Chapter 8
Coupling Behavior-Based Intervention with Pro-Environmentalism. The Dynamics of Energy Usage, Crisis and Its Conservation

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Abstract Higher cost and crisis of energy vis-à-vis increasing consumption have been a twin but contested paradox. The rapidly growing energy demand has prompted many countries, including Canada, to undertake manifold energy-saving initiatives. However, these are predominantly technology driven and no apparent measures are taken yet to address and modify the end users' behavior at the residential sector. In order to reduce the rate of growth of the residential energy consumption, it is critical to engage the end users through better education and awareness while using the inherent pro-environmental behavior (PEB). This is even more critical for groups, such as new immigrants and Canadian indigenous communities. Given this background, this chapter essentially presents (i) the importance of behavior-based, non-technical interventions on end users' perceptions of energy conservation; and (ii) its impact on the nature of consumption at the household level. Empirical findings from the East and current practices from the West are drawn to investigate these phenomena. The other part sheds light on the prospect and need for behavior based interventions toward reduced energy consumption. While the time of use (ToU) is in effect, some forms of PEB exists among the residential users in

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Ontario. With this taken into account, the paper calls for a renewed policy insights on ‘investment’ and ‘curtailment’ behavior approaches to assess the ‘longevity’ effects on energy consumption. This, in turn, stems the foundational need for ‘collaborative’ think-tanks of multi-disciplinary professionals, including engineers, urban developers, environmentalists, planners, sociologists, economists, and psychologists.

Keywords Pro-environmental behavior · Behavioral interventions · Energy crisis · Energy conservation behavior · Energy efficiency

Glossary

BC	British Columbia
DSM	Demand-side management
ECB	Energy conscious behavior
GHG	Greenhouse gas
MURB	Multi-unit residential buildings
NECB	National Energy Code of Canada for Buildings
NG	Natural gas
PEB	Pro-environmental behavior
SDG	Sustainable development goals
ToU	Time-of-use

1 Introduction

Forty percent of global energy consumption and 12% of the global green house gas (GHG) emissions are accounted under the building sector (Environment and Climate Change Canada 2016; Friess and Rakhshan 2017). Moreover, the increasing energy prices create considerable economic pressures on the building sector. These economic and environmental pressures have made building energy efficiency a priority theme in Canada. Therefore, new policies and standards developed in parallel with the climate change mitigation agenda have increased the emphasis on reducing energy use and GHG emissions associated with the building sector (Environment Canada 2015; Karunathilake et al. 2018). These measures provide multiple benefits to the building owners and communities in the form of reduced energy bills, improved energy security, and socio-economic growth in addition to the environmental benefits (Natural Resources Canada 2017). Therefore, improving the energy performance is essential for the environmental and economic sustainability of buildings.

A building that can operate with a lower energy consumption compared to an average building that operates under similar conditions of climate and use without compromising the occupant satisfaction can be identified as an energy efficient building. In net-zero buildings renewable energy sources are used to cater the energy demand, which is already reduced by the use of energy efficiency measures (Torcellini et al. 2006). Over 70% of energy use, environmental foot print, and human health impacts associated with buildings occur during the operational phase of the buildings (Buyle et al. 2012; Deru et al. 2011). Therefore, the operational phase has received a lot of attention in recent energy performance enhancement initiatives such as BC Energy Step Code. Operational energy performance can be improved by two main strategies including technical measures and behavioral changes (Karunathilake et al. 2018). Retrofitting, using energy efficient appliances, and implementing energy conservation technologies are some of the popular technological energy performance enhancement approaches used in building sector (Roulet 2006; Meier and Lamberts 2002). Building energy codes across the world mandate these energy efficient technological advancements, and these approaches have shown significant energy savings. Being one of the most innovative building energy codes currently available, the Energy STEP Code developed by the province of British Columbia, Canada, aims to make all the new constructions energy efficient and net-zero ready by 2032 (Natural Resources Canada 2018). However, the BC Energy STEP Code has room for improvement by prescribing how to achieve these energy efficiency goals through robust investment decisions. Moreover, there lies a question whether Canada has put enough emphasis to develop net-zero ready energy conscious citizens who are compatible with net-zero energy buildings.

