Supporting Domestic Energy Conservation in Ontario through Direct Feedback

By

Cristina Guido

Supervised by:
Ray Rogers

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ABSTRACT

Outside of financial incentives, there is a lack of tools for Ontario households to effectively conserve energy. The traditional and most commonly used policy tools, money and information, are not enough on their own to truly develop a culture of conservation, as set out by Ontario's Long Term Energy Plan. This paper argues that there are gaps in energy conservation policies and programs in Ontario that can be addressed through insights from the social sciences in order to enhance residential energy conservation programs and policies. A review of behaviour literature and decision models from various disciplines of academia will be explained to describe the 'behavioural blind spot' in current policies and programs, thus providing an explanation as to why Ontario is falling short of it's long-term energy conservation targets. A behavioural intervention called direct feedback will be of particular focus in this paper, as studies have demonstrated that providing feedback can, on average, result in up to 15% in household energy savings. Direct feedback has the ability to change household energy behaviours, as it increases energy literacy, instantly reinforces positive behaviours (energy savings), makes energy use 'visible' and is presented in a cognitively stimulating and tailored format.

Ontario is well positioned to support a direct feedback program through the recent introduction of the Green Button program and its transition to the smart grid. Behaviour-based energy programs are making traction internationally through the formation of behavioural working groups such as the United State's Customer Information and Behavior Working Group that focuses on the research and development of behaviour-based energy efficiency programs and the United Kingdom's Department of Climate Change (DECC) that has worked with researchers to contribute to the knowledge of behaviour change programs and

energy conservation. It is recommended that Ontario take a similar approach and create a behavioural working group to contribute to behaviour-based energy research and programs. Supporting direct feedback in the residential sector and forming an energy behaviour working group would significantly assist the Province and Local Distribution Companies to meeting long-term conservation targets.

FOREWORD

"You can't change what you don't measure"

This major research paper came to fruition through a belief that individuals can contribute to mitigating the adverse effects of climate change and that more guidance is needed to create a culture of conservation. This belief directed the focus of my area of concentration, which took an interdisciplinary approach to understanding how to change behaviour. The courses and activities I took through the duration of the MES program were strategically selected to aid learning in economics (ENVS 5164 Environmental Economics), education (ENVS 6151: popular Education for Social change 2), sociology (ENVS 6127: Community Organizing & Development), technology and psychology (ENVS 4401: Fundamentals of Energy Efficiency; Behaviour Energy and Climate Change Conference), policy (ENVS 6121: Community Energy Planning; ENVS 5699: Field Experience), to guide the research undertaken for this major research paper. Understanding the role that government has in facilitating behaviour change and energy literacy was fulfilled through my field experience with the Town of Caledon's Energy and Environment Division. Field experience in the municipal sector provided direct experience in implementing strategic environmental policies, plans and programs which furthered my understanding of municipal operations and the relationship to fostering community engagement and influencing pro-environmental behaviour change. External academic activities such as attending the Behaviour, Energy and Climate Change Conference (BECC) in California, the leading international conference on understanding human behaviour and energy savings, and the QUEST 2014 Conference in Vancouver aided my learning in this area and informed my major research paper.

These activities directed my three major components: behaviour, energy and climate change. My learning objectives involved identifying the existing energy decision models that impact household energy decisions (Learning Objective 1.1), review of interventions that lead to behavioural changes (Learning Objective 1.2), defining energy from a social-psychological lens (Learning Objective 2.2) and making the connection back to human-caused climate change (Learning Objective 3.2).

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To my wonderful field experience supervisors and co-workers, Sara Peckford, Katelyn McFadyen and Shannon Carto, I feel lucky to have gotten the opportunity to work with you. I will always appreciate your kindness, support and guidance with my schoolwork and supporting the development of my professional career. The growth that has amounted through working with the Town of Caledon's Energy and Environment division is immeasurable.

Mom, thank you for your continued love, encouragement and support. Dad, thank you for pushing me to be better, work harder and for challenging me to push my boundaries. Mathew, thank you for providing comedic relief during times of stress. Daniel, thank you for being my guardian angel and guiding me in the direction of greater things.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACEEE	American Council for an Energy-Efficient Economy	**AEEA**	Alberta Energy Efficiency Alliance
APS	Achievable Potential Study	**BECC**	Behaviour, Energy and Climate Change
CCAP	Climate Change Action Plan	**CMD**	Connect my Data
CUB	Citizens Utility Board	**DEFRA**	Department for Environment, Food and Rural Affairs
DMD	Download my Data	**DOE**	Department of Energy
DR	Demand Response	**ECO**	Environmental Commissioner of Ontario
EIA	Energy Information Agency	**EPA**	Environmental Protection Agency
GHG	Greenhouse gas	**GWh**	Gigawatt hour
HVAC	Heating, ventilation and air conditioning	**IESO**	Independent Electricity Systems Operator
kW	kilowatt	**kWh**	kilowatt hour
LDC	Local Distribution Company	**LTEP**	Long Term Energy Plan
MOE	Ministry of Energy	**MOECC**	Ministry of Environment and Climate Change
NEB	National Energy Board	**NR Can**	Natural Resources Canada
PJ	Petajoule	**OPA**	Ontario Power Authority
SEE Action	State and Local Energy Efficiency Action Network	**TJ**	Terajoule
TRA	Theory of Reasoned Action	**TPB**	Theory of Planned Behaviour
TOU	Time-of-use	**TWh**	Terawatt hours
UK	United Kingdom	**US**	United States
VBN	Value-Belief-Norm Theory		

1.0 INTRODUCTION

Human behaviour is challenging to influence, due to its complex nature, heterogeneity and ability to be influenced by several extrinsic (i.e., policies and programs) and intrinsic (i.e., attitude and motivation) factors. Researchers from varying academic disciplines have developed and tested theories, models and frameworks used to explain the causal factors that influence human decisions. Behavioural models are applicable to the context of household energy use, for the purpose of informing behaviour-based program design. Behaviour-based energy conservation programs involve the use of one or more interventions (a measure used to influence behaviour), and are intended to reduce energy consumption. Studies have shown that changing people's behaviour can significantly reduce energy consumption (Karatasou et al., 2014).

Energy conservation in Ontario is regarded as "the cleanest and least costly way to supply energy, with substantial environmental and climate benefits" (ECO, 2016). The Province of Ontario has taken a 'Conservation First' Framework (2015-2020), directed by the Long-Term Energy Plan (LTEP) (2013), meaning that conservation will be prioritized before the production of new energy generation. The Provincial government expects to offset almost all of the growth in electricity demand to 2032 through the use of conservation programs and improved codes and standards (Government of Ontario, 2013). Only five of Ontario's seventy-plus local distribution companies (LDCs) have met both their peak and overall electricity conservation targets for the 2011 to 2014 period (ECO, 2016). In review of the programs offered to the residential sector by LDCs, almost all of them are incentive and financially based programs, meaning limited attention has been given to behavioural programs as a means to meet aggressive conservation targets. Conservation relies on behavioural changes, whether that is a shift in the time of use, turning off appliances or not using them at all (Allcott & Mullainathan, 2010). It is this gap in policy that will be addressed through this research paper.

