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STANDARDS RESEARCH

Energy Behaviour: Considerations for Standardization

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List of Abbreviations

Abbreviation	Term
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BBBC	building blocks of behaviour change
CBSM	community-based social marketing
DSM	demand-side management
GHG	greenhouse gas
HER	home energy report
IEA	International Energy Agency
kWh	kilowatt hour
LEED	Leadership in Energy and Environmental Design
NGO	nongovernmental organization
RCT	randomized controlled trial
SBS	standards-based solution
TOU	time of use
Users TCP	User-Centred Energy Systems Technology Collaboration Programme

Executive Summary

The efficacy of behavioural energy programs (BEPs) can flucutate and the context of a specific program can have significant implications for energy savings. To change energy use behaviour is complex, and often resource-intensive, and doing so relies on a solid understanding of the technological aspects of energy appliances and devices and of the human factors that influence energy use and consumption.

Accounting for the variety and complexity of energy behaviours means that programs include many target audiences, building sectors, behaviours, and approaches. Behaviour change interventions that follow whole-system approaches and applied-system thinking frequently yield positive outcomes. These interventions tend to differentiate between complicated systems, for example, ones that involve technology and follow rules, and complex systems, which consider the interplay between energy supply and demand, technology and human behaviour, and politics and the environment, and are constantly changing.

Although dividing all possible combinations of behavioural approaches neatly into categories is extremely difficult, some typologies have been developed:

- Information-based programs that deliver information to customers (e.g., home energy report s [HERs], home energy labels);
- Social interaction programs that rely on interpersonal interactions (e.g., competitions, games);
- Education and training programs that include customer education (e.g., coaching and training); and
- Monetary or financial incentives to encourage participation (e.g., rebates, rates).

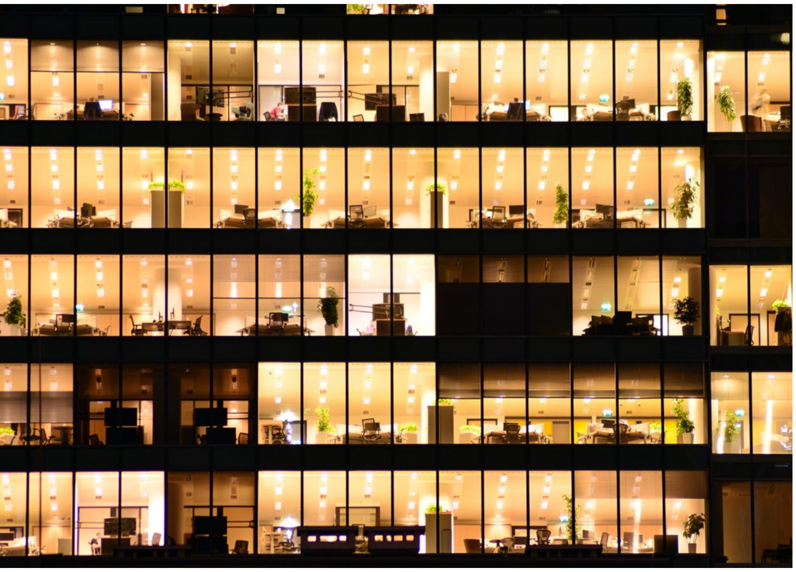
A common challenge is the difficulty in identifying causal relationships between interventions and actual energy use, especially since behavioural programs often use a combination of these strategies. By using standardized and validated measures, researchers and program managers may be able to more easily trust results, compare data, and understand patterns across interventions. Existing energy standards do not directly address behaviour, which leaves room to develop standards and standards-based solutions (SBSs) to support BEPs.

The following recommendations are based on an in-depth literature review of existing standards and research and interviews with 17 behavioural energy research and program experts from industry, research, nongovernmental organizations (NGOs), and government sectors across Canada and the USA:

- Develop definitions and parameter standards. Clear operational definitions for all key terms to establish agreement within a given sector are also necessary to avoid using behavioural terminology loosely.
- Develop minimum requirements standards to highlight potential tools, instruments, and methods that can be used throughout the program development process. Standardizing BEPs or strategies is not recommended, as these evolve as scientific knowledge grows and cultures change.

- Develop standards for evaluation design and data collection and sharing to measure success and support learning across programs. BEPs should include an evaluation of behavioural persistence (over at least 6 to 12 months) and non-energy impacts, including perceived and actual benefits and costs of changing behaviour. Creating standardized data-sharing protocols and platforms for regulators, evaluators, third-party vendors, and utilities would address the issue of energy data (e.g., from smart meters) not being collected, stored, or analyzed inconsistently.
- Develop SBSs – best practices, guidelines, support, and training – to help build individual and organizational capacity and growth in the energy efficiency and demand response workforce. Augment the many available case studies with guidelines detailing how to identify suitable behavioural strategies or ideas for a given context.

To be able to consistently save energy of shifting outcomes via behaviour likely requires a combination of interventions based on different contexts and circumstances, and collaboration and co-design with multiple interested parties. It may yield many possible solutions and will likely not be resolved using technology alone. As such, the development of standards and SBSs for BEPs could potentially offer a significant step toward meeting Canada's emissions targets and goals.



"To support energy management across sectors, practitioners and policymakers must consider human behaviour along with that of ongoing supply- and demand-side technologies in buildings."

1. Introduction

> *"Energy efficiency is not just low-hanging fruit; it is fruit lying on the ground."*
>
> – Former US Energy Secretary Steve Chu

1.1 Defining Energy Behaviour

The Canadian Oxford Dictionary defines "behaviour," as used in psychology, as "an observable pattern of actions (of a person, animal, etc.), esp. in response to a stimulus" [1].

Individual behaviour is often considered a significant factor in meeting energy efficiency and climate objectives. To support energy management across sectors, practitioners and policymakers must consider human behaviour along with that of ongoing supply- and demand-side technologies in buildings.

To accurately define energy behaviour, it is important to understand the differences between influences on behaviour (e.g., habits and routines [2]), dimensions of energy behaviour (e.g., efficiency, conservation, maintenance), the purpose of behaviour change (e.g., using less energy, shifting time of use [TOU]), and the exact behaviour being targeted (e.g., buying efficient light bulbs, turning the thermostat down at night), as all of these elements are important to understanding behaviour.

Similarly, it is beneficial to define energy behaviour in a way that is applicable and relevant to different practitioners, for example, policy analysts, industry program managers, building operators, engineers, and community-based organization leaders. The definition also needs to reflect the ways that practitioners refer to energy behaviour in practice to ensure that they establish a common language across different fields.

For the purpose of this report, energy behaviour "refers to all human actions that affect the way that fuels and carriers (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 they are used, and the mental processes that relate to these actions" [3].

1.2 Why Including Behaviour in Energy Programs is Important

Behavioural energy programs (BEPs), inclusive of energy efficiency and demand response (i.e., balancing the demand on power grids by encouraging customers to shift electricity use to times when electricity is more plentiful or other demand is lower),[1] have the potential to meaningfully decrease energy consumption, both within and outside of the residential sector. Small-scale energy users (e.g., households and small businesses) account for almost half of the total electricity consumption in Canada (around 25% and

1 Note that the literature draws distinctions between behaviour change programs and interventions; however, this report mainly refers to programs as they are more commonly used in North American interventions.

22%, respectively) [4]. However, it appears that a large proportion of the energy savings (or demand-side management potential) in this sector is not realized. This is often referred to as the "energy efficiency gap"—the difference between actual energy use and the potential energy savings that would be cost-effective and relatively easy to implement [5]. To reduce this difference, it is crucial to gain a deeper understanding of the factors that influence human behaviour and behavioural change (an important and often overlooked aspect of energy efficiency). It is estimated that energy-related behavioural change, facilitated or induced by targeted programs, can result in 20% to 30% of electricity savings (sometimes called the "behavioural wedge"; see [5]-[8]).

That being said, the efficacy of behavioural programs appears to vary, and program contexts and characteristics have significant implications for energy savings and program success. Program contexts and characteristics include the behavioural intervention being used, the location in which the program is implemented, and the target audience being addressed. To apply these programs successfully is complex and often resource-intensive. In addition, doing so relies on a solid understanding of the technological aspects and potentials of these programs, and more importantly, the human factors that influence energy use and consumption.

Applying these programs also entails acknowledging and minimizing significant biases, as exemplified by thermal comfort models that are specifically designed for White males. This is essential, as prior research has indicated that such biases can lead to overestimating the average female metabolic rate by almost 35% [9]. Conversely, frequently omitted are the numerous benefits and costs of energy efficiency programs, such as improved comfort or health or increases in individual productivity, which are called "non-energy impacts" or "multiple impacts" (e.g., [10]-[12]).

Additional behavioural considerations related to energy efficiency programs include free-ridership (i.e., when individuals take an action targeted by a program that they would have taken without the program) [13]; rebound effect (i.e., when an increase in energy efficiency is partly or completely cancelled out through an increase in energy usage) [14]; and prebound effect (i.e., the tendency of occupants in less energy-efficient dwellings to take more energy-conserving actions than those in more efficient dwellings, offsetting at least some of the actual difference in energy use [15]; and spillover (i.e., when a specific change in behaviour leads to a change in behaviour in another context or of another kind) [16], [17]. These behavioural considerations should be explicitly addressed upfront when designing new programs and interventions. This proactive approach helps maximize the desired outcomes and avoid unintended consequences. To increase the potential for developing successful behavioural programs, their design and implementation should be informed by behavioural science research and lessons from real-world applications.

1.3 How Current Energy Efficiency Standards Address Behaviour

Existing energy efficiency standards, which are typically associated with buildings, processes, or products, do not directly address energy behaviour, although some indirectly refer to behaviour through performance standards. Conversely, certification programs demonstrate that compliance with standards requirements has been met. ENERGY STAR, a prominent certification program in Canada, the USA, and other countries, describes the technical requirements for different household devices and appliances as well as for entire homes [18]. The ENERGY STAR smart thermostat certification requirements are particularly informative as they specify the data collection and savings calculations of these devices to account for variations in energy savings due to user behaviour [19].

Some certifying bodies, such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), develop standards for heating, refrigerating, and air-conditioning systems and certify the professionals who work on them [20].

Building codes set the baseline requirements for residential and commercial buildings. The only two mentions of "occupant behaviour" in the 1,412 pages of the 2015 *National Building Code of Canada* [21] refer to how the performance calculation requirement can neutralize the impact of occupant behaviour (on page 663 , Division C 2-7) and that "the length of showers depends on occupant behaviour" (on page 1361, Division B 9-633). The introduction of building codes has significantly reduced per capita residential electricity consumption in the USA [22]. The *National Energy Code of Canada for Buildings* also aims to improve energy efficiency and reduce greenhouse gas (GHG) emissions in large buildings [23]. However, "behaviour" is only mentioned once in this 316-page code (on page 205, Division B 8-2), and, as with the *National Building Code of Canada*, only to exclude occupant behaviour influences.