Demand-side management (DSM) programs that can decrease energy use at building level can primarily be classified into three routes; (I) replacing the existing building stock with low energy and passive designs, (II) develop and increase the penetration of low energy (efficient) appliances and equipment, (III) promote and instill energy conscious-behaviours among users (Wood and Newborough 2003). Despite the proven benefits, technological energy efficiency achievements including low energy buildings and efficient appliances have their own limitations in practice due to high costs. Even so, the investments made on energy efficiency in a given building result in benefits localized to that particular building alone, and the impact on the energy performance of other buildings is minimal. On the other hand, behavioral changes require much lower investments to implement. Nevertheless, once implemented, the energy efficiency culture developed among the occupants in a given building propagates around the community, creating a widespread impact on many buildings in contrast to technological measures. Therefore, developing policies to sufficiently promote net-zero ready occupants in parallel to the technological measures can significantly increase the effectiveness of building energy efficiency improvement efforts.

Literature suggests that significant energy savings can be achieved through behavioral pattern changes created by the use of feedback mechanisms (Xu et al. 2018). However, predicting the level of behavioral pattern changes and its impacts on the energy consumption is not a very straightforward process. Moreover, while behavioural modifications can deliver significant benefits once put in place, it is more challenging to change existing patterns of energy use behaviour than it is to simply instigate a technological intervention. Therefore, it is evident that both behavioral and technological energy efficiency solutions have direct and indirect environmental, economic, and social impacts. Hence, careful evaluation of the costs, benefits, and deployment challenges associated with these approaches is needed to identify the best solutions for a given context. Moreover, studies need to be conducted to quantify the effectiveness of non-technical measures in improving the building energy performance, and to identify the best pathways for promoting energy-consciousness. On this backdrop, this chapter specifically focuses on studying the importance of behavior-based interventions on end users' perceptions of energy conservation and their impacts on the energy use trends in households. Moreover, empirical results from Saudi Arabia and a Canadian case-study are used in investigating the aforementioned phenomena. This article will inform the energy planners about the effectiveness of behavioral changes in achieving energy and cost savings. Moreover, policy makers will benefit from the integrated knowledge in improving energy efficiency policies to reach intended emissions targets.

2 Energy Sources and End Uses

Canada mainly relies on five fuels including renewables, natural gas, crude oil, coal, and uranium for the energy needs of the country (National Energy Board of Canada 2019). These energy sources are converted into secondary energy uses such as electricity, motor gasoline, etc. The trend changes of different secondary energy uses over the time is elaborated in Fig. 8.1 (Natural Resources Canada 2019a).

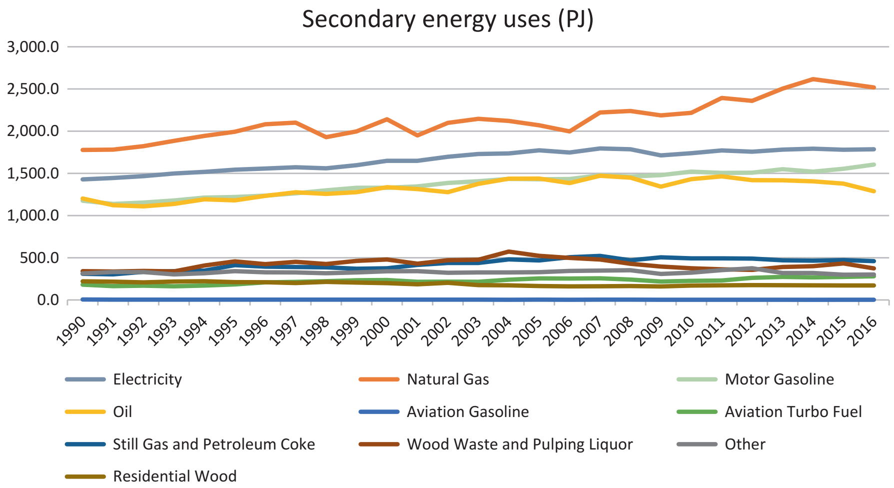

Fig. 8.1 Secondary energy uses (Natural Resources Canada 2019a)

According to Fig. 8.1, natural gas is the main secondary energy source that is closely followed by the electricity. Both these categories have shown increasing trends over the time while NG has shown a relatively higher growth. Motor gasoline (including ethanol) have shown a slight growth over the years following a similar gradient to the electricity. Use of oils (including diesel fuel oil, light fuel oil, kerosene and heavy fuel oil) is similar to motor gasoline except for the reduction indicated after 2011. Other secondary energy uses have not shown significant variations over the years. Even though some energy sources are being used less compared to others, they have higher emissions per unit energy delivered. Therefore, it is important to compare the emissions associated with different secondary energy categories over the years. The historical trends are indicated in Fig. 8.2 (Natural Resources Canada 2019a).