The disciplines of environmental psychology and sociology recognize that there is a role for the social and human dimensions to be considered in energy policies and programs. The important role of individual and household decisions in the trajectory of the future of energy is sometimes overlooked in discussions of energy policy (Dietz et al., 2013). Psychologists have argued that there is a critical underlying behavioural assumption that energy-saving technologies will be adopted once the owners become aware of their benefits (Stern, 1992). These assumptions ignore what Stern (1992) refers to as the 'human dimension' of energy, which includes culture, social interactions, and feelings that influence behaviour and social processes. While energy efficient technology certainly has a role in the realm of reducing energy consumption and adapting to sustainable lifestyles, it must be recognized that people ultimately have to make the decision to adopt them. Similarly, energy conservation relies on human decisions, whether that is the choice to shift time of use, turning off appliances or not using them at all (Allcott & Mullainathan, 2010). This concept will be of particular focus in this paper.

Carbon-intensive energy demand is a deeply rooted issue within climate change. Climate change results primarily from anthropogenic greenhouse gas emissions that leads to atmospheric concentrations of carbon dioxide, methane and nitrous oxide, and are the dominant cause of observed warming since the mid-20th century (IPCC, 2014). Ontario's Climate Change Strategy (2015) plans to reduce greenhouse gas emissions to 80% below 1990 levels by 2050, and build a prosperous low-carbon economy. It is now widely agreed upon that the challenges of climate change are such, that many familiar ways of life and the patterns of consumption that are associated with them, are fundamentally unsustainable (Shove, 2010). If there is to be any effective response, new forms of living, working and playing will have to take hold across all sectors of society (Shove, 2010). Thus, Ontario households constitute as an important target group for energy conservation policies and programs, as they are major contributors to the emission of greenhouse gases. Between 1990 and 2009 Canada's energy use has increased by 23%, where demand in the residential sector grew by 11% (Natural Resources Canada, 2012). Households currently have no means to judge their energy use other than their monthly utility bill, thus making daily consumer interaction with energy-consuming devices and systems performed without the conscious consideration of energy (Pierce et al., 2010).

The primary research question that informs this major research paper is: how can residential feedback programs help Ontario to meet its conservation targets? This question will seek to be resolved by providing a basis to understand the key determinants that influence human decisions and how these findings apply to conservation policies and programs. Therefore, the main argument of this research paper is that government energy policy and utility conservation programs can have a greater impact in influencing voluntary behaviour change through the use of behaviour-based energy conservation programs.

This major research paper will be organized as follows: section two will provide an overview of the energy impacts of the household sector in Ontario and will set the context for behaviour-based energy programs. Section three will discuss the theoretical debate of human decision models and frameworks, as explained by different disciplines of academia. Section four presents an overview of antecedent and consequence behavioural interventions, followed by a case study on direct feedback. Section five will discuss opportunities for Ontario to deploy a feedback program and will provide recommendations for the Province moving forward. The final section will conclude this major research paper.

1.1 Methodology

This section provides an overview of the approach and methods used to identify the relevant literature that informed this major research paper. This paper takes a literature review approach to respond to the following research question: how can residential feedback programs help Ontario meet its conservation targets? This question will be responded to through the theoretical frameworks that have been developed to explain what shapes human decision-making and how these findings can inform energy conservation policy and programs. The findings in this major research paper are derived from two major bodies of academic research. The first comprises of theories and frameworks of decisions and extends across psychology, sociology, and economics disciplines. The second body of research is social-psychological aspects of behaviour change and intervention literature. Intervention literature is conducted through experimentation using a control group to measure the effects of an intervention, quantitatively through household surveys and qualitatively through interviews to provide insight on household lifestyles and habits.

Searches for peer-reviewed journal articles were conducted using the York University library online databases in environmental studies. The journal articles referenced in this major research paper were retrieved from academic databases such as Environment Complete, ProQuest and Google Scholar using key word searches such as: “behavioural decision theory”; “household energy behaviour”; and “effects of feedback on household behaviour”. Much of this report draws on meta-analyses on decision models, interventions, feedback and behaviour change programs (i.e., Wilson & Dowlabati, 2007; Darby, 2006; Fischer, 2008; Ehrhardt-

Martinez et al., 2010; Karlin et al., 2015). The meta-analyses were used to identify overarching themes, existing studies for further research, challenges and barriers and study limitations. The criteria for selecting articles that were reviewed for this major research paper were studies that pertained to:

- Decision models and frameworks in regards to residential energy consumption;
- The relationship between energy consumption and behavioural determinants;
- Household energy conservation practices and energy use consciousness;
- The effects of feedback on residential energy conservation;
- The effects of behavioural interventions on residential energy conservation; and,
- Environmental psychology and social-psychology contributions to energy conservation.

The peer-reviewed articles referenced for this major research paper range in publication dates, as some studies date back to the early 1970s and others are as recent as 2016. Research in feedback literature has been classified into two eras, the 'Energy Crisis Era' (1970-1995) and the 'Climate Change Era' (1996-present). Early feedback research was conducted in field experiments and revealed the potential to continue to develop and improve experiments in this field, as energy savings in households were prominent. The literature referenced in this paper was largely produced in the United States, Canada and the United Kingdom.

Grey literature such as government reports and resources, and conferences proceedings were referenced to provide statistical data on residential energy consumption and the associated environmental impacts, government policies and targets, and provided insight of contribution from social-psychology and sociology to household energy conservation. The grey literature sources are intended to complement the scholarly sources and provide specific data and information. Table 1 below provides a high-level summary of the resource types, sources and number of references utilized in this major research paper.

Table 1: Resource type, sources and number of references selected

Resource Type	**Sources (Journals, databases, etc.)**	**Number of references selected**
Scholarly Sources		
Peer-reviewed journal articles	Energy Policy; Applied Energy; Applied Psychology; Energy Efficiency; Open Journal of Energy Efficiency; Journal of Environmental Psychology; Environment and Behaviour; Journal of Consumer Research; PNAS; Journal of Consumer Policy; Journal of Applied Social Psychology; American Psychologist; Theory, Culture & Society	62
Grey Literature		
Government Databases	ACEEE; SEE Action; IESO; DOE; EIA; ECO; MOE; MOECC; OPA; Statistics Canada; NR Can; NEB	21
Conference Proceedings	Behaviour, Energy and Climate Change (BECC) Conference; Demand Centre	3

The literature that was reviewed and critically analyzed to respond to the research inquiry consisted of a total of 86 scholarly and grey literature sources. The peer-reviewed journal articles were mainly derived from journals pertaining to energy (i.e. Energy Policy, Applied Energy), and environmental psychology and behaviour (i.e. Applied Psychology, Environment and Behaviour). The government databases sourced were from the United States, United Kingdom, Canada and Ontario ministries that were related to energy and behaviour. Finally, the conference proceedings referenced were specific to household energy behaviour and how it is impacted by social-psychological causes and behavioural interventions.

2.0 BACKGROUND

This section will set the context of this major research paper by defining energy conservation and describing the two main areas of energy saving behaviours; 1) introducing behaviour-based energy programs and the academic areas of discipline that inform these programs; and, 2) describing the impact of the residential sector and providing an overview of energy conservation policies, programs and stakeholders in Ontario. Finally, this section will discuss the level of energy literacy in Ontario and how behaviour-based energy programs can enhance residential knowledge of energy and address the barriers that face current conservation programs. A review of the central findings and a minor discussion will conclude this section.