There are also several rating systems for buildings that are meant to work as catalysts to improve the baseline performance of buildings. (Typically, these are the building code requirements mentioned in the previous paragraph.) The premier certification for buildings in North America is the Leadership in Energy and Environmental Design (LEED) building rating system, which grades residential and nonresidential buildings [24]. The most recent version, LEED v5, released in 2023, focuses on the operation and maintenance of existing buildings [25]. In the USA, home energy labelling programs standardize the benchmarking of the estimated energy use of houses and disclose energy efficiency characteristics [26]. Neither LEED v5 nor the US home energy labelling programs take into account occupant behaviour despite the significant impacts on the energy use of residential and commercial buildings [15] and the gap between modelled and actual energy consumption (as much as 2.5 times higher than predicted) [27].

In the commercial sector, ISO 50001:2018 [28] specifies the requirements for energy management systems in buildings and the products within them. The 50001 Ready Canada program [29] verifies the implementation of ISO 50001-based energy management systems in Canadian facilities and buildings. ISO 50001:2018 rarely references behaviour; it supports organizations as they develop and implement energy policies, and establish objectives, targets, and action plans. These organizations are, during the implementation phase, required to ensure that individuals working for the organization understand "the impact, actual or potential, with respect to energy use and consumption, of their activities and how their activities and behaviour contribute to the achievement of energy objectives and targets, and the potential consequences of departure from specified procedures." Although ISO 50001:2018 describes the need to consider individual behaviour, it does not define "behaviour" or provide guidelines on how to take into account individual behaviour.

In addition, ISO 50049:2020 [30] and ISO 17741:2016 [31] provide guidance on the evaluation of energy efficiency measures, with the former addressing energy efficiency at the national level, and the latter at the project level. Although behaviour is referenced as one factor that explains variations in consumption, both ISO 50049:2020 and ISO 17741:2016 address regulatory evaluation and do not explicitly examine user behaviour [30], [31].

In 2017, the Province of British Columbia adopted the BC Energy Step Code [32], which provides performance-based guidance for new buildings and facilities to meet the province's 2032 Net Zero goal. The Energy Step Code does not specify the precise steps builders must take to meet the goals set out in the code, but proposes best practices for achieving these goals and allows builders to select the optimal methods for their situation. As with ISO 50001, the Energy Step Code does not explicitly address behaviour even though behaviour change underpins many of the described goals. For example, the code addresses the importance of effective labelling to increase the visibility and demand for green buildings.

1.4 Report Goals

The core objective of this report is to identify standards and standards-based solutions (SBSs) to support behavioural energy programs (BEPs). The report authors analyzed best practices from primary research, program evaluations, existing standards, and insights from experts in the field to develop recommendations to enhance the effectiveness of BEPs in Canada. With standards or SBSs supporting BEPs, utilities, implementers, and regulators can develop a shared understanding of what constitutes an effective behavioural program and design programs that are informed by these best practices. Standards that support BEPs could also enable investment decisions for retrofitting, encourage the adoption of efficient products and advocate for their most efficient use and maintenance, and support load-shifting demand response, among other benefits.

This report focuses primarily on the residential and small consumer sectors . The intended audience aligns with four main groups : producers (e.g., designers of BEPs); regulators (e.g., policymakers at all levels of government); implementers (e.g., utility administrators and industry program managers); and general interest (e.g., academics, nongovernmental organizations [NGOs], and the public).

1.5 Methods

An in-depth literature review, a landscape analysis, and expert interviews were used to gain an understanding of BEPs and strategies to promote sustainable energy practices. Findings were analyzed and integrated to inform key recommendations for BEPs and possible opportunities for standardization.

1.5.1 Interested and Affected Parties and Expert Interviews

The report authors interviewed key experts and interested and affected parties on topics related to BEPs. Interviews lasting 30 to 45 minutes with 17 members of the following six groups were conducted between July and August 2023:

- Associations and consumer-based organizations (n=2)
- Government (n=4)
- Implementers (n=3)
- Research (n=3)
- Training organizations (n=2)
- Utility or industry (n=3)

In addition to balancing type of interested and affected parties, the report authors prioritized interviewees from several geographic regions of Canada (East, West, and Francophone). The interview roster also included non-Canadian experts with specific expertise and insights on BEP design, implementation, and evaluation from global behavioural program vendors, major energy utilities, government agencies, and leading research NGOs. The semi-structured interview approach was based on an interview guide (see Appendix A). This approach allows for expanding on important areas raised in each interview.

A content and thematic analysis extracted common insights from across the interviews. Quotes that highlight and support literature review findings are included in this report (see Section 2). These interviews indirectly informed our overall findings by guiding us to additional resources or areas of focus in the literature review and directly informed our recommendations for BEPs and possible opportunities for standardization.

1.5.2 Landscape and Literature Assessment

The literature review established the current state of behavioural science theory and practices relevant to promoting energy efficiency (i.e., providing the same level of service with equipment that uses less energy) and demand-side management (DSM; a strategic approach to energy conservation that seeks to manage consumer demand for energy). In turn, the literature review and an assessment of the current BEPs and standards landscape informed our expert interviews.

An integrated, narrative review and classification of behavioural science literature, BEP solutions, and evidence implemented in Canada and elsewhere allowed for an evaluation of the current state of knowledge on BEPs, standards, and SBSs. Any specific gaps provided a means to help develop recommendations. The report authors reviewed primary and secondary literature on behavioural theories, strategies, programs, standards, and SBSs, with a focus on peer-reviewed publications in academic journals, technical reports, industry trade publications, and online government resources. Although reports published within the last five years were prioritized, the literature review included seminal literature within the field published several decades ago. Altogether, more than 150 publications were identified and reviewed. For a summary of the current understanding of behavioural science and BEPs, see Section 3; for identified gaps and recommendations, see Section 4.

2 Informant Interviews

2.1 Behavioural Priorities for Standards

Overall, the interviewees agreed that all sectors need to consider energy behaviour. Frequently emphasized was the point that energy behaviour needs a higher profile and credible validation so that decision makers are more likely to recognize and support BEPs. Interviewees agreed that a standard, if developed correctly, could contribute to this. Although interviewees were unsure about the scope of such standards and wanted greater clarity on the definition of energy behaviour that will be used in the context of standards, they supported the development of BEP standards in general.

The following five key perspectives were held by all the interviewees:

- Standards are useful to clarify common understanding and best practices: Given the confusion about what constitutes "behaviour," the interviewees agreed that defining this term could be a common starting point for standards.
- Standards are best suited for distributors and implementers and implementers: The interviewees were clear that the public would not typically be the target audience for standards or SBSs such as guidelines and supporting tools, however some SBSs may be designed for public use.
- Standards should be included in a suite of solutions because behaviour is complex: The interviewees agreed that standards should focus on the process, and not the programs, to maintain creativity and flexibility for innovation in the field of energy behaviour.
- Accessibility is a key consideration in standards and SBSs: Since standards are often written in a specific and technical format, SBSs may be needed to help utilities and vendors use them as intended. A good example is the 50001 Ready Navigator tool [33] developed by the Lawrence Berkeley National Laboratory to help US federal agencies apply ISO 50001. Such tools may be particularly important in energy behaviour applications because expertise in this field is still limited.
- A key role of standards is to help raise the profile of behavioural approaches in energy efficiency or demand response: Interviewees saw the role of standards as both supporting and promoting behavioural approaches in the field of energy efficiency and demand response, which often leans heavily on technical solutions, ignoring the importance of human factors in the adoption and use of these technologies.

> "On-site source separation is challenging due to lack of worker awareness, insufficient volumes of generated materials to cover transportation costs and distances to recycling centres. The infrastructure at the recycling facility also affects the uptake if, for example, there is only one weighing station. Each bin would have to be brought in separately, adding to the time and labour required to bring in the recycled materials. The investment in these efforts does not have sufficient return to make it cost-effective for many projects." —**Association**

Most interviewees agreed that increasing a shared understanding of energy behaviour through standards would be beneficial. Many reported that they value standards and SBSs because of the rigour, review processes, and testing that goes into developing them. Others expressed concern that the dynamic nature of human behaviour may make it difficult to develop relevant standards or that efforts to do so could inhibit creativity if these are developed incorrectly. For example, in 2009, the State of California restricted behaviour-based energy programs to comparative energy usage disclosure programs (e.g., home energy reports [HERs]) that "[disclose] information to residential subscribers relative to the amount of energy used by the metered residence compared to similar residences in the subscriber's geographical area" [34], and adopted a policy to measure and count savings using experimental design methodologies and only credit behaviour programs on an ex-post basis (D. 10-04-029) [35]. This decision, which was upheld in 2012 (D. 12-11-015) [36], limited the type of programs that could be offered in the state for several years.

The above definition of BEPs introduced by the State of California provided an important starting point to identify what counts as "behavioural" while addressing perceived risks of double counting, persistence, and uncertainty. However, as the need for demand-side savings grows, so too does the need for continued innovation in approaches to BEP design. While the reported savings of 1% to 3% for HERs are promising, social science research has identified numerous behavioural strategies beyond comparative energy use that can also drive energy efficiency behaviour. McKinsey & Company found that behavioural interventions could lead to reductions of between 16% and 20% in residential energy use in the USA [37]. As such, a broader definition is needed to allow for more creative, innovative, and iterative approaches, leading to additional savings and a more engaged population.

2.2 Defining Energy Behaviour

The interviewees agreed that a standard could help clarify definitions and terms to support a common understanding of energy behaviour. They recommended developing a flexible definition that is acceptable and relevant across sectors; that promotes a range of actions for various audiences and takes into account various processes; and that does not impede the field from evolving and the development of new program approaches (e.g., beyond HERs) or end-user behaviours (e.g., moving from efficiency to demand response). A definition that is too narrow or prescriptive (e.g., defining energy behaviour as only including individuals as opposed to communities) might limit options and therefore the creativity to try new approaches. In addition, the interviewees noted that energy behaviour goes beyond efficiency interventions and includes applying a behavioural lens when, for instance, designing demand–response interventions. The interviewees suggested taking a systems view[2] and examining the issue within its broader context, including interactions with other stages, instead of in isolation, so that the work can happen at the right level (or multiple levels). This systems view could include culture and lifestyle change, and opportunities to practice new perspectives and actions.