Emissions intensity of NG has shown a slight increment over the years according to Fig. 8.2. However, the impacts associated with this change cannot be neglected as NG is the most used secondary energy source in Canada. It is important to note that emissions associated with unit energy of electricity has reduced by one-third from 2000 to 2016. This greatly helps off-set residential emissions resulted from energy use. The emissions and the energy prices associated with NG and electricity have considerable impacts on residential energy use trends as they are the most commonly used secondary energy sources in Canadian residential sector. The emissions associated with other secondary energy sources have not changed much over the time except for still gas and petroleum coke. However, the contribution of these energy sources to the national GHG emissions through various means including transportation and industries should not be missed out.

The above-discussed energy sources are used for many end-use sectors, including residential, commercial, industrial, transportation, and agriculture (Natural Resources Canada 2011). Out of these sectors, transportation is identified as the least efficient sector with 75% losses while the residential sector converts 75% of the energy supply to useful work (National Energy Board of Canada 2019). However, when considering all the energy end-use sectors in Canada, only 33% of the

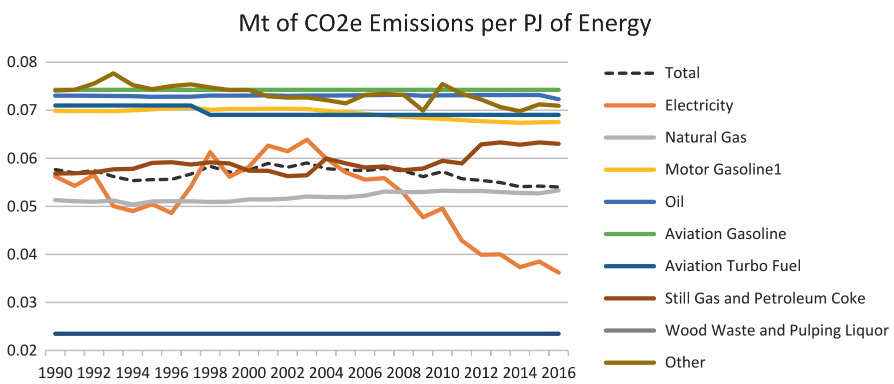

Fig. 8.2 Emissions per unit energy (Natural Resources Canada 2019a)

supplied energy is converted to useful work (National Energy Board of Canada 2019). Therefore, energy conservation practices and efficiency improvements can greatly contribute in reaching Canadian emission targets. Therefore, paying enough attention towards minimising energy losses and energy conservation practices are as important as striving to increase the renewable energy penetration in the country. With this understanding, improving the energy performance of building sector has received much attention.

Residential buildings contain multiple energy consuming components including space heating and cooling, water heating, lighting, and appliances. Figure 8.3 shows the percentage contribution of different energy end-uses for the overall energy consumption of Canadian residential building sector (Natural Resources Canada 2011, 2015a).

Space heating accounts for the highest energy consumption of Canadian residential buildings. Approximately 50% and 25% of the residential heating needs are catered by natural gas and electricity respectively. The heating performance of houses is significantly improved with higher penetration of energy efficient furnaces and improved building envelops (Natural Resources Canada 2019b; Karunathilake et al. 2018). Water heating is the second highest energy consumer of residential buildings. At present water heating is mainly done by natural gas and electricity with percentage contributions of 68% and 29% respectively (Natural Resources Canada 2019b). It is important to notice that use of heating oil, wood, and other fuels are significantly decreased over time. Efficiency of all major appliances such as refrigerators, freezers, dishwashers, clothes washers, and cloths driers have improved from 1990 to 2015. On the other hand, the use of minor appliances including electronics have increased over the time. Therefore, the energy savings generated by efficiency improvement of major appliances have been off-set by the minor appliances (Natural Resources Canada 2019b). Lighting energy requirements of a household has shown a huge reduction (18%) from 1990 to 2015. Natural Resources Canada (NRCan) attributes this efficiency improvement to multiple