2.1 Defining Energy Conservation

Energy efficiency and energy conservation are two terms used to describe energy saving actions. Energy efficiency refers measures that deliver greater or equal levels of service while using less energy (Mallinson, 2013). Gillingham et al. (2009) conceptualizes energy as an input into the production of desired services (i.e. heating, lighting, motion), rather than as an end in itself. In this framework, energy efficiency is typically defined as the energy services provided per unit of energy input, for example the energy efficiency of an air conditioner is the amount of heat removed from air per kilowatt (kW) of electricity input (Gillingham et al., 2009). 'Efficiency' behaviours save energy through a one-shot action such as purchasing more efficient technologies or equipment. In contrast, energy conservation can be defined as a reduction in the total amount of energy consumed. Conservation can be referred to as a 'curtailment' behaviour, which modifies a person's use of energy systems that are already in place, such as lowering the thermostat. Through the analysis of fieldwork, Pierce et al. (2010) defined a vocabulary of five household energy conservation and efficiency interactions:

1. **Cutting:** powering off or putting in an extremely low power state i.e. powering off the television or putting it into a standby state
2. **Trimming:** using a lower, more energy-efficient setting when using a product, i.e. lowering the thermostat or washing clothes with a cold temperature
3. **Shifting:** shifting use to a different time or place, without necessarily reducing the total energy consumed by that product i.e. washing clothes at night during off-peak hours of low energy demand
4. **Upgrading:** acquiring a more energy efficient product to replace a product of the same type i.e. replacing a refrigerator with an EnergyStar model
5. **Switching:** using a more energy efficient product in place of a product with similar but different functionality i.e. using a ceiling fan instead of an air conditioner

The behaviours described above are the purpose for putting energy conservation policies and programs in place in Ontario. Stern and Gardner (1981) suggest that behaviours involving the adoption of energy-efficient technologies generally offer more potential for conservation than behaviours involving the curtailed use of existing systems. However, many studies suggest that people fail to adopt efficiency behaviours and existing technologies that would save them money, such as insulation and efficient appliances (Allcott & Mullainathan, 2010). The concept of the “energy efficiency gap” or the “energy paradox” describes the large untapped potential to save money, improve environmental quality and failure to take full advantage of cost-effective, energy-conserving opportunities (Hirst & Brown, 1990). These failures relate to individual-decision making and are pervasive facets of human behaviour such as risk aversion, uncertainty, sensitivity to changes in the attributes of energy services (Wilson et al., 2007). Another challenge with efficiency behaviours is the rebound effect. Studies indicate that people tend to increase their energy use when they switch to more efficient measures, thus partially attenuating the energy efficiency gains (Herring & Sorrell, 2009). The rebound effect occurs when the savings from an applied efficient technology are equal to or more than the consumption before the efficiency improvements were put in place (Gillingham et al., 2009). If a homeowner replaces incandescent light bulbs with energy-saving light bulbs in their home, they may then leave the lights on for longer because they believe they are doing less harm as the lights are more efficient. The efficiency approach requires little to no behaviour change of the users, consequently the user could still waste energy in the same way (Ting et al., 2011). For example, if a homeowner were to purchase a more fuel-efficient vehicle, they could reverse the positive environmental impacts by driving more, even though these vehicles have a gauge that indicates when the operator is driving more efficiently. This is an interesting example, as it represents the information-action gap, which will be discussed further in the subsequent chapter. Curtailment behaviours will be of particular focus throughout this paper.

2.2 Overview of Behaviour-Based Energy Programs

Environmental psychologists argue that many of environmental problems are rooted in human behaviour and can be managed by changing the relevant behaviour so as to reduce its environmental impacts (Steg & Vlek, 2009). Changes in human behaviour are believed to be necessary because technical efficiency gains tend to be overtaken by consumption growth (Midden, Kaiser & McCalley, 2007). Behaviour change in most climate change policies focuses primarily on voluntary reductions of energy use by individuals that is encouraged through programs that focus on energy savings resulting from non-price interventions informed by the social sciences (SEE Action, n.d). A growing body of research in psychology and behavioural economics suggest that non-price interventions can be just as powerful as prices in changing consumer choices (Allcott & Mullainathan, 2010). Customer information and behaviour energy strategies differ from traditional programs that are technology or standards-based because they recognize people's motivations to implement efficiency can be swayed by social, psychological, political and moral factors (Ehrhardt-Martinez, 2008). As previously indicated by Wilson et al. (2007), who produced a meta-analysis of the impact of behaviour change theory and the implications for the design of interventions and energy policy, pervasive facets of human behaviour and cognitive tendencies directly impact individual decision-making, including decisions related to energy consumption. Non-price based approaches are informed by the social sciences, and are thus designed to consider the facets of behaviour in the design of their programs and interventions.

A 2016 publication by the American Council for an Energy-Efficient Economy (ACEEE) reviewed the effectiveness of behaviour change programs and concluded that they can reduce energy consumption. Programs that target curtailment behaviours are the clearest examples of behaviour change program because human behaviour is the sole cause of energy savings (Sussman & Chikumbo, 2016). The ACEEE (2016) review of behaviour change programs recommends that programs that target curtailment behaviours should: (1) change habits; (2) provide intrinsic motivation; (3) change how people think about the behaviour; and (4) change the perception of future costs (i.e. making the new behaviour easier and less costly to continue than to abandon) (Sussman & Chikumbo, 2016). More research is required about the persistence of savings from behavioural programs.

The social science academic disciplines that inform behaviour-based energy programs are realms of psychology such as environmental and cognitive psychology, and sociological realms such as environmental sociology. Social-psychology which considers social contexts in addition to an individualist perspective, also informs behaviour-based programs.

Environmental psychology identifies factors that influence environmental behaviour such as weighing costs and benefits, moral and normative concerns, affect, and habitual behaviour (Steg et al., 2009). Although a variety of energy conservation actions are technically and economically viable, widespread energy conservation is lagging and policymakers are increasingly looking to psychologists for guidance (Karlin et al., 2015). Environmental sociology aims to recognize the impacts and responsibility of society in regards to environmental issues. Environmental sociologists examine and theorize the complex multi-faceted relationship between human beings and their natural environments (Nagel, 2010). Environmental sociology has developed over time and has expanded its field of inquiry beyond environmentalism as a social movement and began examining the underlying organizational, economic, cultural and emotional factors that have shaped modern industrial society's relationship to the biophysical world (Nagel, 2010).

Psychological models believe that behaviour is driven by individualistic factors such as attitude, values and motivation. Psychology contributes to energy conservation policy due to its emphasis on the energy consumers point of view (Stern, 1992). On the other hand, sociological models remove the responsibility from the individual and consider the macro-level contexts and structures that shape society and drive behaviour such as technology, economy, demography, institutions and so forth. Societal models are important especially for policy developers, since it is also necessary to examine the contextual factors that may directly limit behavioural options (Karatasou et al., 2014). The findings from psychology and sociology indicate the complexities within human behaviour and the micro and macro determinants that drive energy choices. Both of these academic disciplines have their own set of behaviour frameworks, which will be further discussed in chapter three.

2.3 Setting the Context: Energy in Ontario

This section will provide context about the impact that the residential sector has on energy consumption in Ontario and Canada overall. This section will demonstrate that the residential sector's energy consumption is unsustainable and is challenging the Province and Local Distribution Companies ability to meet their conservation targets.

2.3.1 Energy Consumption in the Residential Sector

Energy is vital to North American ways of living, as energy is used to provide a variety of 'essential' services including, but not limited to: heating and cooling, lighting, cooking, hot water and so forth. Household energy use is described as considerably variable, even in nearly identical units as studies have reported large (200-300%) variations in energy use (Lutzenheiser, 1993). This variation can simply be based on differences in individual behaviour and most notably at the end use level (i.e. appliances, heating, hot water use). According to Statistics Canada (2012), in 2008 the household sector accounted for 2,425,068 terajoules (TJ) of energy. In a breakdown of Canada's energy use by sector, as seen in Figure 1, residential energy accounts for 17% of Canada's total energy demand (Natural Resources Canada, 2013).