> "A lot of current practices, policies, and programs don't keep up with what's really needed, and recognizing the importance of behaviour is one of them. It needs to be more ubiquitous. Can you really get a certification right without including the human component? It's often in there [e.g., Certification of Energy Managers, CEM or energy audits] via case studies, but [they] could use some more structured best practices and case studies." — **Implementer**

2.3 Thoughts on Behavioural Energy Programs

The interviewees observed that BEPs often focus on economic and technological changes, which are relatively easy to quantify. They suggested that these programs should expand their focus and use mixed methods such as behavioural and social science strategies, field research, support on decision-making and thought processes, assessments, and interventions (e.g., feedback, gamification, promoting permanent upgrades, and investment behaviours in deep retrofits). This description aligns with research findings [38] that BEPs are best applied to a process rather than a particular stage.

2 i.e., examining the issue within its broader context, including its interactions with other stages (e.g., the overall system) instead of in isolation.

"The narrow classical definition [of comparative energy usage disclosure programs] ... mostly focuses on consumption behaviours and conservation behaviours rather than purchases, and includes some kind of RCT [randomized controlled trial]. It usually excludes financial incentives. That definition has excluded some of the most impactful behaviours like purchases, weatherization, etc., from behaviour change programs. I believe everything is behaviour – decision-making is behaviour – so we should open up the interventions we are using. Encourage us to [consider] energy behaviour programs as a process and approach rather than a specific set of intervention tools." — **Implementer**

Some interviewees also differentiated between systems that are "complicated" (e.g., involving pure technology and following knowable rules) and "complex" (e.g., involving human behaviour and constantly changing) and suggest that complex systems require more creative approaches [39]. Energy management is still seen by many as a purely technical issue, and human behaviour is not often considered part of the solution. This view is driven by engineers who make up the largest proportion of energy professionals and who are trained to resolve complicated problems that often have right and wrong solutions. In contrast, energy behaviour, which applies to people and culture, is a complex problem that does not generally have a specific solution and is often driven by user perceptions and needs. Engineers who agree that people are part of the solution may not be equipped to work with social science strategies central to energy behaviour.

"A lot of my colleagues are engineers and physical scientists who think the social sciences are soft and easy `but I know they are much more challenging and complex. The technical stuff is easy – it's more predictable, less complex, more solvable [than] working with physical systems. Human brains change all that." — **Implementer**

For utilities, energy programs need to show progress, claim savings, and provide a return on investment in what is perceived as a reasonable amount of time. These priorities usually do not include time for field studies or qualitative evaluations of targeted energy users' lived experience. This results in programs that are overly focused on economic and technological changes, which are relatively easy to quantify. Programs are often reduced to campaign-style information-sharing or mass marketing, which excludes a lot of harder-to-reach energy users. Behavioural science and other social sciences can help program designers, implementers, and evaluators clarify specific target audiences and specific target behaviours, such as promoting existing "good" energy behaviours (e.g., those that save energy or use energy more efficiently). Behavioural and social sciences may enhance the structure and customization of programs for specific contexts, circumstances, and organizations.

"People [like energy auditors] usually are not trained to [focus on the human and behavioural aspects], even though it is easy to include at least some human components. It's inexcusable not to do it, really. I work in the conventional world of engineering and retrofits and verification, and I really advocate [for] collecting data on the people, not just the numbers from the BAS [Building Automation System] or meter. How do people perceive their environment? Do they feel included in the processes that are meant to provide them [with], for example, thermal comfort? We need systemic ways of engaging with people, preferably face-to-face or at least via surveys." — **Implementer**

"The ASHRAE thermal comfort standards were designed around adult White males in the 1960s. And we want low or zero carbon energy services delivered equitably to any population? How can that be if it's based on a small privileged subset only – and that's a key international standard! Hundreds of millions of dollars are spent on energy assessments, yet it is very uncommon for these assessments to even survey the occupants first. We just assume ASHRAE is the target, and that includes all sorts of assumptions which are only partly accurate and not verified. Assessors use HVAC [Heating, Ventilation, and Air Conditioning] setpoints as their data – they seldom survey occupants, which would be best practice. You can't just assume that they are happy with the services they are getting; they may be over- or underserved."— **Implementer**

"What is working, is a general trend toward understanding that behavioural science can have an impact. And I'm seeing more behavioural scientists [being] engaged and for behavioural science [being taken] more seriously. People understand that they can't just use technology to get around the problem, or you know, ignore the human element of these problems. So I think that there is a general appreciation for the field, which is a good thing. But the problem is, what's not working is real evaluation of the projects, so that stifles the creativity of the field in terms of implementing behaviour change programs."— **Evaluator**

The interviewees observed that BEPs are often repackaged for a specific purpose, sector, or audience or a combination of many different strategies and tactics. Some noted that the early stages of program conceptualization and implementation should be about experimenting with approaches, and that the actual program must be context-specific and therefore flexible and adaptable to a given circumstance. Interviewees also expressed a desire to see BEPs mature by establishing a common understanding of definitions, theories, applications, and measurements, among others.

"I know on the bills, the hydro bills that we get, they're now comparing our home to others that are like our home. And so that's… I guess that could be a tool that one would think of in terms of behaviour change. So if there are practices that could be taken up by the various utilities, like, if there could be an agreed-upon set of practices at a minimum, that all [utilities] would be delivering." —**Association**

Some interviewees noted that programs do not focus enough on people and that they become too cumbersome and misunderstood by energy users. Misunderstanding the intent of the program or the steps involved, because of a lack of familiarity with such programs or ineffective communication about them, results in frustration and unmet expectations. Government grant programs can have long processing times, too many steps, and slow feedback on queries as well as impact, sometimes taking months or even years between updates [40]. This can be demotivating and lead to low uptake or early withdrawal. Some interviewees observed that engaging with energy programs is logistically difficult (e.g., too many people or agencies to check with along the way), which creates barriers, especially when applying for and accessing incentives and rebates.

Working with people means recognizing cultural contexts, including "energy cultures," [41] and acknowledging that cultures shift over time. For associations that support members and sectors, continuous and isolated interventions that impact energy consumption behaviours are as important as formal programs, particularly for individuals beginning the process of energy management. Interviewees noted that pilot projects that address the specific needs of populations at a smaller scale and quantitative and qualitative field data collection are some of the ways that BEPs can support the development of energy culture.

"It's systemic changes, rather than just [a] mechanical kind of action, like getting people to turn off the lights [that will impact energy culture]. Like that's not gonna have the same kind of impact in the system shifting, so that it views energy management as being one of the drivers or outcomes or part of culture and practice."
— **Researcher**

"Working with people means recognizing cultural contexts, including "energy cultures," and acknowledging that cultures shift over time."

2.4 Thoughts on Evaluating Behavioural Energy Programs

Many interviewees observed that collecting and comparing evidence is hard, largely because there is limited or no guidance on what is considered adequate to evaluate, especially at smaller scales. They noted a lack of data collection that goes beyond individual program evaluation to support comparisons between BEPs. This applies to self-comparison of the same program over time and comparisons across different programs, interventions, or audiences at the same time. Some interviewees observed that there is often not enough evidence to assess the direct impacts of programs on behaviour.

The scarcity of tools to evaluate BEPs may be due to a variety of reasons:

- Existing data do not reveal the whole picture or may be misleading.
- New data streams are difficult to set up and standardize for comparison.
- Knowledge and training in research and behaviour change design are limited.
- Insufficient value is placed on the expertise required to complete reliable evaluations.

"Standard reporting frameworks and data systems are incredibly important. There are different markets… we don't want monopolies – different vendors should be able to innovate. But, we need a well-thought-out, cleanly structured system that makes it easy for utilities to share data with the regulator or evaluators or third-party vendors… We spend so much time getting data clean, it would be easier if in-house people would follow standard data collection [methods]. It often means you can't compare one program to another. So there was a lack of foresight and capacity to build out those standards." — **Researcher**

Despite a lack of evidence, interviewees said that BEPs are implemented more or less adequately, even if they are rarely properly evaluated. They reported that program evaluations are rare because they are extremely difficult to do well, particularly in the case of opt-in programs (e.g., audits, rebates, demand responses). In some cases, program evaluators turn to traditional measurement and verification protocols, such as pre–post intervention comparisons or RCTs, or draft their own evaluation protocols to apply to their specific set of circumstances. Predetermined evaluation criteria such as these can stifle creativity as people strive for common metrics and do not include what makes sense and works best in a given context (see Section 3.5.2).

3 Landscape and Literature Assessment

Our landscape and literature assessment is summarized in the next five subsections.

3.1 Describing Energy Behaviour

Residential energy behaviour includes many actions with different psychological motivators and varying environmental impacts [42], [43]. For instance, when considering energy efficiency to do with lighting, distinct behaviours include turning off lights when leaving a room, installing energy-efficient lighting or remote sensors, or setting light timers or other means of automation. Although these actions all decrease overall energy use, they differ in how, when, and why individuals engage in them, as well as their complexity, financial costs, savings, and behavioural persistence (i.e., if and for how long a behaviour change persists [44]). As all of these complexities influence the actual (rather than technological) potential of energy efficiency solutions, a solid understanding of how human behaviours interact with energy-efficient technology should be incorporated in both the design and distribution of these solutions.

Common characteristics of BEPs include understanding how people make energy use decisions, interact with technology, and use energy. BEPs help us to understand individuals and facilitate improvements in energy consumption behaviours by learning from users and evaluating program impacts, including measurements that audiences care about. For example, outcomes are often measured in kilowatt hours (kWh) or GHG emission reductions, both of which are quantifiable and thus at the heart of most energy efficiency intervention metrics measured by producer and user interest groups. However, it is also crucial to identify non-energy impacts, such as improved comfort or health or increases in individual productivity. Such qualitative and subjective benefits are often critical motivators for energy users. Misunderstandings or misalignments between user motivations and energy programs introduce barriers to adoption and contribute to the energy efficiency gap [5].

As with the observed differences in program outcomes of interest (e.g., kWh reduction vs. non-energy impacts), the focus in government and industry on technological fixes and energy efficiency retrofits continues to outpace investment in behavioural programs that target the correct use, programming, maintenance, and repair of these technologies. This oversight minimizes savings and sometimes leads to unintended consequences (e.g., switching to energy-efficient heat pumps but not understanding how to use them properly, thereby using more energy). Focusing on technological solutions without taking into account the accompanying behaviours to facilitate energy efficiency often leaves the energy user without sufficient information on the energy systems in their home and overlooks their participation in reducing energy consumption [45].

3.1.1 Dimensions of Energy Behaviour

A growing body of research shows that energy behaviours vary and that it is important to distinguish between specific energy behaviour dimensions for greater predictive validity and to improve programs [46]-[48]. Earlier work in the field suggested that energy behaviours can be classified into two dimensions, commonly referred to as “curtailment” and “efficiency” [49]. Curtailment behaviours, also referred to as “habitual” and “conservation” behaviours, refer to daily or regular changes to energy consumption. Some define curtailment behaviour primarily by its outcome (e.g., reducing comfort), others by its frequency (daily or regularly), and yet others by the effort or money required (little to none) or motivation (energy conservation). Efficiency behaviours, also referred to as “purchase-related,” “investment,” and “technology” behaviours, refer to one-time actions that are long term or permanent. The defining features of efficiency behaviours include frequency (one time or infrequent), cost (required for purchase and/or installation), and cognition (requiring a conscious action).