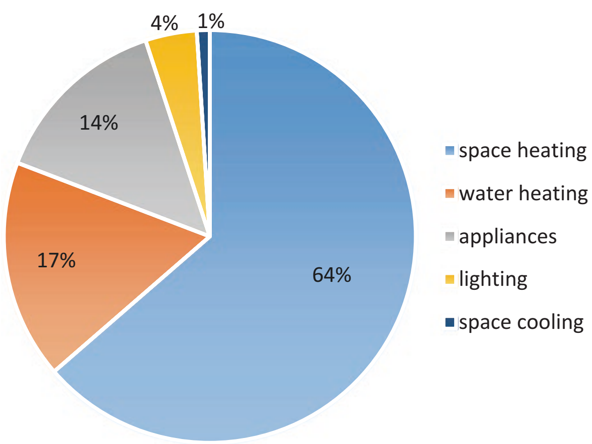

Fig. 8.3 Building energy end-uses (Natural Resources Canada 2011, 2015a)

factors including the market penetration of LEDs, motion detectors, timers, task lighting, light dimmers, and behavioral practices such as turning-off unnecessary lamps (Natural Resources Canada 2019b; Karunathilake et al. 2018).

Over the past three decades, significant changes occurred in Canadian residential building sector. The number of households in Canada increased from 9.9 million to 14.1 million from 1990 to 2015 (Natural Resources Canada 2019b). The other noticeable change is the increase in the cooled area percentage with respect to occupied spaces (Natural Resources Canada 2011, 2019b). The percentage differences of the changes occurred from 1990 to 2015 in residential buildings are indicated in Fig. 8.4 below. These information are derived from statistics provided by NRCan (Natural Resources Canada 2019b).

Energy use varies significantly with weather, occupancy patterns, and the energy efficiency of the equipment being used. NRCan attributes residential energy consumption changes over the said time period to five factors including activity, structure, service level, weather, and energy efficiency attempts (Natural Resources Canada 2019b; National Energy Board of Canada 2016). Except the structure and energy efficiency efforts, all the other factors have resulted significant increases in total energy consumption. If the energy efficiency efforts were not present, then the total energy consumption of the residential building sector would have increased by 54% by 2015 compared to 1990. Percentage increment of energy use was limited to 8% due to energy efficiency interventions including introduction of CFLs and LEDs, insulation upgrades, roof and window modifications, and use of energy efficient appliances (Natural Resources Canada 2019b). The said measures were able to avoid 27.8Mt of GHGs in 2015. Nevertheless, the GHG emissions associated with residential buildings are predicted to be increased by 15% compared to 2012 levels due to growing energy demand (Natural Resources Canada 2019b; Environment Canada 2014). Therefore, the energy efficiency improvements have to be a continuously improving process in order to bring the residential energy demand and related GHG emissions to a plateau or to a decreasing trend despite of the growing number of households.

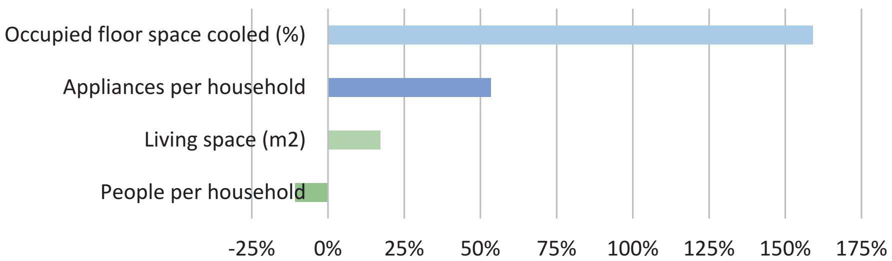

Fig. 8.4 Percentage differences of the changes occurred from 1990 to 2015

3 Energy Efficiency Strategies: A Bird's Eye View

Introduction of technological interventions in the form of retrofits is popular in Canada for achieving energy efficiency in buildings. Energy retrofits can be classified into three categories, namely minor energy retrofits, major energy retrofits, and deep building retrofits. Minor retrofits are defined as focused energy saving measures that can achieve energy savings up to 15% from the original consumption. Similarly major and deep retrofits are expected to produce energy savings from 15 to 40% and greater than 40% respectively (Natural Resources Canada 2016).

Energy efficiency measures are popular in residential building sectors of BC and many other provinces of Canada. Statistics show that at 82% of the residential buildings have adopted one or more energy conservation measures and 37% of the households have implemented energy retrofits (Statistics Canada 2011). Energy efficiency of new residential buildings is expected to be improved by 27% compared to 1997 with the introduction of new building codes such as NECB and BC Energy STEP Code (Natural Resources Canada 2015b; Government of Canada 2016). Moreover, 0.7% annual reduction in energy use per unit indoor area is expected from 2016 to 2040 with the planned energy efficiency efforts (National Energy Board of Canada 2016).

