possible, design evaluation studies using Randomized Controlled Trials or quasi-experimental methods for selecting control groups.
- Equivalency Checks: Ensure similarity between treatment and control groups in terms of energy use and household characteristics before the intervention.
- Pre-Intervention Data: Collect at least one year of energy data before the intervention for accurate pre-post assessments.
- Establish Hypotheses: Define null hypotheses (e.g., percent savings needed for program effectiveness) and consider a program effective if savings are statistically significant at a 5% level or lower.
- Context Matters: Recognize that no single program is universally effective; effectiveness depends on context, location, target audience, and delivery strategies.

Although kWh energy use is the most used metric in evaluating BEPs, there are additional variables and metrics beyond the meter that help to identify the success of these programs. For instance, a review of 85 studies on behaviour-based energy interventions found that 69 of them collected data related to energy knowledge, attitudes, and behaviour (Karlin et al. 2015). Surprisingly, only four studies published their survey instruments, making cross-study comparisons extremely challenging.

Due to existing inconsistencies in data collection and evaluation, this research strongly recommends the development and use of standardized measures to facilitate comparisons across studies and programs. These measures were discussed through preliminary consultations with interested and affected parties (please see section “Consultations” for additional details. The consistent use of validated measures will allow researchers and program managers to trust results, compare data, and identify patterns across interventions. Demographic (e.g., age, gender, homeownership) and psychographic (e.g., motivation to save energy) information can also help understand whether findings from one program may apply in a different context.

Furthermore, experts emphasize the importance of measuring non-energy impacts of behavioural energy efficiency and demand-side management interventions (Sutter et al. 2024). Non-energy impacts include but are not limited to indoor air quality, physical comfort and wellness, and motivation. These impacts are often considered "soft measures" and are more challenging to quantify than direct kWh or monetary savings. However, BEPs should consider measuring these impacts from the design stage to facilitate later evaluation and interpretation.

Interviews

This research project conducted interviews with 17 diverse subject matter experts to identify existing challenges and opportunities facing BEPs. Interviewees included individuals from associations and consumer-based organizations, government, Implementors; researchers, trainers, and utility/industry professionals. The interviews provided insights into the existing trends and needs of the behavioural energy sector in addition to evaluating their views on developing standards to support the sector. Four key takeaways were identified from these interviews:

1. Standards can serve as a starting point for supporting the design and development of new BEPs.
2. Energy behaviour standards should be process- (not program-) focused, to avoid restricting creativity or holding back innovation in the behaviour energy program space.
3. Standards-based solutions should be included with the standards for user accessibility. For example, the ISO 50001 standard is accompanied with supporting tools (such an ISO 50001 Ready Navigator tool is used by federal agency staff.)
4. Standards can help raise awareness for emerging efforts in new sectors and the implementation of new technologies.

The interviewees pointed out that BEPs often prioritize economic and technological changes, which can be more clearly quantified. However, a comprehensive approach that can be implemented through BEPs includes mixed methods such as behavioural and social science strategies, field research, decision-making support, and targeted interventions, which will expand potential impact. This combination of tools may include feedback mechanisms, gamification, and the promotion of permanent upgrades. Interestingly, research findings suggest that BEPs are most effective when applied as a continuous process rather than focusing on specific stages of implementation (Mundaca et al. 2023).

Given the prevalence of engineering professionals in the field, energy management is frequently perceived as a purely technical matter; however, this approach overlooks the critical role of people and behaviour in establishing efficient energy use. Engineers are adept at solving intricate problems with clear right or wrong answers. Conversely, energy behaviour, which centres on human decision-making and contextual factors, presents a complex, interdisciplinary challenge without straightforward solutions. Unfortunately, engineers who acknowledge the importance of people in the energy equation may not possess the resources or interest to engage with the social science strategies that are integral to understanding and influencing energy behaviour.

Furthermore, when utilities design and implement energy programs, they must demonstrate progress, validate savings, and deliver a reasonable return on investment (ROI) within a practical timeframe. However, these priorities often neglect the time required for field studies or qualitative assessments of energy users' real-world experiences. This leads to an oversimplification of programs down to campaign-style information sharing or mass marketing, which tends to exclude harder-to-reach end users and other context-specific requirements of end users.

Several interviewees highlighted the challenges in collecting and comparing evidence, particularly when evaluating BEPs at smaller scales. They emphasized the lack of clear guidelines for determining what constitutes sufficient evidence. Additionally, data collection often remains limited to individual program evaluations, prohibiting the capacity to make meaningful comparisons across different BEPs, thereby reducing the chances of building upon findings and improving programs. These limitations extend to self-comparisons within a program over time or across diverse program interventions and audiences. Furthermore, there is often insufficient evidence to directly assess the impact of programs on behaviour. The scarcity of evaluation tools for energy behaviour programs can be attributed to several factors, including:

- Incomplete Data: Existing data may not provide a comprehensive view or could be misleading.
- Complex New Data Streams: Implementing and standardizing novel data sources for comparison can be challenging.
- Limited Research and Behaviour Change Training: A lack of expertise in research and behaviour design hampers effective evaluation.
- Undervaluing Expertise: The importance of specialized knowledge required for reliable evaluations is sometimes overlooked.

Consultations

Consultations were held over two half days in May 2024 and included subject matter experts from utilities, governments, and the private sector with experience in program design, implementation, evaluation, education, and research. The objective of these consultations was to discuss the research recommendations from our previous work (Rotmann, Karlin, and Cowan, 2024) and examine existing gaps and needs for standards and standards-based solutions in support of BEPs. Specifically, we discussed ongoing challenges and opportunities in BEP design and implementation, as well as develop actionable next steps for developing a new standard that supports BEPs.