Figure 1: Dimensions of energy behaviour based on frequency and cost

	Low Frequency	High Frequency
Low Cost	Maintenance	Curtailment
High Cost	Efficiency	(n/a)

Still, curtailment and efficiency behaviours are interrelated and these definitions may present a false dichotomy (see Figure 1) that does not adequately dimensionalize energy behaviour [50].

To address these limitations, some researchers have proposed dimensions of energy behaviour beyond curtailment and efficiency. These include:

- Investment versus management of efficient equipment [51];
- Weatherization, equipment, maintenance, adjustments, and daily (WEMAD) behaviours [8];
- Maintenance and management of energy devices, advanced energy efficiency (e.g., purchasing a smart thermostat), and appliance efficiency [52]; and
- Family style, "call an expert," household management, and weekend projects [53].

In addition, the increased availability of and need for renewable energy has brought about a need to consider a new set of behaviours that are related to demand response [54], [55], demand flexibility (i.e., the ability to vary customer demand for electricity in response to generation, network, or market signals) [56], and DSM [57]. While the focus for decades has been on overall energy reductions, behaviours related to load shifting or changing the TOU have moved to the forefront. Therefore, it may be beneficial to clearly define target behaviour(s) before designing BEPs.

3.1.2 Existing Resources for Energy Behaviour Dimensions

While the types and names of energy behaviour dimensions vary, the behaviours would nonetheless benefit from categorization. Several vendors and utilities across North America have created their own lists of energy behaviours and characteristics that can be referenced across a wide variety of programs and communications, including home audits, HERs, newsletters, and websites. In some cases, these lists have been developed and adapted into collections of energy-saving tips that can be added to outreach material. Unfortunately, these lists are typically confidential or behind a paywall, resulting in significant redundancies. Some researchers [53] have developed lists of behaviours coded according to behavioural attributes.

3.2 Behavioural Theories

The factors that are evaluated to determine the success of an effective BEP depend on the disciplinary assumptions of the program, as each discipline varies in its focus, methods, and goals [58]. A recent systematic literature review [59] mapped the landscape of behavioural theories and identified 62 theories from disciplines as varied as health care, computer sciences, engineering, urban planning, architecture, and environmental science. However, in the energy sector, the three core disciplines of economics, psychology, and sociology have informed most of the programs to date. In recent years, criticisms that these approaches reflect a Eurocentric, White, middle-class worldview [60] have been met with attempts to incorporate Indigenous traditional knowledge and decolonize thinking [61], [62]. Nonetheless, the focus of this report reflects the vast majority of evidence available to date, which is largely based on Western science.

There is naturally a lot of diversity within – and crossovers between – disciplines (see Sections 3.2.1 to 3.2.3). Although no single discipline provides a complete picture of energy behaviour, all aim to understand and explain the complexity of human behaviour in order to make changing energy behaviours manageable or, at least, more manageable. Explicating the theories underlying a behavioural program allows program designers to assess whether duplicating the program for a particular target audience, behaviour, or context is relevant.

3.2.1 Psychological Theories

A psychological approach to energy-related behaviour can be summarized as follows: "Energy use can be affected by stimulus–response mechanisms and by engaging attention" [63]. This means that decision-making is aimed at making choices, which are informed by both emotional and cognitive factors. People change their behaviour when they have a strong positive intention, no major logistical constraints, and the necessary skills to perform the behaviour [64]. Programs based on psychology are often designed around identifying motivators for and barriers to a desired behaviour and seeking to increase the former and decrease the latter.

The most common subdiscipline of psychology applied in the field of energy behaviour is social psychology, which considers the individual and their decisions as embedded within groups and influenced by their social context. Some of the most widespread BEPs, such as HERs, consider individuals as operating as part of a collective (e.g., by imitating the behaviour of important others or through the influence of social norms and social learning [65]). "Social psychologists talk about 'behaviour,' which originates in the individual, and is the product of their beliefs, attitudes, and other motivational factors" [2].

The following are among the most common factors in psychological theories of behaviour:

- ***"Attitudes"*** are "the product of our beliefs about a behaviour (or object), combined with the value we attach to those beliefs" [66].
- ***"Social norms"*** are a person's "perception that most people who are important to [that person] think that [the person] should or should not perform the behaviour in question" [66].
- ***"Agency"*** is "an individual's sense that they can carry out an action successfully, and that that action will help bring about the expected outcome" [66].
- ***"Habit"*** is "an individual's 'standard operating procedure'" [48], which is particularly prevalent in energy-using behaviours [2].

These psychological factors can impact personality, lifestyle, social status, activities, interests, opinions, and attitudes.

Most energy efficiency research fails to include psychological segmentation (i.e., dividing user groups by psychological characteristics or tendencies) in research methods and analysis (see [67]), which limits understanding of the effectiveness of many energy efficiency programs.

3.2.2 Economic Theories

Traditional economic theory, as applied to energy, can be summarized as follows: "Energy is a commodity and consumers will adapt their usage in response to price signals" [63]. When individuals make energy decisions in this largely rational and price-driven manner, behaviour is assumed to be fairly predictable. Even though research over the last few decades has poked holes in this theory, economists who rely on this assumption continue to assert prominent influence over policy and program design, often at the expense of energy justice considerations [68]. Newer economic disciplines, such as behavioural economics, incorporate a more realistic understanding of human behaviour [69].

Behavioural economics integrates principles from psychology (see Section 3.2.1) with economics in order to understand how humans make decisions. Behavioural economics has significantly influenced government approaches to behavioural interventions in recent years via the installation of various "nudge units" or "behavioural insight teams" [70], [71]. Behavioural economics can bridge purely quantitative methods (e.g., measuring simple cause and effect) and qualitative, explanatory methods (e.g., seeking to understand the why and how of a program).

"When individuals make energy decisions in this largely rational and price-driven manner, behaviour is assumed to be fairly predictable."

It describes how an individual's behaviours and decision-making processes are often influenced by systematic cognitive biases (e.g., "choice architecture," "discounting," and "loss aversion") [70].

A behavioural program that utilized nudging tested nonfinancial mechanisms to drive the Province of Ontario's demand management goals under the time-of-use (TOU) pricing structure. A behavioural economics review found that "motivating consumers to stimulate increased adoption of TOU via consumer-centric communication strategies is a cost-effective and manifest direction" [72]. In Finland, energy users with access to feedback and energy-saving tips showed a 10% reduction in energy consumption [73].

Criticisms of the widespread use of behavioural economics in energy programs include the "morality of 'libertarian paternalism'" [71] and that using neuroscience in nudges is not always empirically tested and "borders on the unscientific" [74]. The field of behavioural economics is also criticized for frequently failing to take social context into account when applying nudges (see Section 3.2.3).

3.2.3 Sociological Theories

A sociological approach to energy behaviour can be summarized as follows: "Modern energy use is largely invisible, energy systems are complex, and daily practices are significant" [63]. Many sociologists argue that the central focus of energy programs should be on social practices, which include routine activities and habits (e.g., turning down the thermostat at night) [75]. The economic view that individual energy users are "micro-resource managers" who make "constant and active choices" about their behaviour is overly simplistic when considering how daily activities unfold in the home [76], [77]. Family members and other social variables are integrated with individual actions, so much of our behaviour includes negotiated norms and changing routines, usually embedded within a wider social context.

"Practice theory" is an area of sociology that has influenced behaviour change research and policy [78]. In its simplest form, "materials (objects and hard infrastructure), competencies (skills and know-how), [and] images (meanings, ideas, and interpretations)" inform the emergence of certain practices [2]. From a sociological approach, the main factors believed to influence domestic energy consumption are physical systems and infrastructures, social norms, comfort preferences, daily routines, practices, and options for control; however, it is difficult to examine their influence on energy behaviour.

3.2.4 Multidisciplinary Approaches

Researchers have differentiated between individualistic models of energy behaviour (predominantly from psychology and economics) and social models of energy behaviour (which include macro-level societal factors, such as technology, politics, and the economy) [2]. Table 1 summarizes the various pros and cons of individualistic versus social models of energy behaviour.

Rather than choose between these two worldviews, the energy behaviour theories discussed within psychology, economics and sociology can be integrated into multidisciplinary models for implementation. These multidisciplinary approaches to behaviour change seem to be more effective at leading to lasting change than those derived from a single discipline [3]. For instance, social ecology is a widely respected transdisciplinary approach to addressing societal issues within the behavioural and social sciences. It takes a "broad, interdisciplinary perspective that gives greater attention to the social, psychological, institutional, and cultural contexts of people-environment relations than did earlier versions of human ecology" [79]. The core principles of social ecology include: (a) multilevel analyses of people–environment relationships; (b) the use of systems theory principles, particularly feedback and interdependence; (c) translation of theory into real-world interventions and policies; (d) combining academic and non-academic perspectives, including lay citizens and community groups; and (e) transdisciplinary values and orientation, synthesizing concepts and methods from many fields [80].

Behaviour change interventions that follow whole-system approaches and applied system thinking are often very successful. These interventions tend to differentiate between complicated systems (e.g., pure technology) and complex systems, which consider the interplay between energy supply and demand, technology, and human behaviour, and politics and the environment [38], [81], [82].

Table 1: Differences between individualistic and social models of energy behaviour

Individualistic models		Social models	
Pros	**Cons**	**Pros**	**Cons**
Often scalable (due to their basis in global theories of cognition)	Do not always incorporate social context	Use a systems approach, including social context	Lack of scalability due to differing social contexts
Easy to follow and apply across settings	Need to target each individual	May reach more people through social groups	Measurement is more difficult
Can look at individual influencing factors	Influencing factors may not be individualized	Looped models may be more realistic	Causal relationships are hard to determine
Known and tested	Effect sizes (i.e., measurable impact) are often small	May have a larger impact due to social influence	Approaches are more difficult to test
Very powerful with audience segmentation	Complex, and realistic models are hard to use	Foster collaboration among groups	Relies on soft skills like trusted relationships that are not easily scalable

Applying behavioural theories from the perspective of any academic discipline without the process of change might not necessarily lead to successful behaviour change interventions. Most importantly, theory alone is insufficient when generating effective interventions as these also rely on careful program design (see Section 3.3).

3.3 Behavioural Energy Programs and Strategies

3.3.1 Behavioural Energy Program Categories

Although it is extremely difficult to divide all possible combinations of behavioural approaches neatly into categories, some typologies have been developed [83], [84]. These can be summarized as follows:

- Information-based programs that deliver information to customers (e.g., HERs, home energy labels);
- Social interaction programs (e.g., competitions, games);
- Education and training programs (e.g., coaching and training); and
- Monetary or financial incentives to encourage participation (e.g., rebates, TOU rates).