A case study in the Major Retrofit Guidelines (MRG) report prepared by NRCan shows some insightful cost benefit figures for energy retrofits. Costing information including investment cost, savings, and payback period from the mentioned case study is summarised in Fig. 8.5 (Natural Resources Canada 2016).

Cost information in Fig. 8.5 indicate that higher energy savings can be achieved with higher initial investments. Moreover, it shows that the payback period for other retrofits except for AHU motor considered in the case study generally increases with the increasing investments. It can be seen that if higher energy savings in the range of C$5000 are anticipated, then the investments are in the range of C$70,000–100,000 leading to major and deep retrofits. However, this level of

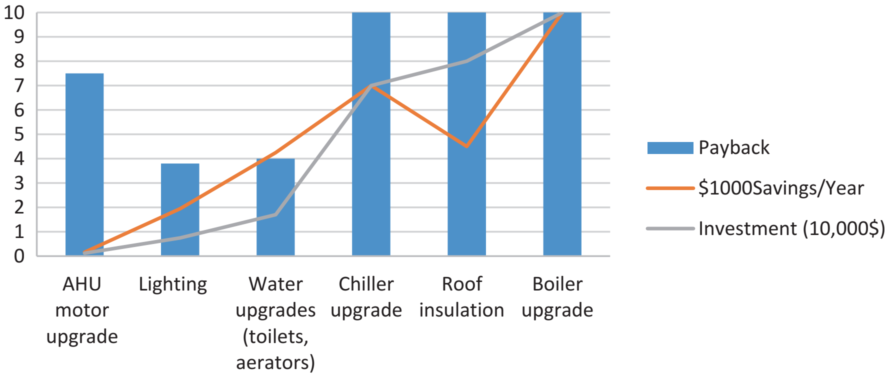

Fig. 8.5 Cost information of retrofits (Natural Resources Canada 2016)

investments is not always possible for residential building owners spanning from single family detached houses to multi unit residential buildings. When it comes to rentals, the tenants get to pay the utility bills while the owner is responsible for the retrofits. In situations such as MURBs, the owners of the apartment units cannot do any major or deep retrofits by themselves without the consent of strata management. MRG highlights that aligning these deep retrofits with scheduled maintenance activities produces better results. Therefore, the interventions have to be waited until a suitable execution point reaches in the building energy system to reap the maximum economic benefits. Essentially, there are visible challenges hindering the implementation of technical energy efficiency interventions due to financial constraints, irregular division of costs and benefits, and management and scheduling complications.

In contrary to retrofitting interventions, behavioral changes can produce energy savings at minimal or zero costs. Both responsibility and benefits of energy efficient behaviors are held by the building occupants and not by the owners. Behavioral changes can be initiated at any point of time without waiting for major energy system renovations. These characteristics of behavioral interventions reduce the complications in cost benefit divisions, scheduling issues, and financial constraints. Therefore, it can be argued that the behavioral changes are an effective tool that can take the message of Canadian energy efficiency practices to the buildings that have difficulties in implementing technical measures. On the other hand, building automation systems and the sensor-based technologies have their limitations in response times. For an example, lights and heating elements that can operate automatically based on occupant presence and absence take some time before turning off after the occupants leave the space, leaving some room for further improvement. Unarguably, this technology is important in avoiding any prolonged energy losses due to mistakes of occupants. However, if this technology can be combined with energy conscious behavior, energy wastage can be minimized further. Moreover, there is a potential that people pay relatively less attention to energy conservation when energy efficiency technologies and building automation techniques are implemented without proper awareness regarding occupant responsibility. This issue can be easily resolved by energy conscious behavior and awareness programs that continuously remind occupants about their role in energy efficiency. A recent study reveals that buildings occupied by educated occupants have 1.3% higher energy efficiency compared to the other buildings. Authors of the study attribute this observation to energy conscious technology choices and behavior (Kavousian et al. 2015). This strengthens the fact that the implementation and usage of the energy efficient technologies can be improved by fostering the energy conscious behavior and awareness of the occupants. Therefore, it is important to investigate methods to educate the occupants about energy conscious behavior in parallel to energy efficient technologies in order to reach the Canadian emission targets as expected.