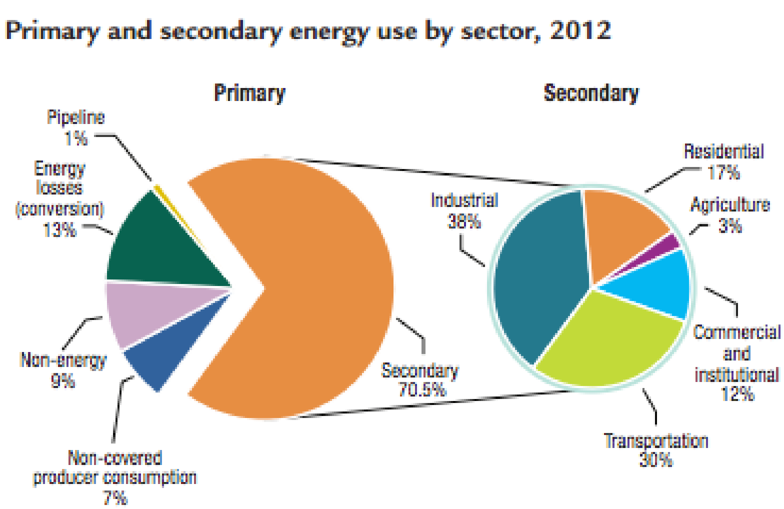

Figure 1: Primary and secondary energy use by sector (Natural Resources Canada, 2013).

Between 1990 and 2010 the population grew 23% (6.4 million people) and the number of households increased by 35% (Natural Resources Canada, 2013). Due to population growth, residential living spaces are being built at a constant rate. The rise in number of households, combined with increased average living space and higher rate of appliances, contributed to the increase of 6% or 78.4 petajoules (PJ) in residential energy use, from 1282PJ to 1360PJ (Natural Resources Canada, 2013). Statistics Canada (2011) data shows that in 2009 the residential sector was the second largest consumer of the country's electricity supply and natural gas, which is commonly used to heat and cool spaces. More Canadians are living in bigger and air-conditioned homes, as the amount of occupied floor space with air-conditioners rose to 788 million m^2 in 2010, from 267 million m^2 in 1990 (Natural Resources Canada, 2013).

In terms of residential appliance use, the increased number of minor appliances offset the benefits of the energy efficiency gains of major appliances from 1990-2010, as seen in Figure 2 below (Natural Resources Canada, 2013). In comparison, in 1990 the average number of appliances per household was fifteen and in 2012 the average was twenty-one appliances per household (Natural Resources Canada, 2015).

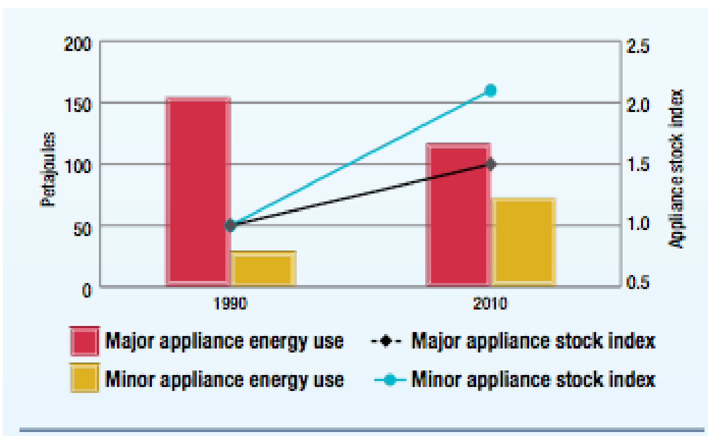

Figure 2: Residential Energy Use and Appliance Stock Index by Appliance Type, 1990 and 2010 (Natural Resources Canada, 2013).

While the statistics captured of residential energy use indicates an increasing rise in household energy consumption, there is opportunity through curtailment and efficiency behaviours to conserve energy. The Achievable Potential Study (APS) (2016) provides an estimate of the short-term electricity conservation potential that is achievable within the Conservation First Framework (2015 – 2020) time frame for the province and for each electricity distributor (IESO, 2015). The APS (2016) indicated that the residential single-family subsector accounted for the largest electricity use by subsector, with 29,794 GWh consumed per year. There is considerable technical potential of savings, as the residential sector accounts for 40% of persistent savings in 2020, with the largest savings potential from single-family homes.

2.3.2 Energy Conservation Policies and Forecasts

Ontario's Long Term Energy Plan (LTEP) 2013, set the direction for conservation, as the plan aims to put conservation first in planning, approval and procurement processes and as a policy for both electricity and natural gas utilities. Ontario has also adopted a Conservation First Framework (2015-2020) that maps out the province's energy conservation goals through a coordinated effort with sector partners and supports LDCs. The goal of the framework is a total reduction of 8.7 terawatt hours (TWh) of electricity consumption in Ontario by 2020, with 7TWh to come from conservation programs delivered by LDCs to residential and business customers (IESO, 2015). The IESO guides the province's electricity conservation efforts, working collaboratively with Ontario's more than seventy LDCs (IESO, 2015).

The LTEP (2013) has a goal to offset almost all growth in electricity demand to 2032 by using programs and improved codes and standards. The 2013 long-term conservation target is 30TWh by 2032, which represents a 16% reduction in the forecast for gross demand of electricity. Ontario's newly released Climate Change Action Plan (CCAP) may impact the 2013 LTEP conservation target, as the CCAP considers the increased use of electricity for residential and commercial space and water heating. Ontario's greenhouse gas (GHG) reduction targets are 15% by 2020, 37% by 2030 and 80% by 2050. Currently, natural gas combustion and carbon-based electricity emissions from buildings represent 24% of Ontario's climate-change causing air pollution (Government of Ontario, 2016). GHGs resulting from electricity have substantially been reduced through the elimination of coal in Ontario and the reliance on hydro and nuclear power. Ontario's Planning Outlook (2016), prepared by the IESO, considered a range for electricity demand in Ontario from 133TWh to 197TWh in 2035, compared to 143TWh in 2015, which reflects the actions identified in the CCAP.

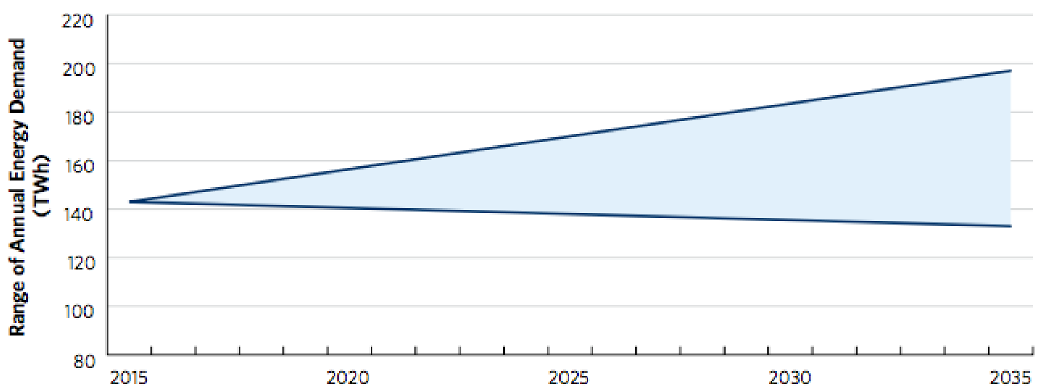

Figure 3: Range of annual energy demand (TWh). (IESO, 2016).