Comparing the effectiveness across program types is challenging because of confounding factors such as the difficulty in controlling for differences in design and evaluation across programs [85], as well as the diversity of programs within each category. Most HERs are opt-out programs, which lend themselves to evaluation via RCTs [65]. However, across types of programs, those with opt-in designs [86] and those that draw on multiple behavioural strategies are more effective in terms of customers saving more energy and becoming more engaged with their utility [83]. That being said, opt-in programs are often more difficult to scale; the greater overall efficacy of opt-in programs is a result of program participants (who self-select) being more motivated to change their behaviour than those people who elect not to opt in [86].

As such, defining BEPs has proven to be difficult. The International Energy Agency's (IEA) User-Centered Energy Systems Technology Collaboration Programme (Users TCP) is a partnership of 15 IEA countries that provides socio-technical research on the design, social acceptance, and usability of technologies to inform policy making for energy transitions. Work conducted during Phase 2 of the Users TCP Task 24 [87] discussed how (narrow) regulatory and regional contexts greatly influence the breadth and extent of what can be classified as a behavioural program [88], [89]. One of the Canadian participants in a Task 24 workshop described their challenges with definitions as follows: "It all depends on how you define 'behaviour.' You would say everything we do is behaviour, and we'd say hardly anything is – by our regulator's definition [88]. Hence the recommendation to clearly define "energy behaviour," "behaviour change," and "behavioural energy programs."

3.3.2 Behavioural Strategies

Complex behavioural programs, such as HERs, competitions, and low-income audits, often draw on multiple behaviour change strategies. Examining programs through the strategies they employ can help researchers identify more precisely which behavioural techniques are most effective. A second-level meta-analysis of strategies used to promote pro-environmental behaviours (including but not limited to energy) identified six primary strategies [90]:

- **Appeals:** Urge people to act sustainably by targeting their values or responsibilities.
- **Commitment:** Motivate people to commit to sustainable behaviours.
- **Education:** Increase knowledge about behaviours by providing factual information.
- **Feedback:** Provide individuals and households with information about their behaviour.
- **Financial incentives:** Use monetary rewards to incentivize sustainable behaviours.
- **Social norms:** Highlight the behaviours of peers as a means to increase target behaviours.

Based on this meta-analysis, Bergquist et al. [90] found that the interventions that use social norms (e.g., highlighting usage compared to that of peers) and financial incentives (e.g., subsidy programs for weatherization) had the greatest impact when integrated into a BEP, whereas those that used feedback and education had the lowest impact. Although education had the smallest impact, this does not mean it is unimportant in terms of behaviour change; the authors caveat that in many situations education may be necessary but insufficient, such as when combining education and social norms to promote energy conservation. Indeed, none of these strategies alone are silver bullets, and their context is hugely important. Each either works very well or not at all in different contexts and locations, with different target audiences, and through different delivery strategies.

Of these strategies, financial incentives have the largest impact on programs that target energy conservation [91]. Information sharing and feedback together also had a greater overall impact than social norms and commitment combined. Of note, in the context of promoting energy-saving behaviours, social norm strategies may be relatively less effective and feedback may be relatively more effective compared to other strategies when their effect is averaged across environmental behaviours.

When implementing multiple strategies to target energy conservation, a combination of motivation, feedback, and monetary incentives is particularly effective [91]. The least benefit is observed when combining social norms and feedback (see [90] and [91]) and only diminishing returns from combining social norms, feedback, and information.

Finally, there is a small, negative relationship between study length and impact for those using monetary and feedback strategies, indicating that the effectiveness of these programs, on average, may decrease over time. Studies with opt-in designs also generally show a larger impact on behaviour, whereas household size and other demographics are not shown to significantly moderate program effectiveness.

It is important to note that these strategies have a tendency to evolve. Behavioural science is not static, and as a result of research in the field, we are constantly learning about the human condition . For example, innovative research led to social norms, such as the use of HERs, being applied to energy efficiency programs two decades ago [92]-[94]. These interventions were highly effective and spawned an enormous market of BEPs. For most of this time, social norms were divided into descriptive categories (what others do) and injunctive categories (what others think is right) (see [95]), until Sparkman and Walton [96] introduced the concept of dynamic norms. Now, barely six years later, this newly identified form of social norm messaging is being utilized in behavioural energy programs, with positive impact.

3.3.3 Resources for Strategies in Behavioural Energy Programs

As behavioural strategies are so important in informing BEP design, the following is a list of some current resources.

- Houde and Todd's [97] *List of Behavioral Economics Principles That Can Inform Energy Policy* breaks up behavioural economics principles into five concepts: framing, bounded rationality, prosocial behaviour, commitment mechanisms, and incentives. The specific behavioural science principles are delineated, as are their implications for understanding behaviour and examples of their application to energy policy.
- "Behavioural Science Tools to Strengthen Energy and Environmental Policy," a report targeting practitioners and policymakers, recommends approaching behavioural environmental policy from the perspective of 13 discrete behavioural tools and the behavioural targets that each tool can address [98]. The authors identified the following four primary targets of BEPs: capturing attention, engaging a desire to contribute to the social good, making complex information more accessible, and facilitating an accurate assessment of risks, costs, and benefits. Using these behavioural goals as their basis, each behavioural science tool is mapped to the behavioural targets it can be used to address.

- The "Behavioural Insights Toolkit," developed by Users TCP to expand the adoption of behavioural science best practices, is an interactive resource that allows policymakers to receive tailored recommendations for designing policy and other interventions by inputting key information about their specific case [99]. For instance, in the section on buildings (there are also sections on industry and transport), users choose the behavioural dimension (e.g., conservation or technology adoption), then indicate strategies they are willing to implement (e.g., banning, incentives, or services), and receive detailed information about the behavioural factors affecting the efficacy of each instrument so they can consider their relevance to a specific policy or program, and choose their instruments accordingly.

3.4 Approaches to Designing Behavioural Energy Programs

Three commonly used behaviour design approaches are community-based social marketing (CBSM), behavioural economics, and design thinking. A fourth approach, the building blocks of behaviour change (BBBC) process integrates the previous three approaches.

3.4.1 Community-Based Social Marketing

CBSM is a widely used BEP [100] that includes five broad steps:

1. **Select behaviours:** Because energy behaviours are quite diverse (see Section 3.1), CBSM works best when the target behaviour is an indivisible action (e.g., "turn off lights when leaving a room" instead of "use less energy") .
2. **Identify barriers and benefits:** Talk to people and identify specific barriers (e.g., those that inhibit behaviour change) and benefits (e.g., those that motivate people to change their behaviour) relevant to the target behaviour.
3. **Develop strategies:** CBSM recommends developing strategies that leverage social science principles to address barriers and benefits during program design.
4. **Pilot-test strategies:** Try out the strategies on a subsample of the intended population to see if they work, which involves data collection and analysis.
5. **Implement and evaluate strategies broadly:** After pilot-testing the program, it can be scaled up if successful and adjusted if not.

CBSM is generally well-regarded, with workshops delivered to more than 70,000 practitioners world-wide. CBSM is easy to learn and use, requiring minimal training. Because program managers are encouraged to interview as few as a dozen customers to identify barriers, CBSM requires minimal funding. The popularity of CBSM has waned in recent years, possibly because its reliance on the local context often makes scalability difficult. A recent article claimed that there are few clear examples of successful CBSM implementation in the field [101]. That said, CBSM methods are still used in Canada and elsewhere [102].

3.4.2 Behavioural Economics

Many government departments and private firms have created behavioural economics models, each with its own interpretation of the basic approach, although there are similarities. The overall process used by the Government of Canada's Impact Canada is as follows [103].

1. **Identify:** Consult with interested parties to identify target outcomes and behaviours. Discuss existing approaches and opportunities for innovation.
2. **Understand:** Conduct preliminary research (e.g., literature reviews) to identify hypotheses around behaviour drivers and barriers, followed by a second round of mixed-methods research (e.g., surveys, interviews, secondary data analysis) to test these hypotheses.
3. **Design:** Use a combination of research findings and literature to brainstorm solutions, then present ideas to partners. Iterate and prepare chosen solutions for testing.
4. **Test:** Develop a plan to conduct experimental or quasi-experimental tests of the chosen design solution. Conduct a pilot program, collect data, and present analyses and results.

"Design thinking frameworks focus on developing an "empathetic" understanding of people's needs and barriers."

5. **Scale:** Leverage insights from testing to revise the program and iterate once more for broad dissemination and execution.

These processes encourage testing and evaluating interventions and program components to determine whether they are effective. Behavioural economic models are far more scalable than CBSM approaches because they focus on identifying universal principles of behaviour change (called heuristics) and applying them across a broad population. However, behavioural economic models focus less on gaining a deep qualitative understanding of the audience, and intervention strategies are typically optimized for single-time behaviours (e.g., signing up for automatic retirement savings), rather than sustained behaviour change (e.g., adopting a plant-based diet). In addition, there is some debate around an overreliance on, and the morality of, the application of behavioural economics to behaviour change [104]-[106].

3.4.3 Design Thinking

Design thinking frameworks (e.g., [107]) focus on developing an "empathetic" understanding of people's needs and barriers. Methods often include qualitative approaches such as observation, interviews, and collaborative workshops. These techniques can be used to support buy-ins, audience research, and the evaluation of materials. The design thinking approach is composed of the following steps [108]:

1. **Empathize:** Observe and engage with people to understand their experiences. Set aside assumptions and gather real insights that are relevant to the behavioural goal.
2. **Define:** Gather insights and make sense of the landscape of solutions. Identify patterns and develop a creative brief.
3. **Ideate:** Develop potential solutions, based on the creative brief, through brainstorming, mind-mapping, and graphic design.
4. **Prototype:** Transform ideas into tangible "artifacts" that are tested by end-users. Proposed solutions may be improved, redesigned, or rejected after this phase.
5. **Test:** Get rapid productive feedback from people who represent those you are trying to influence through A/B (or split) testing, eye tracking, or a qualitative sharing session.

Design thinking is typically conducted quickly, in "design sprints" that can take only a day or a week. Thus, although this method can be applied quickly, it often lacks the depth of those frameworks that have more rigorous research approaches to identifying barriers. Compared to a behavioural economics approach, design thinking tends to rely less on established scientific heuristics. It is also highly collaborative and often involves co-design, which enables uncovering and addressing end-user barriers and needs [109], [110]. At its best, such co-design can create innovative and user-centred solutions, but it can also stray away from evidence-based evaluation of effectiveness (e.g., see [109]).