Occupant behavior is identified as one of the main uncertainties faced by the energy planners in system designing and operation scheduling. Literature suggest that the energy wastage occurring due to the uncertainties introduced to planning by the occupancy patterns and occupant behavior can reach up to 30% from the intended energy use (Jia et al. 2017; Wang and Shao 2017). Codes and standards such as NECB (National Energy Code for Buildings), BC Energy STEP Code, and ASHRAE are widely used to help energy designers to overcome these challenges. However, the unpredictable energy behavior of the occupants still causes losses in the energy system operation due to the mismatch in user expectations and government policies, because the energy standards look at the building energy performance in an energy efficiency lens while the building occupants are more focused on the economic performance of their energy system. This priority mismatches in decisions further poses challenges to energy system operation schedules due to the discrepancies caused by unexpected behavioral patterns (Wang and Shao 2017). If the occupant energy behavior can be made consistent by awareness programs leading to energy conscious behavior, then money, time, and effort in energy system designing and operation scheduling can be reduced significantly while minimizing the energy losses in the practical operation. Many technological interventions such as submetering techniques, internet of things (IoT) based techniques, non-intrusive load monitoring techniques are being implemented with the aim of reducing energy wastage by optimizing the energy system operation with real-time monitoring (Anderson et al. 2012; Martín-Garín et al. 2018). However, these approaches need expert knowledge and high initial investments. Moreover, it is difficult to implement some of these technical measures in buildings at a later stage after construction. Therefore, promoting the consistent adoption of energy conscious behaviors can be easier compared to the implementation of technical solutions proposed.

Energy conscious behavior (ECB) can be defined as the process of eliminating non-essential energy uses through actions initiated by the occupants. These behaviors can be in many forms including turning-off unnecessary lights and unplugging unused appliances, selecting appropriate room temperatures to match the needs and occupancy levels, wearing suitable cloths to avoid unnecessary increments in heating and cooling loads, and avoiding the instances of running the washers and driers at partial loads (Mills and Schleich 2012; U.S. Department of Energy 2016). The idle energy consumption of devices are found to be in the range of 7.3–10.7% of total household energy use according to the studies done in Australia, China, and Japan (Kelly 2012; Ouyang and Hokao 2009). For an example, the energy used by a microwave oven for heating is lesser than the energy consumed to operate its' digital display throughout the day (Province of British Columbia 2008). This indicates that simple attitude changes can produce significant energy changes without any additional investments. ECB is an effective tool that is strongly interlinked with energy conservation measures as discussed above. However, implementation of behavioral interventions has its own challenges if effective ways to bring it to the people were not found. Literature highlights that consumer behavior is largely influenced by the costs, required effort, and the convenience (Steg 2008). Public awareness programs are an effective way to promote conservation techniques that don't incur significant costs, require less user effort, and cause minimal inconveniences. Effectiveness of the behavioral interventions can be further enhanced with feedback mechanisms to inform the users about their energy performance (Steg 2008). Research shows that 5–15% energy savings can be achieved by providing detailed real-time energy use information through smart meters, mobile phone applications (Darby 2006). A mobile phone application to report the residential energy use is successfully practiced by Ontario residents.

Financial incentives are identified as another effective way for promoting energy conscious behavior within all the social groups including Canadian citizens, indigenous people, and immigrants. These incentives can be introduced in the form of taxes and subsidies (Lindén et al. 2006). Moreover, energy prices can be used as a direct influence to change the energy use trends. Time-of-use (ToU) pricing technique have proven to provide greater leverage to the utilities to direct the less urgent energy use applications such as cloths washing towards off-peak hours (Strbac 2008). This approach is been proven to produce mutual benefits to both utilities and occupants according to a research conducted in Sweden (Campillo et al. 2016). The users can shift their less priority energy needs to off-peak times and benefit from the low energy bills while the utilities can manage the peak demand with minimal installed capacity as the load profile is becoming flatter when the loads are shifted to off-peak times. In some provinces including British Columbia, ToU approach is only applied to commercial and industrial sectors while Ontario (ON) has employed this for residential buildings too. ON uses three time periods including off-peak, mid-peak, and peak to apply ToU pricing (Ontario Energy Board 2019). However, public awareness and acceptance of the ToU schemes are still at a questionable state according to the expert opinion. Nevertheless, outcomes of previous studies indicate that maintaining peak power rates around four times higher compared to off-peak rates produce positive results (Pittis 2019). Block tariff schemes are another commonly used billing strategy by the utilities to control the cumulative electrical energy usage of buildings. In this method, users have to pay incrementally higher prices after exceeding pre-set energy use thresholds. However, this approach is not directly supporting the load curve management. Looking at the energy use from a different perspective, governments are introducing the Carbon taxing policies in the view of reducing GHG emissions. These taxes apply on fossil fuel production, distribution, and use in relation to the associated CO_2 emissions. However, the effectiveness of carbon tax in regions where the energy cost is significantly low is arguable (National Energy Board of Canada 2019). Considering all these factors, literature suggest the use of appropriately high energy prices that can create significant cost increments and reductions depending on the energy consumption practices to foster energy conscious behavior in communities (Loi and Loo 2016).