Overall, participants agreed on the importance and need for a standard to support the BEPs to provide clear guidance and establish a shared understanding of BEP recommendations without being overly prescriptive. Participants highlighted a need for foundational work on definitions, resources, and frameworks to facilitate a better understanding and opportunity for learning among stakeholders. In developing these tools, existing resources should be leveraged where possible to maintain international consistency.

These consultations clarified a need for a new standard to identify and define key terms that are commonly used across BEPs, including relevant behaviours, energy terminology, and behavioural science terms. These definitions should be clear, specific enough to guide program development, and adaptable to various contexts. This addition would allow for greater consistency and understanding across all interested and affected parties.

Additionally, our discussions highlighted the need for a new standard to offer guidance without constraining innovation. This may include a set of minimum recommendations for BEPs to support a consistent, evidence-based development of programs, which will allow for inter-program comparison to promote sector-wide learning. These minimum recommendations for BEP design and implementation may include the following: (1) consistency across demographic data captured through BEP design and implementation, (2) ethical considerations, (3) fundamentals of research design, (4) engagement and communications with end users and affected parties. The recommendations for program design and implementation should be practical, flexible, and applicable to a wide range of contexts, and focus on important elements of a BEP without constraining innovation.

These suggestions from our consultations offer valuable considerations for next steps in developing a new standard in support of BEPs. The precise scope and details of the standard will be developed over the coming months by a technical sub-committee. They will also help determine what will be included in the standard itself or in support tools (e.g., standards-based solutions) so emerging utilities are well-equipped to design and implement BEPs in a range of contexts.

A Path to Standardization

Standards development is carried out by convening a technical sub-committee of subject matter experts from different interested parties' backgrounds. For instance, the development of a standard to inform BEPs may be guided by a technical sub-committee with representation from a regulatory perspective, producers (i.e., program designers), a user interest group (i.e., implementers of the programs), and general interest group (i.e., the public). The standard emerging from this sub-committee serves as a roadmap to guide regulation and contribute to economic well-being, among other benefits.

Standards development is specifically designed to ensure:

- Cost Reduction and Increased Productivity: Implementing standards helps businesses streamline internal processes, decrease waste, and reduce internal costs. This efficiency boost translates to better productivity and resource utilization (ISO 2018).
- Better Regulation: Standards provide a consistent, transparent, and targeted framework for developing national and international regulations. By adhering to standards, time is saved, and barriers to trade are reduced (ISO n.d.).
- Innovation and Market Success: Incorporating innovative aspects into standards can catalyze market success. When products align with standardized requirements, they are better prepared for adoption and acceptance (ISO 2018).

- Risk Reduction: Standards mitigate risks by ensuring compliance with established norms. Businesses can make informed decisions, knowing that their practices align with recognized standards (ISO 2018).
- International Expansion: Standards facilitate international trade and expansion. When products meet global standards, they gain access to broader markets and build consumer trust (ISO n.d.).

Standards play a crucial role in various sectors, including energy. Although existing standards often focus on buildings, processes, or products, the literature review and interviews conducted in this project point toward a growing need for standards that specifically support energy behaviour programs. These standards will aim to:

- Enable investment decisions for retrofitting.
- Encourage the adoption of efficient products.
- Advocate for their efficient use and maintenance.
- Support load shifting and demand response.

Current energy standards indirectly address behaviour by outlining performance criteria and offering certifications such as **ENERGY STAR®** provide technical requirements for household devices and appliances. Notably, **ENERGY STAR®** smart thermostat certification considers data collection and savings calculations, accounting for variations due to user behaviour. Additionally, building codes (such as the National Building Code of Canada 2015) set baseline requirements for residential and commercial buildings. While these codes reference occupant behaviour, their impact on reducing per capita residential electricity consumption in the US has been significant.

By developing standards to support the behavioural energy program sector, we anticipate the following benefits:

1. Unified (cross-border) definitions for behavioural energy programs, allowing a wider pool of such programs to be developed and categorized under this broad umbrella.
2. A common minimum pool of parameters that allow for a systemic needs assessment, ensuring all key criteria are evaluated and facilitating comparison between programs so developers may identify trends and insights between iterations of programs.
3. Standards allowing government entities to set the minimum acceptable requirements for such programs and include them in their roadmaps to electrification, demand management, and net-zero grid. The use of standards (national / bi-national / tri-national or international) would also facilitate knowledge transfer across regions.
4. The creation of an institutionalized library of best practices and a baseline for future program development that meets the needs and general requirements of all interested parties involved in the process and the lifecycle.

Conclusion

Throughout the world, governments are engaging behavioural insights teams to examine opportunities to integrate behaviour into program and policy development. For instance, the European Union shared behavioural insights for energy under the knowledge of policy in early

2024, where it detailed the importance of behaviour and how it can help in meeting the aggressive targets (Knowledge for Policy 2024). The development of standards and standards-based solutions established under a consensus-based approach by a group of representative experts of the sector provide a significant starting point for sector development and regulatory support, thereby increasing opportunity for BEPs to maximize their impact on sustainability goals. In Canada, many utility companies are implementing BEPs to support the short-term implications of the push towards electrification. Some utility companies have successfully implemented BEPs and are looking to apply the behavioural lens to a variety of programs, thereby resorting to a wider range of behavioural science methods. Other utility companies are critically re-evaluating their programs and looking into ways to optimize the impacts and ensure their sustainability or perseverance. To this end, a new standard on definitions and minimum recommendations will be developed with an expected publication date in 2025.

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