3.4.4 Building Blocks of Behaviour Change

The BBBC approach [111] was designed for a North American energy utility that had participated in workshops and trainings in CBSM, behavioural economics, and design thinking and required a behaviour change process that integrated the best elements from all three approaches. The BBBC approach consists of the following steps:

1. **Discover:** Align interested parties on project goals and ground the team in the necessary background through a landscape assessment.
2. **Define:** Conduct audience research (e.g., surveys, interviews, observation) to define motivations and barriers toward target behaviour(s) without preconceptions.
3. **Design:** Identify behavioural strategies to overcome identified barriers and conduct qualitative (user experience, or UX) and quantitative (A/B) testing to refine program content.
4. **Deploy:** Combine findings and measure how the overall program design affects actual behaviour. Includes program (or pilot program) launch, evaluation and measurement, and continuous improvement.

This framework is grounded in a multidisciplinary behavioural science approach, integrating the qualitative focus of CBSM and design thinking with the quantitative focus of behavioural economics. Programs are based on audience research, tested conceptually before implementation, and optimized based on key variables and strategies. A key limitation to this model is the amount of time and money that may be required to complete all the phases in the process.

3.4.5 Resources for the Behavioural Energy Program Design Process

Many resources support the approaches described in Section 3.4. These resources facilitate the application of behavioural science and improve the efficacy of behavioural interventions. We identified the following tools that are currently available to support the development of BEPs:

- The BASIC toolkit is a process-based framework for applying behavioural science to policy problems developed by the Organisation for Economic Co-operation and Development (OECD) [112]. The BASIC toolkit provides both a high-level introduction to this step-by-step process for decision-makers who may be less familiar with behavioural science, and an in-depth guide to facilitate its application.
- The Behavioral Design Team Toolkit introduces the concept of a behavioural design team and explains how government departments can develop their own behavioural design team if they would like to apply behavioural science to their in-house programs [113].
- The EAST Framework is a behavioural economics–focused framework developed by the UK-based Behavioural Insights Team [114], [115]. The framework focuses on the importance of using behavioural strategies to make target behaviours Easy, Attractive, Social & Timely and provides strategy examples that can be used to achieve each of these objectives [114].
- The BBBC approach provides a sequential guide to using behavioural science through four design phases: discover, define, design, and deploy; and five distinct building blocks: audience, behaviour, content, delivery, and evaluation [111]. This framework has been applied successfully in field applications [82] and case study comparisons [38], [116].

Program design resources can include behavioural training. Most energy sector program managers do not have social or behavioural science backgrounds, and capacity building is essential to appropriately apply behavioural science in practice. A wide variety of behavioural science training programs are available; these four focus on or, at minimum, address energy behaviour:

- Fostering Sustainable Behaviour Workshops are based on CBSM, the popularity of which has diminished (see Section 3.4.1), likely due to a combination of saturation (i.e., many practitioners have already attended these workshops) and their mixed results [117].

- The UK-based Behavioural Insights Team offers several in-person and online training options, from a three-day crash course on behavioural science in practice to extended courses in which the Team works with an organization to help them build their own behavioural science team [115].
- The Behavioral Economics Bootcamp is a general behavioural design program offered by Irrational Labs, which also runs courses that focus on applying behavioural science to specific areas such as health care and finance [118].
- The Home Performance Advisor training program for energy auditors, based in Aotearoa, New Zealand, was specifically adapted for non-energy professionals in the community [119]. It has been used extensively and successfully to equip frontline providers (especially those who can contact the hard-to-reach energy users that traditional programs cannot) to provide simple and clear energy behaviour messages via in-home and face-to-face interactions.

The following training resources include or incorporate behavioural training in the commercial sector:

- Behaviour, Energy, and Sustainability Training (BEST) is a training program designed for commercial sector energy managers and building operators that was funded by the province of Ontario's Independent Electricity System Operator (IESO) [120].
- The 50001 Ready Navigator is a training program that supports US federal agencies in the use of the 50001 Ready Navigator tool and, ultimately, in meeting the standards set out by ISO 50001 [121]. Report authors Karlin and Rotmann developed a behavioural science module for inclusion in this training in 2021.
- The Strategic Energy Management Hub (SEMHub) is a resource for commercial energy users that provides online and in-person training that is focused on building energy awareness, designing an energy management plan, monitoring and evaluating energy performance, and similar topics [122]. The Energy Management Assessment tool is a SEMHub feature designed to help organizations assess their performance in implementing best practices and identify opportunities for improvement [123].
- Patterns in Energy Management Behaviour, developed by report author Cowan, is an active learning program that integrates human-focused energy management into operations by linking energy behaviours with business objectives to reduce waste, plan for future requirements, minimize facility complications, improve safety, and reduce GHG emissions [124].

3.5 Evaluation of Behavioural Energy Efficiency Programs

As more governments and utilities focus their attention on behaviour-based energy interventions, it is urgent to evaluate these programs as rigorously as possible. One of the most common criticisms of the usefulness of behavioural programs is the difficulty in identifying direct causal relationships between the intervention and the desired outcome [85]. For instance, even if there is a reduction in electricity billing after an HER is implemented, ascertaining what end use was impacted is difficult without smart technology and metering that is capable of disaggregating home appliance use. What's more, it is impossible to determine how or why the end use changed without collecting qualitative insights from the energy users. In this section, the report authors review how past studies have measured energy behaviour, discuss a few key considerations for evaluation and measurement, and present some currently available resources.

3.5.1 Evaluation Design

RCTs are widely considered the gold standard for testing the efficacy of behavioural interventions [125], [126]. RCTs involve the random assignment of individuals to a group that receives the intervention being studied and a control group that does not. Random assignment ensures that any differences between groups can be attributed to the intervention and not to any pre-existing differences.

However, RCTs are expensive and time-consuming to conduct and are difficult to implement for opt-in programs. In addition, many behavioural programs, for example, competitions, curricula, and community outreach, are administered to groups and not individuals, which can make conducting an RCT difficult or impossible. RCTs can be conducted with other means of investigation that take into account context and scale [127].

Todd et al. [128] reviewed the issues and opportunities in the design and implementation of BEPs and made the following key recommendations:

- To avoid potential conflicts of interest, use independent third-party evaluators to define and implement analyses, evaluate impacts, assign households to conditions, and report results.
- Design evaluation studies using RCTs, whenever possible. If an RCT cannot be conducted, use quasi-experimental approaches to select a control group.
- Before the intervention, conduct equivalency checks on energy use and household characteristics to make sure the treatment and control groups are similar.
- Collect at least one complete year of energy data prior to the intervention for accurate pre- and post-treatment assessments.
- Establish a null hypothesis (e.g., percent savings needed for the program to be effective) and determine whether a program is effective if the savings are statistically significant at a level of 5% or lower.
- Do not report savings as a function of interaction variables (e.g., whether the program worked better for some households than others) as primary findings, but as secondary findings.
- Estimate the double-counted savings by calculating the difference in measures from other programs for both the control and treatment groups.
- Evaluate the program every year initially and any time the program is expanded to new participants. If the population does not change, evaluations can be conducted every few years after the first few years. Maintain a control group for every year that program impacts are estimated if the program continues for multiple years.

A final key consideration for evaluating the design of BEPs is the persistence of behavioural change, that is, the maintenance of a given behaviour beyond the duration of a program [44]. Measuring outcomes for as long as possible is important to ascertain the durability of the savings estimates claimed. One example is the BC Hydro Power smart home program, which measured savings persistence using a variety of methods and found an average savings decay rate of 23% per year over four years [129]. BC Hydro also found that the participants who repeatedly engaged in challenges were more likely to maintain savings. Similar efforts to measure persistence have been added to the US Green Building Council's LEED program [24].

3.5.2 Evaluation Metrics

While kWh reduction remains the most commonly used metric when evaluating BEPs, metrics for how and for whom programs work continue to be developed. A review of 85 studies that examined behaviour-based energy interventions found that 69 collected data about energy knowledge, attitudes, and/or behaviour [85]. Although 62 of these studies collected the data using surveys, only four published their instruments, which makes accurate cross-study comparisons or replication impossible. Throughout this review, the authors found little consistency or agreement on what data to collect or how to ask questions, and the measures used were rarely validated [85].

In the review, Karlin et al. [85] recommend the use of standardized measures to enable comparisons between different studies and programs. By consistently using a standardized set of validated measures, researchers and program managers could compare data and understand patterns across interventions, and have greater trust in their results. This approach can also help identify differences between populations of program recipients, that is, what works in a middle-class neighbourhood may fail in a low-income one. Collecting demographic (e.g., age, sex/gender, homeownership status) and psychographic (e.g., motivation to save energy) information can help researchers and program managers understand whether findings from one program are likely to apply to another.

"When targeting more vulnerable or hard-to-reach energy users, an overreliance on kWh or GHG reductions as primary objectives can backfire when, for example, suggesting to further reduce heating or cooling could lead to health implications."

In addition, many experts (including the IEA [11]) highlighted the importance of measuring the numerous non-energy impacts of behavioural energy efficiency and DSM interventions [10], [12]. The difficulty in measuring non-energy impacts lies both in their number and their complexity; also, they are often regarded as "soft measures" that are harder to quantify than direct kWh or monetary savings. Ideally, BEPs include, from the design stage, an evaluation of both behavioural persistence and non-energy impacts.

A final note on behaviour metrics is the focus on diversity, equity, and inclusion in the provision of energy programs and services. When targeting more vulnerable or hard-to-reach energy users, an overreliance on kWh or GHG reductions as primary objectives can backfire when, for example, suggesting to further reduce heating or cooling could lead to health implications [11], [67], [110]. Thus, the choice of evaluation metrics should be determined based on the desired outcomes and costs (e.g., reduction in kWh vs. self-reported improvements in comfort and well-being), specific audience characteristics (e.g., homeowners living in smart homes vs. renters living at low income), target behaviours (e.g., single purchases vs. family habits), and broader outcomes (e.g., decarbonization vs. energy poverty).

3.5.3 Existing Resources for Behaviour Program Evaluation

Regulators across various local and regional jurisdictions often have their own processes for evaluating energy efficiency programs, including (but not limited to) behavioural programs. The following resources are currently available to support behaviour program evaluation across Canada and elsewhere:

- The IESO *Evaluation, Measurement and Verification (EM&V) Protocol,* which was updated in 2021, describes eight steps for evaluating energy programs, with detailed instructions and guidance [130].
- BC Hydro has moved beyond the traditional economics engineering paradigm of evaluating energy savings by gathering survey data to complement meter data [129]. Instead, it draws on a range of data sources to perform mixed-methods evaluations of their BEPs [131]-[133].
- *Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations* is a comprehensive report on customer information and behaviour that was developed by the State and Local Energy Efficiency Action Network (SEE Action) Working Group [128].