Ontario's future electricity demand has a large range of uncertainty and is largely impacted by the increased use of electricity for space and water heating, a recommendation from the CCAP. Under Ontario's Planning Outlook's four scenarios of a low demand outlook, flat demand outlook and higher demand outlooks, the residential sector's electricity demand has the second greatest demand forecasts of 64TWh by 2035 next to the commercial sector of 69TWh in 2035. The residential sector's forecasted demand is greater than the industrial, electric vehicle and transit sectors. Higher demands will require additional electricity resources to meet the associated levels of demand growth. Steep electricity demand will also require significant investments in Ontario's transmission system and at the distribution level. The scale, cost and practical challenges of implementing options to address greater electrification further highlights the importance of conservation as a method of moderating electricity demand growth (IESO, 2016).

2.3.3 Current Residential Conservation Programs

In Ontario, local distribution companies (LDCs) such as Hydro One and Enbridge Gas offer programs to the residential sector to encourage energy conservation. The Green Energy and Green Economy Act, 2009 made conservation integral and core to LDCs regulated tasks and assigned conservation targets which LDCs must meet as a condition of their license (Government of Ontario, 2013). LDCs are responsible for creating, marketing and delivering conservation initiatives directly to their customers and are responsible for reporting annually on their results and achieving their conservation targets (Government of Ontario, 2013). Provincial programs delivered by LDCs include incentives for lighting upgrades, purchasing energy-efficient products and replacing inefficient equipment (IESO, 2015c). The conservation programs offered to Ontario households by LDCs in 2015 included incentive-based and financial assistance programs delivered through coupons and SaveONenergy incentives. The The SaveONenergy program is operated by the IESO and provided by LDCs.

The Environmental Commissioner of Ontario (ECO) reports on the annual progress of activities in Ontario that reduce and make more efficient use of energy including electricity, natural gas and transportation fuels. The Annual Energy Conservation Progress Report (2015–2016) measured the results of electricity conservation for each LDC from 2011–2014 and found a wide variation in performance. Variations in performance across LDCs reflect the degree of effort that the utility put towards promoting conservation programs to its customers and the fit between an LDC's customer base and conservation programs offered (ECO, 2016). Forty-three of seventy-six LDCs met their energy target, but only five LDCs met both their energy and peak demand targets (ECO, 2016).

The Province has taken a dominantly economic approach to conservation by using demand response (DR) to offset peak demand. DR enables consumers to reduce their electricity consumption in response to prices and system needs (IESO, 2016b). The Peaksaver Plus is an optional DR program that helps residential consumers reduce energy during peak demands by allowing their utility to remotely cycle down their air conditioners and water heaters (IESO, 2016b). The residential sector in Ontario is also subject to Time-of-Use (TOU) rates, a load-shifting measure to persuade customers to curtail electricity usage during peak periods and shift that usage to less expensive mid-peak and off-peak periods (Faruqui et al., 2016). An analysis of the effectiveness of TOU rates showed high participation during the initial program roll-out of 2012, however the impact has gradually declined, as displayed in Figure 4.

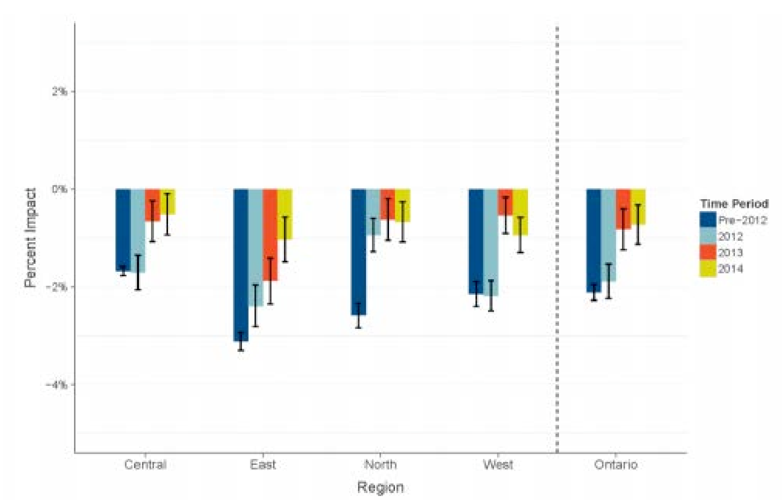

Figure 4: EM&V Peak Demand Period (June, July, August, 1pm to 7pm) Residential Load Shifting Results. (Faruqui et al., 2016).

Few behavioural programs are currently offered by LDCs through energy audits and home energy reports. Energy audits provide recommendations in person to homeowners of measures that can be taken to conserve energy through retrofits and behaviour. Home energy reports compare a homeowner's energy use against that of their neighbours, as a social normative effort to reduce energy consumption.

2.4 Energy Literacy: A barrier to energy conservation?

The APS (2016) reviewed existing conservation programs offered by LDCs in Ontario and identified challenges and barriers for each program. Common challenges and barriers identified for residential programs are: a lack of customer knowledge of efficient products, the time required to educate consumers about "do-it-yourself" energy savings products and efficiency measures, and low participation rates (Childs et al., 2016). These barriers can perhaps be attributable to the lack of energy literacy in Ontario. A survey was conducted across Canada in 2012 to probe the literacy of Canadians with regards to varying topics of energy knowledge including energy issues, environmental attitudes, willingness to pay and government action on energy (Turcotte et al., 2012). The survey indicated notable gaps in electricity literacy and overall energy literacy, which can be described as a combination of knowledge and behaviour consistent with that knowledge among residents of Ontario (Turcotte et al., 2012). Perhaps, crucially, households lack accurate, accessible and actionable information on how best to achieve potential savings through their own steps (Gardner and Stern, 2008). Available evidence indicates that although many householders are motivated, they lack the necessary knowledge to act (Gardner and Stern, 2008). This particular argument will be of focus throughout this paper, as current incentive-based programs are geared toward efficiency behaviours, which as previously stated, requires little to no behaviour change of the users and therefore does not contribute to the improvement of energy knowledge.

2.5 Chapter in Review

Ontario has taken a predominantly economic and policy-driven approach to conservation, through TOU pricing and demand-side management, and offers limited behaviour-based programs. Some researchers argue that efficiency behaviours obtain more savings than curtailment behaviours, however the energy efficiency gap and rebound effect describe why there is large untapped potential in the adoption of efficient technology and how behaviour can waste energy regardless of the technology's efficiency. Behaviour-based energy programs are informed by the social sciences and recognize the social, psychological and moral factors that are otherwise ignored in traditional programs. These programs acknowledge that human behaviour is central to energy conservation and aim to change energy-wasting habits.

The residential sector has large forecasted demands, which will require additional resources and investments to meet growth. Energy conservation is integral to the LDCs regulated tasks, and the APS (2016) indicates that there is considerable technical savings potential for the residential sector, particularly from single-family homes. A review of existing conservation programs offered in Ontario identified that lack of customer energy knowledge and low participation rates are common challenges facing LDC residential programs. In comparison with other provinces across Canada, residents of Ontario were found to have one of the lowest levels of energy literacy. Therefore, this paper will demonstrate that behaviour-based energy programs have the potential to enhance energy literacy among homeowners and support energy conservation, which can combat these identified challenges of LDCs and Ontario meeting their conservation targets.