The above discussion emphasizes the need for combining technical and social factors with economic forces to guide residential buildings towards greater energy efficiency. Multidisciplinary studies are needed to strengthen the residential energy demand management programs (Steg 2008). Upcoming sections of this article discusses the lessons learned from an empirical study on behavioral changes conducted in Saudi Arabia to discuss the practical challenges and opportunities in implementing energy conscious behavior.

4 Lessons Learned: An Oxymoron from the East and West

Climate change mitigation efforts and human behavior can greatly vary from one country to another with the differences in socio-economic dimensions. However, lessons learned through studying the best and contemporary practices along with the underlying causes can be globally applicable. Therefore, this section compares energy use and pro-environmental behavior (PEB) trends with reference to Saudi Arabia and Canada.

4.1 Saudi Arabia in Focus

Saudi Arabia is amongst the most energy intensive countries when comes to per capita consumption (Alshehry and Belloumi 2015). The conventional perspective about the daily energy behavior of the Saudi population could be characterized as 'not-so-thoughtful' (Nahiduzzaman et al. 2018). Therefore, people seem to demonstrate rather lavish energy consumption behavior. Understandably, this is partially attributed to the fact of relatively cheaper energy prices resulting from substantial governmental subsidies and higher per capita income. However, a recent study by Nahiduzzaman et al. (2018) suggests that some degree of energy conservation practices exists among the families, which could be understood as partial form of PEB, away from the ideal behavior that refers to practices consciously seeking to minimize the negative impact of one's actions through reduced resource and energy consumption, and waste generation (Kollmuss and Agyeman 2002). However, this seems to imply that if people from countries with higher energy availability per capita implicitly possess the sense PEB with a record of its partial demonstration in daily consumption, essence of PEB could be easily adapted in countries like Canada where cost of energy is relatively higher. Furthermore, it is going to potentially encourage individual users to reflect that ideology into regular practices, if context-specific non-technical behavior based interventions are designed to implement. Due to positive directives emanating from the 'unorthodox' result from an energy-rich context, the study by Nahiduzzaman et al. (2018) is particularly critical. If the inherent PEB embedded in energy-rich individuals could be unleashed into an energy-responsive behavior, the outcome might be more promising where cost of energy is much higher. Bearing that in mind, the key lessons of the study are worth a deliberation. The study suggests that there is always a pressing need for behavioral (non-technical) intervention to establish the norm of energy conservation at the individual levels. The contextualized interventions with a multi-pronged approach (e.g. a composition of video based education, stickers based messages, weekly meetings, etc.) could potentially save more energy while establishing a pressing sense for conservation. The study further amends for a positive relation between the adults members in the family and their level of education with the total energy consumption while number of female members in family, household size, building area demonstrate a negative association attributing to 'economies of scale' and existence of some degree of PEB. Hoisting the importance of 'investment', aiming to enhance the energy efficiency standard of a dwelling, that study emphasizes on the 'curtailment' behavior, which seeks to achieve energy saving by altering behavior (Han et al. 2013; Testa et al. 2016) in order to establish such norm for conservation. The essence stem further questions that whether (i) Canadian families is ready to be potentially intervened through non-technical behavioral tools; and (ii) if the inherent PEB among the Canadians could be capitalized into a responsible energy saving behavior.