- The Uniform Methods Project, developed by the National Renewable Energy Laboratory (NREL), provides in-depth recommendations for evaluating the savings from residential behavioural energy efficiency measures, based on RCTs and randomized encouragement designs to best estimate these savings [17]. (Randomized encouragement designs are similar to RCTs except that participants choose whether to adhere to the experimental condition.)
- Building Energy Data Exchange Specification (BEDES) was developed by the US Department of Energy to standardize the collection of digital energy data [134].
- The Beyond kWh Toolkit is a set of questions for self-report data collection that was funded and published by the Emerging Technologies Coordinating Council of California [135]. The toolkit shows inconsistencies in how behaviour is measured and provides a template for how survey instruments might be validated and standardized across the field [135].

4 Recommendations, Benefits, Risks, and Limitations

The benefits and risks of developing standards for energy behaviour programs are discussed, in addition to the limitations of this research.

4.1 Recommendations

Recommendations for standards and SBSs related to BEPs , based on findings from the key informant interviews (Section 2) and literature review (Section 3), are summarized in Table 2. These recommendations specify the group for which each recommendation is relevant and are expanded on in the next sections.

4.1.1 Develop Definitions and Parameter Standards

Since energy behaviour has several dimensions but few agreed-upon definitions, it is imperative to clearly define and understand the target behaviours before designing programs. The authors recommend using a common definition, such as the IEA Users TCP Task 24 definition, which was co-created by behavioural experts and interested parties from different countries and sectors and has been widely disseminated: "Energy behaviour refers to 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 they are used, and the mental processes that relate to these actions" [3].

The authors also recommend clear operational definitions for all key terms used in this work. A glossary or other resource defining key terms to establish agreement within a given sector is necessary to avoid using behavioural terminology loosely.

4.1.2 Develop Minimum Requirements Standards

Standards that identify minimum requirements for the design, implementation, and evaluation of a BEP may help to clarify what steps can support the process of changing behaviour. Standardizing behavioural programs or strategies is not recommended, as these evolve with the growing body of scientific knowledge as well as with changing cultures. For example, for many people, life since the COVID-19 pandemic differs from how it was before March 2020. Standards for the design, implementation, and evaluation of BEPs may be used to highlight potential tools, instruments, and methods that can be used throughout the program development process.

Frameworks such as the ones described in Section 3.4 help to ensure that both processes and outcomes are measured, to allow behaviour change interventions and programs to be improved upon over time, thereby building the overall case for claiming subsequent savings. Many are grounded in robust social science theory to ensure that resulting trials, tests, pilot tests, or programs can be better evaluated, thus providing an opportunity to replicate results through similar interventions. Our primary recommendation is to use a robust framework that treats behaviour change as a process in the development of standards or SBSs.

Table 2: Summary of recommendations and relevance to interest groups

Recommendation	Specified interest group			
	Producers (e.g., behavioural energy program designers)	Regulators (e.g., policymakers at all levels of government)	Implementers (e.g., utility administrators)	General interest/ other (e.g., academics, NGOs, the public)
1. Develop definitions and parameter standards	X	X	X	X
2. Develop minimum requirements standard	X		X	
3. Develop evaluation and data handling standards	X	X	X	X
4. Develop SBSs for strategies and programs	X	X	X	X

4.1.3 Develop Data Handling and Evaluation Standards

One of the biggest challenges with energy behaviour change programs is demonstrating their success and for whom they are relevant (see Section 3.5.2). This includes showing a change in energy use (e.g., by comparing billing data before and after an intervention), and also understanding why and how the energy use changed following the implementation of a program. The report authors recommend developing standards for both evaluation design and data collection and sharing to support learning across programs.

Evaluation design standards should include, but not be limited to, RCTs, as these tools are effective but not always efficient at or even feasible for many behavioural programs including population level–intervention strategies. Evaluation designs for BEPs should address behavioural persistence (over at least 6 to 12 months) and non-energy impacts, including both the perceived and actual benefits and costs of changing behaviour.

Standards that support data collection and evaluation may include the development and dissemination of evaluation tools and instruments (e.g., psychometrically tested survey questions). These resources would allow evaluators to compare the relative effectiveness of programs. Reporting demographic information will allow evaluators to identify variables that make an intervention more effective for one group or another.

Finally, interviewees brought up the issue of energy data (e.g., from smart meters) not being collected, stored, or analyzed consistently. This makes analysis difficult and resource-intensive. Creating standardized data-sharing protocols and platforms for regulators, evaluators, third-party vendors, and utilities would address some of these challenges.

4.1.4 Develop Standards-Based Solutions on Strategies and Programs

While standardizing BEP strategies or approaches is not recommended (see Section 4.1.2), developing SBSs to help build individual and organizational capacity in developing and implementing BEPs is valuable. Since most of the professionals currently working in the energy efficiency and demand response industry do not have formal behavioural science training, the potential to develop best practices, guidelines, and training to help develop capacity and support the growth of this workforce is considerable. Some promising SBSs are described below.

4.1.4.1 Synthesize Research to Support the Selection of Behavioural Energy Program Strategies

There are many published case studies of successful BEPs. However, case studies often fail to address how and for whom their program worked, making it difficult to know whether a program would be similarly successful if implemented under different conditions in other jurisdictions. Augmenting the many available case studies with secondary research, such as meta-analyses, to compare studies is recommended. Also recommended is determining what program strategies and components work across studies and which are program specific. This could help developers of new programs identify suitable behavioural strategies or ideas for a given context rather than assuming that anything found in a case study will also work for them.

4.1.4.2 Guidelines or Resources on Heuristics and Strategies

Since there are hundreds of behavioural science heuristics and behaviour change strategies – with more published each year – practitioners may benefit from lists of behavioural science heuristics alongside strategies to manage them as they develop programs. These may include biases such as anchoring (i.e., relying heavily on the first piece of information encountered on a given topic) , temporal discounting (i.e., a preference for rewards/benefits now over those in the future) , and the fundamental attribution error (i.e., attributing an individual's actions to their personality or trait more than to environment factors), and/or descriptions of how to implement various strategies such as those listed in Section 3.3.2.

4.1.4.3 Training and Capacity Building

The energy sector has traditionally employed those with a background in engineering or business. However, the energy efficiency gap shows that ignoring the human factor comes at a great expense and exacerbates current global polycrises such as climate change, energy poverty, energy security, and access issues. Although engineers cannot be expected to become social science experts, training to upskill and build capacity in this area should be provided.

First, we need to clarify what engineers can and need to do or know to integrate behavioural approaches into their energy programs. These are similar to the skills that may be taught in a master's or doctorate programs in behavioural science, such as:

- Behavioural science theory (e.g., psychology, behavioural economics, sociology);
- Qualitative data collection methods (e.g., ethnography, interviews, focus groups);
- Quantitative data collection methods (e.g., survey design, conjoint models, maximum difference scaling [MaxDiff]);
- Statistical analysis methods (e.g., analysis of variance [ANOVA], regression, cluster analysis);
- Qualitative analysis methods (e.g., coding, computer-assisted qualitative data analysis software); and
- Understanding of heuristics (e.g., anchoring, temporal discounting , biases).

Training can also be provided in the soft skills, such as how to build relationships across diverse parties and end-user segments, active listening, collaboration, and engaging in participatory co-design with energy end-users. Training and/or toolkits can also be provided to community-based organizations and frontline providers so that messaging is targeted to different audiences (not least if dealing with vulnerable or hard-to-reach energy users). Co-designing resources and training with end-users and community representatives is highly recommended to mitigate bias and ensure cultural appropriateness.

It is important to note that behavioural training should be delivered by experts in behavioural science with advanced, specialized degrees and significant real-world experience of the subject matter and target audiences.

4.2. Benefits of Standards in Energy Behaviour

Three key benefits of standards and SBSs for BEPs were identified.

4.2.1 Consistency Around Program Definitions, Parameters, and Design

Developing a common definition of energy behaviour (such as the one used in this report; see Section 1.1) through a consensus-based approach would help establish a shared understanding of the areas in which behavioural interventions are applicable. For example, conservation and efficiency behaviours typically fall under behavioural programs, whereas billing behaviours, such as switching energy rates with important implications for TOU and renewable rate adoption have not been focused on. Going further with the identification of key parameters and a design process for behaviour change (e.g., the BBBC approach; see Section 3.4.4.) would lead to more effective intervention design and evaluation, and give practitioners a common toolkit for implementation. Currently, practitioners draw on a range of processes for program development, leading to the inconsistent application of best practices and complicating comparative analysis. A potential advantage of standardizing the behaviour change process is that it might create a more balanced environment for various actors across sectors. This could be achieved by demonstrating that the process of behavioural change has a degree of universality, with numerous similarities across sectors, end uses, and users.

Standardizing data collection is important on multiple levels – and for a variety of interested parties. Initiatives such as the Uniform Methods Project [17], and others from the US Department of Energy, standardize consumption and device data, ensuring data quality and facilitating evaluation across projects. In the absence of standardized data protocols, data sharing across organizations and comparing data from disparate programs is challenging. In tandem with efforts to standardize energy data, the field could also benefit from standardizing consistent evaluation methods and data collection and analysis. For instance, the Beyond kWh Toolkit (described in Section 3.5.3) shows inconsistencies in how behaviour is measured and provides a template for how survey instruments might be validated and standardized across the field [135].

4.2.2 Establishing Best Practices

Section 3.5 detailed the results of behaviour programs where designers are not able to find comparable data in different programs, hence precluding learning from experience to improve future designs. Standardizing the design process and making sure that minimum sets of parameters are investigated or addressed and included in the behaviour programs would create a generation of programs that follow an agreed-upon and curated methodology that fosters a culture of best practices.

Standards developed with the participation of experts from all types of organizations involved in behavioural program development should feature the elements needed, per life-cycle node, for the BEPs to succeed and flourish. A process like this would be building on decades of program development, implementation, and evaluation.

The most effective approach to addressing energy behaviour is to understand the existing landscape, the interested parties, the target audience(s), and the exact behaviour under consideration. Pilot testing and prototyping (e.g., split or A/B testing vs. user experience or UX testing) should precede full-scale rollout. Programs should be iterative and continue to evolve based on evaluation and learning; they should also continually incorporate key informant and end-user engagement information and feedback.

4.2.3 Facilitate Knowledge Transfer Across Disciplines

Standards follow a globally approved structure. They start by listing reference documents, the scope, definitions, and clauses specific to the topic at hand.

"Energy management is a complex issue with many possible solutions that may not be resolved using technology alone"

Topics are broken down into clauses that address each subject, clearly stating inclusions, exclusions, and systemic steps. Furthermore, standards are developed by a pool of experts in the field based on general unanimity. The experts participating in standards development fall into four categories:

- Regulatory authorities: representatives from all government levels.
- Producer interests: representatives from the producer of the products that the standard serves.
- User interests: the users of the standard being developed, that is, the entities, such as implementers, that will be relying on the standard (e.g., to respond to a request for proposal or determine eligibility for grants).
- General interests: the public, which could include researchers, consultants, energy users, etc.