3.0 UNDERSTANDING BEHAVIOUR

The aim of this chapter is to describe the behavioural determinants that are applicable to household energy behaviours and demonstrate the importance of the 'human factor' when designing programs for residential energy conservation policies and programs. The theoretical pulse within the scope of this major research paper results from the sheer abundance of literature on the frameworks to understand human behaviour, developed under several academic disciplines. Developing a better understanding of how individuals make decisions is important for researchers and intervention designers concerned with the impact of human behaviour on energy use and the environment (Wilson & Dowlatabadi, 2007). Energy conservation ultimately relies on individuals to make different choices regarding they way in which they consume energy and the types of purchases they make. Academic decision models can provide better insight to human tendencies, such as habit formation, which can be addressed in conservation programs and policies.

This chapter will provide an overview of the relevant theories and models that are applied to human decision-making in an energy context. The academic realms that will be considered are conventional economics, psychology, sociology, and social psychology. The different models of decision-making and behaviour that will be described below vary widely in their basic assumptions, independent variables, structures and scale (Wilson & Dowlatabadi, 2007). The decision models that will be discussed in this section have been identified through Wilson and Dowlatabadi (2007), Moezzi and Lutzenheiser (2010), and Karatasou et al. (2014) reviews of models of decision-making and residential energy use. These reviews were greatly resourceful to identify decision models and authors, as there are countless theoretical frameworks of understanding human behaviour. Table 2 below provides a high-level summary of the academic disciplines and decision models that will be discussed in this chapter.

Table 2: Academic disciplines and decision models summary

Academic Discipline	Model of Behaviour	Decision Models	Independent variables
Economics	Individualist	▪ Rational Choice Theory ▪ Discrete Choice Models	▪ Costs and benefits of outcomes, preferences
Psychology	Individualist	▪ Theory of Reasoned Action (TRA) ▪ Theory of Planned Behaviour (TPB)	▪ Attitudes, intentions, norms, perceived behavioural control
Sociology	Societal	▪ Energy as a social construct ▪ Habits and Lifestyle	▪ Social, cultural and technical determinants of energy demand embedded in routine behaviour
Social-Psychology	Individualist and Societal	▪ Energy-saving Behaviour Model ▪ Value-Belief-Norm (VBN) Theory	▪ Social norms, socio-demographics, incentives, skills, capabilities and resources

3.1 Decision Models

A decision is defined by the acts or options among which one must choose, the possible outcomes or consequences of these acts, and the contingencies or conditional probabilities that relate outcomes to acts (Tversky & Kahneman, 1981). Decisions can range from being highly deliberative, informed, and conscious choices to habitual, instinctive, and subconscious "non-decisions" (Kahneman, 2003). Residential energy use is characterized by a wide range of decision types that contains psychological and contextual influences on behaviour (Wilson & Dowlatabadi, 2007). The models and frameworks that will be discussed in this section are the rational economic model, psychological and attitude-based models, sociological and societal-based models and finally, social-psychological models.

3.1.1 Conventional Economics: Rational Economic Theory

Economic theory has been the base for modeling many aspects of human behaviour, that has been built around the principles of utility theory and rational choice (Karatasou, 2014). Rational behaviour is broadly defined as meaning sensible, planned and consistent behaviour (McFadden, 1999). Traditional economic theory postulates that human decision-making and behaviour are purely based on rational choices that rest on several fundamental assumptions, namely that people have rational preferences among outcomes, strive to maximize utility (individual's expressed preferences) and act independently based on full and relevant information (Frederiks et al., 2015). This theory assumes that there is a linear relationship between human decision-making and information, as it is believed that behavioural choices can be improved by providing people with more information (i.e., by increasing knowledge/awareness) and/or more options (i.e., by increasing choices) (Frederiks, 2015).

> Consumers are believed to make choices by first, surveying the available alternatives; second, collecting and accurately weighing all the information relative to each alternative; third, considering this information to determine the costs and benefits associated with each potential strategy and making probability judgments about the risks and uncertainties associated with the adoption of any given course of action; and fourth, electing the most cost-effective strategy that maximizes positive utility while minimizing costs (Yates & Aronson, 1983).

Based on this rational-economic model, major energy policies to date have tended to assume that information, rising prices and technological improvements will produce the shifts needed to combat climate change and conserve resources (Allcott & Mullainathan, 2010). Critics of traditional economic theory argue that individuals do not always make rational decisions and invokes simplifying assumptions that abstract from the complexities of real-world choices (Howarth & Sanstad, 1995). For example, Ontario's LTEP (2013) states, "to help consumers choose the most efficient products for their homes and businesses, Ontario will provide information and incentives”. This is a direct example of the rational economic theory that simplifies the human decision-making processes and assumes that increasing information and reducing costs to Ontarians, will ultimately lead to conservation behaviour. Ontario’s SaveONenergy program is also based on the rational economic model, as it takes a price-based approach to influence homeowners to conserve energy by offering financial incentives and coupons. However, the effects of financial incentives are often short-lived and/or inconsistent, resulting in behaviour reverting back to baseline levels upon the removal of the reward (Frederiks et al., 2015). These approaches lack supplementing traditional policy tools with insights from behaviour change theory to equip homeowners with the skills and knowledge needed to conserve energy. Psychological studies have identified cognitive tendencies that impact the way in which humans make decisions and the insights from this area of academia should be adopted into Ontario energy conservation policy and programs.

3.1.2 Psychology: Attitude-Based Models

Psychology decision models consider mental processes that affect human behaviour. Psychological decision models aim to understand and influence individual perceptions and actions related to energy use (Moezzi & Lutzenheiser, 2010). In contrast to the rational economic model, psychology studies have identified factors that influence psychological elements such as attitudes, intentions and subjective norms. Psychological research on the determinants of energy use generally supports a multistage causal model that involves learning, which as a consequence, influences specific attitudes and beliefs about energy (Stern, 1992). Early psychology studies focused on the influence that attitude has on behaviour. As energy prices and the associated incentives to conserve receded through the 1980s, attention shifted from deficient information as a source of market failure to the role of psychological constructs (values, attitudes, norms) framed by environmental concerns (Wilson & Dowlatabadi, 2007). Attitudes play a dominant role in psychological decision models and explores the antecedent factors that contribute to form the attitudes (Karatasou et al., 2014). This realm of decision-making suggests that if knowledge is insufficient or attitudes to the subject matter are unfavourable, policies and programs may be ineffective (Stern, 1992). For example, the theory of reasoned action (TRA) finds that the immediate antecedent of any behaviour is the intention to perform the behaviour in question. The stronger a person's intention, the more the person is expected to try and, hence, the greater the likelihood that the behaviour will actually be performed (Azjen & Madden, 1985). The TRA specifies independent determinants of intention: one being attitude toward the behaviour and refers to the degree to which a person has a favourable or unfavourable evaluation of the behaviour in question; and the second predictor being the subjective norm, a social factor; it refers to the perceived social pressure to perform the behaviour (Azjen & Madden, 1985).