4.2 Energy Pricing and PEB in Canada

While the energy demand at the residential sector is on the rise, whether the families have been really efficient in energy usage as opposed to the potential savings remains to be answered. Following are amongst the most notable energy efficient measurement tools that government found to be effective in downsizing the burgeoning demand for energy in Canada: fostering innovation and competitiveness, development and enforcement of regulations, standards and codes, the administration of voluntary certification, benchmarking and information-based programs, and domestic and international partnerships (Ipsos Reid 2015). The 'innovation' and 'standards and code' parts entail hard core technology driven measures that are equally vital to address the current mounting energy demand while achieving higher efficiency in usage. However, they have been conceptualized and practiced with rather a narrow insight. They largely exclude the potential role of the individual (*end-*) users that would have been manifested through everyday behavior in order to contribute to achieving higher energy efficiency (Nahiduzzaman et al. 2018; Chelleri et al. 2015, 2016). Therefore, 'end-user' centric intervention targeting individual's behavior to curtail the level of consumption and gain higher efficiency of usage resulting in the reduction of overall energy demand is somewhat absent in research axioms and think-tanks. As a result, the concept of and need for such non-technological intervention in energy research and practices are pervasively missing across the Canadian provinces: (i) addressing consumption behavior of the individuals; (ii) potential for better efficiency after a detail profile of end users' consumption behavior.

Understandably, ToU is a regulatory tool for behavioral intervention. It is designed to control the volume of energy usage during off-peak, mid-peak and on-peak hours through differentiated price rates. The resulting outcomes suggests that each household tends to use two-third of their electricity during off-peak hours while the remainder being split between mid-peak and on-peak (Ipsos Reid 2015). Governed by the prices, the residential users tend to operate in certain ways to manage the monthly energy bills in line with their financial affordability. This seems to advocate that the temporal dimension of pricing has partially unleashed the inherent PEB of the residential users. This is a 'sporadic' and weaker demonstration of PEB that is not consciously addressed to unearth its full potentials. Such situation-specific demonstration could be perceived as *pro*^{2} (pro- pro)-*environmental behavioral* (P^2EB), which has not been attempted to unleash and capitalize into energy saving actions with scientifically designed non-technical interventions.

Canada being a diversified immigrant-driven society demands a thorough and thoughtful approach for behavior based intervention that encourages better conservation practices. In order to achieve this, a multipronged approach should be adopted combining videos and stickers based conservation messages, and regular dissemination of information through social and TV media, community based dialogues, workshops and meetings, among others. A future study considering the diverse societal landscape should substantiate the context appropriate modes for interventions. However, it needs to be carefully designed after a thorough identification and characterization of the families through the lens of cultural, socio-economic, education, demographic, linguistic, and religious diversities (Nahiduzzaman et al. 2018). These features might be critical and even sensitive, especially for the new immigrants, families with low-income and education, and first nation Canadians (Ng 1998; Wee and Choong 2019). This is more so when many families do not even aware about ToU and its intended benefits (Ipsos Reid 2015; Shi et al. 2019). While they might be at constant struggle to survive than living, ToU alone would barely be able to transform the PEB into a desirable conservative actions.

5 Conclusion: A Way Forward

Unarguably, there is a continued need for technological interventions to regulate the current and future energy consumption and sequent crisis. However, this alone could only do a little without having a marital tie with non-technical interventions that fosters PEB among the clusters of families with various demographic, social, economic, cultural, religious, and personal traits. Therefore, it is compelling to embrace the significant importance of twin-ventured intervention where individual's behavior and smart technologies to combine in order to reduce the surge of residential energy demand. The growing need to establish a sustainable practice of conservation at the households is also critical to meet the sustainable development goals (SDGs) and envision 2030 that Canada pledged for (UN 2018; Gupta and Vegelin 2016).

As hinted out earlier, the current academic think-tank associated with energy research in Canada is somewhat lacking the perspectives of interdisciplinary focus despite of the efforts made by knowledge networks, such as Pacific Institute for Climate Solutions (PICS). Human interaction and behavioral demonstration in the built environment demands for greater unions of scholars to fill the vacuum of trans-disciplinary knowledge and perspectives. On that front, energy research should be conducted while taking all pertinent fields of knowledge, including engineering, environment, urban planning and design, architecture, psychology, economics and sociology into account. Failing to do so, the outcomes of the scholarly endeavors would merely be partial to deal with the ongoing energy crisis and stemming adversities. Furthermore, contemporary endeavors to achieve energy security and sustainability would be questionable while leaving the future with uncertainties. Therefore, this paper calls for a 'collaborative' think-tank for energy research where 'humane' attributes are to be equally accounted along with other essential parameters. In order to do that, the strategic thought-led policies need to undergo certain changes where the 'collaborative' think-tank would inform the executive actions in different forms of interventions, leading to an energy efficiency and 'net-zero' development. There is also a need for renewed policy insights and resulting actions on integrating 'investment' and 'curtailment' behavior approaches into research and practices. This will help assess the 'longevity' effects of twin interventions in actualizing P^2EB into an energy responsive behavior.

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