This process of developing standards ensures that the knowledge is accessible and available to all disciplines and interested parties and that the application of the standard is within everyone's reach. As standards adhere to very strict technical jargon, SBSs are often used to help users navigate them. One example is the 50001 Ready Navigator tool that the Lawrence Berkeley National Laboratory developed to help apply ISO 50001 [33].

4.3. Risks of Standards in Energy Behaviour

4.3.1 Underestimating Context Complexity

Professionals in different sectors approach energy behaviour from different starting points and may not consider the entire background or rationale for selecting a specific model or theory to guide a given program. A standard that is tailored to one problem, sector, discipline, or role may not apply to different contexts, a reality that could dissuade practitioners from including behaviour change in their interventions.

Energy behaviour is nested within complex socio-technical systems. If the interactions between energy behaviour and technology, infrastructures, markets, regulations, and laws are not adequately considered, standards may affect different population groups unequally or cause other unintended consequences. For example, when designing messaging around energy curtailment (e.g., kWh reduction), some populations may require different interventions, or no interventions at all, if changing the temperature of their homes could be harmful to their health.

Energy management is a complex issue with many possible solutions that may not be resolved using technology alone. Energy management often requires a combination of approaches and solutions based on collaborating with many interested parties with different mandates and organizational structures and different understandings of the nature of the problem. To achieve persistent energy efficiency, we need to acknowledge its place as part of a complex ecosystem that emerges from human interactions with physical and mechanical energy systems as well as organizational structures and interpersonal relationships. Although the complexity is inherently unpredictable, it can be understood to possess emergent properties from adaptive and dynamic circumstances.

Unfortunately, it is also rare to find practitioners who have been trained to deal with complex problems that may not have straightforward solutions. For example, there are numerous building types, business functions, specialized equipment, and infrastructure in commercial operations and a wide variety of roles, decision-makers, policies, and priorities within organizations; together, these drastically increase the complexity of any energy performance program. Yet, many programs are designed as a "one-size-fits-all" model or follow step-by-step phases. In real-life situations, multiple, competing, and even contradictory activities can occur simultaneously. To work with complex problems thus requires planning for and anticipating these potential interactions during the early stages of program development.

4.3.2 Overregulation Could Render the Standard Too Stringent

Balance is needed in the development process to ensure that regulatory needs and subject needs are met equally and that one does not stifle the other. This being said, when developing regulations, programs, and specifications, BEPs should leave room for less stringent parameters than would be the case with technical subjects. These parameters would include, but are not limited to: context (e.g., hard-to-reach populations), starting point (existing baseline), and different, including qualitative, perceptions of success (e.g., kWh reduction vs. improvement in comfort).

4.3.3 The Standards Development Process Could Slow Down the Adoption of New Technology

The standards development process involves consensus, public review and balloting to ensure that all parties' needs and concerns are addressed equally and that no one party is favoured in the terms and conditions. This is often a lengthy process. Typically, standards are developed over at least 18 months, a timespan that is out of sync with a lot of technological advancements, which can slow down technological progress.

Organizations that develop standards have been working with their executives and members to try to streamline their processes and overcome this issue of timing. On the other hand, achieving widespread consensus and impact does take some time.

4.3.4 Potential Resistance to Change

Given the complexity of human behaviour, behavioural change constitutes an additional dimension for energy, building, and human resource managers to deal with. In recent years, change management has been gaining momentum within organizations, something that has been lived and experienced throughout the COVID-19 pandemic. A shift in work modality and the office culture has paved the way for change management hirings and strategies.

However, people are creatures of habit and, particularly in commercial situations, the perception of risk from changing management, infrastructure, or operational procedures is likely to upset or create controversy. The reason why behaviour change models and processes have been studied is to try and understand and map theories and strategies and their applicability and success in specific contexts and environments.

4.4. Limitations of this Study

4.4.1 Available Literature

While there is an abundance of literature on energy efficiency and behaviour, there is hardly anything on applying or developing standards or SBSs for BEPs.

The report authors attempted to synthesize the behavioural energy literature and make recommendations around the gaps highlighted by the literature review and noted in expert and expert interviews.

4.4.2 Lack of Diversity and Inclusion

Thermal comfort study data, upon which the majority of space-conditioning designs are based, are largely derived from mid-to-high income energy customers who are White (see Section 3.2). Energy users from other racial or ethnic groups have often been put in the "too hard basket," and thus have been underserved by many energy efficiency programs. Now that energy transition needs to include justice and equity considerations (see [136],), data need to be collected on populations who should be prioritized.

Any standard or SBS in this area should also prioritize interdisciplinary engagement through a diversity, equity, and inclusion lens to enhance the efficacy of interventions. Without this forethought, practitioners may, for example, expect that they will create an effective intervention simply by following a template for data collection and calibration, which may have been based on biases or assumptions (e.g., data and norms that are based on White, middle-class males, or on economic theories that misunderstand human behaviour).

4.4.3 Lack of Reliable Data

With a lack of regulation or requirements for data collection, data sharing, and reporting, available data are mostly self-declared, with very little traceability and accountability. This makes data sharing between interested parties almost impossible. In addition, the abundance of "big data" (e.g., from smart metering or smart appliances) and the difficulty of handling it (e.g., due to privacy, storage, computing, or analysis issues) excludes many interested parties, including the energy users from whom the data were collected.

4.4.4 Representativeness

The report authors are known subject matter experts, with more than six decades of theoretical and practical experience on behaviour change and energy behaviour change between them. Although the aim was to remain neutral in this analysis, the small project budget precluded additional research; as a result, the authors had to rely mainly on their existing collective knowledge. Coming from certain disciplinary (social ecology) and practitioner perspectives (particularly work in commercial, institutional, and hard-to-reach energy sectors), they tend towards multidisciplinary, whole-system, co-designed collaborations and processes. Interviews with experts from other disciplines and industry backgrounds, who encompass a wide range of policy, program, and practitioner insights, added to the authors' perspectives and experiences. Still, the pool of interviewees engaged in the work, though varied in terms of interests and experience, remains somewhat restricted in terms of representativeness, being predominantly White, middle-class professionals.

5. Conclusion

Energy behaviour is notably intricate, and it is beneficial to understand and consider these behaviours to improve energy efficiency, DSM, or decarbonization initiatives and programs. If user and demand factors that are central to our energy system are not recognized, there is a risk that regulators might repeat mistakes that have contributed to energy being a significant factor in causing the climate crisis. There is room for improvement.

The aim of this project was to explore if energy behaviour standards and SBSs would benefit Canada's energy sector professionals. Overall, standards may have the potential to address certain specific challenges faced by energy program managers and support new energy behaviour efforts. However, there are limitations to the possible impacts of such standards. Their development would likely necessitate broad multidisciplinary and multisectoral collaboration to be both meaningful and widely accepted.

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Appendix A – Interview Guide

First we'd like to ask about your experience and thoughts on energy programs in general.

1. Tell us about your background and experience in energy behaviour programs.
   [Probe to ask about program design, research, implementation, and evaluation]
2. How would you define energy behaviour programs? What do you think it includes?
   What do you think it excludes?
3. What do you think is working / not working in energy behaviour programs?
   a. Have you received any feedback from surveys? [probe for examples]

Now we'd like to ask about your thoughts on energy behaviour standards.

4. [unaided] What comes to mind when I say "energy behaviour standards"?
5. [aided] "Canadian Standards Association (CSA Group) is a non-profit standards development organization that creates voluntary, consensus-based standards developed by subject matter experts. Standards provide a set of agreed-upon rules or guidelines and establish accepted practices, technical requirements, and terminologies. They can help build value, support innovation, and reduce our environmental impact across many fields. "
   What do you think about the idea of CSA developing standards for energy behaviour?
6. Do you think the energy behaviour space is in need of standards and/or standards-based solutions?
   Why or why not?

Now we're going to talk about standard-based solutions or program support.

7. Are there any current tools, solutions, guidelines, etc. that you particularly like or utilize in your energy behaviour work?
8. Can you think of any additional resources that would be helpful to people working on energy behaviour programs?
9. Who (position, role, sector) do you think would most benefit from standard-based solutions in energy behaviour? Who would most likely implement them?

Finally, I have a question just for your expert type.

Type	Question(s)
Research	Where do you think research can have the most impact on energy behavioural programs?
Government	Can you think of an example of a well-designed standard and/or standards-based solution that we could model our effort after?
Utility / Industry	What considerations do you think are most important to designing successful energy behaviour programs?
Implementers	How do you utilize behavioural science when implementing programs? Do you use any standards-based solutions in your work? If yes, what are they?
Associations	What are the key pain points for your members with regard to energy behaviour?
Trainers	Where do people seem to struggle the most in the energy program process? What skills do you think are most important for behaviour programs to succeed?

Glossary

Type	Question(s)
demand flexibility	The ability to vary customer demand for electricity in response to generation, network, or market signals
demand response	Balancing the demand on power grids by encouraging customers to shift electricity use to times when electricity is more plentiful or other demand is lower
demand-side management (DSM)	A strategic approach to energy conservation that seeks to manage consumer demand for energy rather than simply supply it
energy behaviour	"All human actions that affect the way that fuels and carriers (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 they are used, and the mental processes that relate to these actions" [3].
energy efficiency	Refers to providing the same level of service with equipment that uses less energy
energy efficiency gap	The difference between the potential for energy efficiency or savings and the actual energy efficiency or savings in a given context
free-ridership	When individuals take an action targeted by a program that they would have taken without the program [13]
non-energy impacts	Impacts of energy behaviour outside of direct energy effects, such as health benefits or increases in individual comfort or productivity [10]. Also called "multiple impacts."
Prebound effect	The tendency of occupants in less energy-efficient dwellings to take more energy conservation actions than those in more efficient dwellings, offsetting at least some of the actual difference in energy use [15]
Rebound effect	When an increase in energy efficiency is partly or completely cancelled out through an increase in energy usage [14]
Spillover	When a specific behaviour change leads to a behaviour change in another context or of another kind [16]
weatherization	Retrofit measures taken to improve a building's energy efficiency and ability to withstand the elements, by addressing the building shell, ventilation, internal components such as water heating and piping insulation, and appliances and equipment [67]

CSA Group Research

In order to encourage the use of consensus-based standards solutions to promote safety and encourage innovation, CSA Group supports and conducts research in areas that address new or emerging industries, as well as topics and issues that impact a broad base of current and potential stakeholders. The output of our research programs will support the development of future standards solutions, provide interim guidance to industries on the development and adoption of new technologies, and help to demonstrate our on-going commitment to building a better, safer, more sustainable world.

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