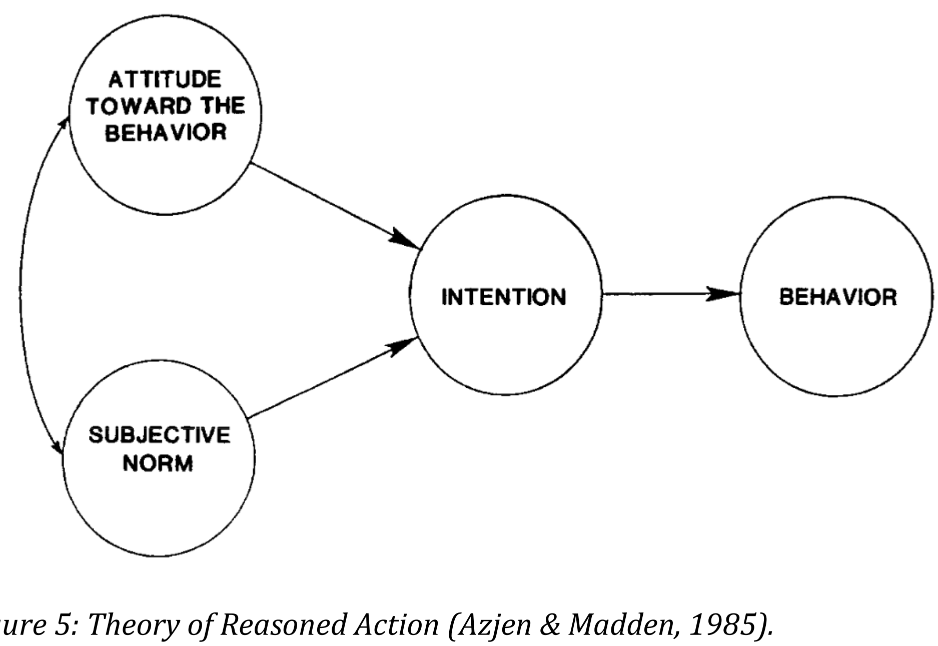

Figure 5: Theory of Reasoned Action (Azjen & Madden, 1985).

The ‘theory of planned behaviour’ (TPB) was developed as an extension of the TRA that accounts for the concept of behavioural control. It is argued that it is possible to measure perceived behavioural control, which is the person’s belief as to how easy or difficult the performance of the behaviour is likely to be (Azjen & Madden, 1985). Similar to the TRA, attitude toward the behaviour, subjective norm and perceived behavioural control are treated as partly independent determinants of behaviour.

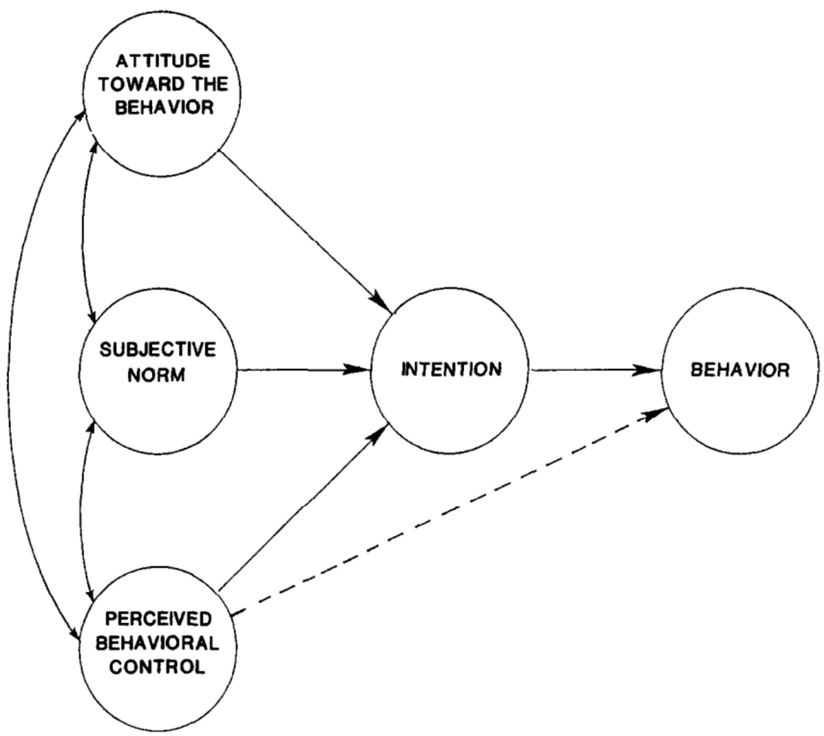

Figure 6: Theory of Planned Behaviour (Azjen & Madden, 1985)

Psychological models, such as the TRA and TPB, have limitations to predicting and changing behaviour. For one, a person’s attitude and intention does not always lead to action, “the theory’s boundary conditions remain unresolved, for the most part these conditions have to do with the transition from verbal responses to actual behaviour” (Azjen & Madden, 1985). For example, a person may have a positive attitude and intention to pursue pro-environmental behaviours toward climate change, but it may not directly result in the execution of the behaviour. Single policy tools have been notably ineffective in reducing household energy consumption, such as mass media appeals and informational programs that are aimed to change attitudes and increase knowledge, but they normally fail to change behaviour (Dietz et al., 2009). This phenomenon is referred to as the attitude-action gap. Hence, other factors in addition to attitude and intent must be considered for the design of policies and programs.

3.1.2.1 Cognitive Psychology

Findings from cognitive psychology go beyond attitude as a behavioural determinant and look into elements of human psyche that influence behaviour. These findings are particularly relevant to understanding behavioural changes of individuals and would be extremely useful for energy conservation policy and program design. Research has demonstrated that ordinary people in ordinary situations rely on a range of entirely irrational methods of dealing with cognitive demands of choice (Pierce et al., 2010). Frederiks et al. (2015) reviewed critical insights from behavioural economics and psychology, to illuminate the key cognitive biases and motivational factors that may explain energy-related behaviours to help design more cost-effective and mass-scalable behavioural solutions. The cognitive tendencies that have been identified by Frederiks et al. (2015) that have the potential to impact conservation choices are summarized in Table 3. A key observation is that people are more likely to act on a behaviour that requires the least amount of effort (satisficing), is familiar to them and is trust-worthy, has the least amount of loss or risk associated with the action (loss and risk aversion) and is socially rewarding (social norms). In parallel, social-psychological phenomena such as normative social influence, intrinsic and extrinsic rewards and trust also play a key role (Frederiks et al., 2015). Social norms are an important facet to human behaviour, as social comparisons and evaluation of one's past performance makes energy saving practices more desirable. This will be described further in the subsequent section of this chapter.

Cognitive psychology explains why rational approaches fail to change behaviour, as they do not make the desired actions any easier (Dietz et al., 2009). According to the economic rational model consumers have stable preferences and the acceptance or rejection of energy efficiency or conservation reflects a rational evaluation of the relevant costs and benefits (Sanstad & Howarth, 1998). This model fails to characterize heterogeneous preferences in human decision-making, which is revealed by behavioural inconsistencies such as framing, time inconsistency (Karatasou et al., 2014) and other behavioural tendencies identified in Table 3. Framing refers to the format in which information and communications are delivered, which has a drastic effect on behaviour. Cognitive psychology finds that information that is simple, vivid and emotionally charged is more likely to reduce barriers to behaviour change. Unnecessary complexity and overload should be avoided by framing messages in a clear, concise and comprehensible format. Ontario's approach of using information as a tool to create conservation behaviours would benefit from these cognitive insights, as they are more likely to resonate with consumers.

Table 3: Cognitive tendencies that impact conservation behaviour. Adapted from Frederiks et al. (2015).

Cognitive tendency	Description	Example	Lessons for Policies/Interventions
Status Quo	Stick to default settings or defer decision-making entirely, especially as the amount or complexity of information increases.	People tend to resist change and maintain pre-set options, even where alternatives may yield better.	Directly targeting energy-related practices that can easily and effortlessly be modified using default settings—for example, encourage house- holders to perform one-off actions such as setting a dishwasher or washing machine's default program to 'short-cycle' and/or to 'cold' water
Satisficing	Exerting only the effort needed to achieve a satisfactory rather than an optimal result, which facilitates more rapid, less effortful information processing, problem-solving and decision-making.	People typically process only enough information to reach a satisfactory decision rather than processing all available information to reach an optimal decision, as the latter demands much more time, effort and resources	Simplification strategies to reduce cognitive overload and facilitate more effective decision-making are to make a desired action easier, quicker and more convenient (e.g., automating relevant technology), minimizing the physical and psychological demands needed to perform the action (e.g., making it the default) and reducing perceived uncertainty
Loss Aversion	Weighing losses more heavily than equal-sized gains	People typically focus on the risks, costs or losses associated with adopting a new behaviour, such as financial costs, social costs, and ecological costs	Frame energy-saving messages in terms of avoiding or minimizing prospective costs and losses, as this may make the information more salient, memorable and motivating
Risk Aversion	People prefer to avoid risk given the prospect of positive outcomes (i.e. gains), but the reverse is true given the prospect of negative outcomes (i.e. losses).	People are more willing to take a change to avoid a certain loss than to secure an equal-sized gain	Focus on the low-risk of energy-saving practices and investments that are safe, stable and secure
Temporal or Spatial Discounting	People perceive things as less valuable or significant if further away in time or space, even if such things afford long-term benefits.	Preferring smaller immediate rewards over larger future rewards.	Draw attention to the longer-term payoffs of energy conservation when framing customer-focused messages.

Social Norms	Make social comparisons, following the behaviour of others, that is, the explicit and implicit 'rules', guidelines or behavioural expectations within a group or society that shape what is deemed normal or desirable.	People tend to make social comparisons and evaluate their own performance, possessions, and wellbeing, not in absolute terms, but relative to others.	Frame energy- saving practices as both common and socially desirable. For example, advising consumers that neighbours are using less energy or taking certain energy-saving actions, in addition to conveying social approval of such actions, will likely motivate them to reduce their consumption.
Rewards or incentives	People are motivated by rewards and incentives. However, the effects of financial incentives are often short-lived and/or inconsistent, resulting in behaviour reverting back to baseline levels upon the removal of the reward.	Intrinsic rewards: acting altruistically; Extrinsic rewards: monetary	Non- pecuniary rewards such as praise, recognition and social approval should be capitalized on to incentivize energy conservation.
Free-riding	Reduce effort, withhold resources, or contribute less to the common good if the same benefits can be gained without contributing.	People tend to exert less effort to achieve a goal when working in a group than when working independently.	Creating a shared group identity where people can feel their individual contribution is important, and emphasizing that many other consumers are also actively saving energy (i.e., capitalizing on descriptive social norms)
Trust	People use trust as a simple decision-making heuristic when assessing risk. An entity's trustworthiness is rested on apparent expertise and experience, perceived openness, honesty, and concern for others.	If the source of the message seems untrustworthy, unfair or incompetent, people can be sceptical and either disengage or react defensively to the information	Information and incentives are likely to be more motivating, and therefore have greater behavioural impact, if they stem from credible, trustworthy sources.
Availability Bias	People draw on readily available information that is easily accessible in memory.	Personal anecdotes of family/friends, customer testimonials.	Consumer-focused messages should incorporate examples of energy-saving actions that are easily available in consumers' memories (e.g., recent, frequent, concrete, personally relevant) and especially salient (e.g., vivid, emotionally charged).

3.1.3 Sociology: Energy as a Social Construct

Sociological decision models shift the emphasis from energy using behaviour to the role of and demand for energy services. Sociological researchers contest individualist models of predicting human behaviour and argue that individual decisions are instead constructed or determined by social and technological systems (Wilson & Dowlatabadi, 2007). Needs, attitudes and expectations are not individual in nature but are part of a complex relationship between social norms and relations, technologies, infrastructures and institutions (Summerton, 1992). The demand for energy is considered to be indirect in sociology studies, as it is created by services such as comfort and cleanliness, which in turn, are provided by devices (i.e. light fixtures, washing machines) and by infrastructures (transmission grids) (Shove, 2003). Therefore, demand is not a consequence of individual decisions or a belief manifest over short time frames but is something that is systematically configured over the long term (Van Vliet, 2005).

Sociological theories of energy behaviour reject theories of rational behaviour, as they believe that energy behaviours are habitual, based on routines and decisions are made unconsciously due to energy being fabricated into one's lifestyle and society. This theory is supported with qualitative and quantitative studies of households and how they interact with energy. Pierce et al. (2010) suggests that energy consumption behaviour is not the result of conscious and motivated action. Rather, everyday consumption behaviours appear to be strongly shaped and enforced by micro-level systems (i.e. thermostat interface) and macro-level systems (i.e. HVAC standards and infrastructure) (Pierce et al., 2010). This conclusion was drawn from common findings in qualitative interviews where participants acknowledged the routine use in their domestic behaviour, a particular example is the unchanged hot temperature settings on washing machines. Study participants indicated that they do not lower their temperature settings because they have never done it before, so habitually they use more hot water.

Shove (2010) critiques psychological views on behaviour, which views citizens as consumers and decision makers, positioning governments and other institutions as enablers whose role is to induce people to make pro-environmental decisions for themselves and deter them from opting for other, less desired, courses of action. Shove (2003) engages with the issue of establishing sustainable lifestyles and the barriers to decreasing domestic energy demand through the domains of 'comfort, cleanliness and convenience'. The ability for humans to adjust virtually any indoor space to a desired or comfortable temperature changed the definition of comfort, expanded the market for air conditioning and created expectations set by institutional structures as well. Engineers have noted that it is hard to meet the standard and narrow definition of thermal comfort without mechanical systems (Shove, 2003). These standards have changed expectations of comfort regardless of the season, where by default householders will first alter indoor temperatures before performing conservation behaviour such as putting on an extra layer of clothing (Shove, 2003). Shove's definition of comfort and expectations, provides an example of the relationship between technology and society, that takes a socio-technical view of energy consumption and behaviour.

3.1.4 Social-Psychological Models

Social-psychologists consider contextual factors in addition to psychological determinants of behaviour change. In contrast to attitude-driven psychological models, evidence from social-psychology suggests that not only are some behaviours not the result of attitude or intention, but that people sometimes incorrectly infer attitude and intention in order to explain their own behaviour (Pierce et al., 2010). This importantly suggests that behaviours can be changed without necessarily first altering attitudes. This is particularly relevant to attitudes toward energy conservation, as cutting direct energy use is often perceived as a sacrifice, whereas adopting a new technology is perceived as an improvement in quality of life (Stern, 1992). Under social-psychological views of behaviour, a negative or neutral attitude towards the environment or climate change may not need to be altered to achieve the result of a pro-environmental behaviour change. Instead, through in-home interviews, Pierce et al. (2010) fieldwork uncovered that descriptive social norms, which refers to perceptions of not what others approve but of what others actually do, greatly influences behaviour. Cialdini, who is often referred to as one of the founding theorists of social norms, conducted several experiments demonstrating that people frequently ignore or severely underestimate the extent to which their actions in a situation are determined by the similar actions of others (Cialdini, 2007).

The 'energy-saving behaviour model' that addresses the determinants of energy conservation behaviours focuses on context, demographic and interpersonal factors and housing characteristics as behavioural influences (Han et al., 2013). Although people often seem to be aware of environmental and energy problems, they often do not act in line with their concerns because they rarely make a conscious decision to use energy (Stern and Aronson, 1984). This can be ascribed to users failing to make the connection between behaviour and energy use, and are impacted by contextual factors such as government policy, programs, demographics, income, etc.

The energy saving behaviour model, pictured below, demonstrates how individual psychological determinants and context-specific determinants are fed into energy saving behaviour. This model shows how external sociological factors influence internal psychological motives. The energy saving model produced by Han et al. (2013) was constructed based on the results of a study that asked households a series of questions including what mechanisms they would need to help them conserve energy.

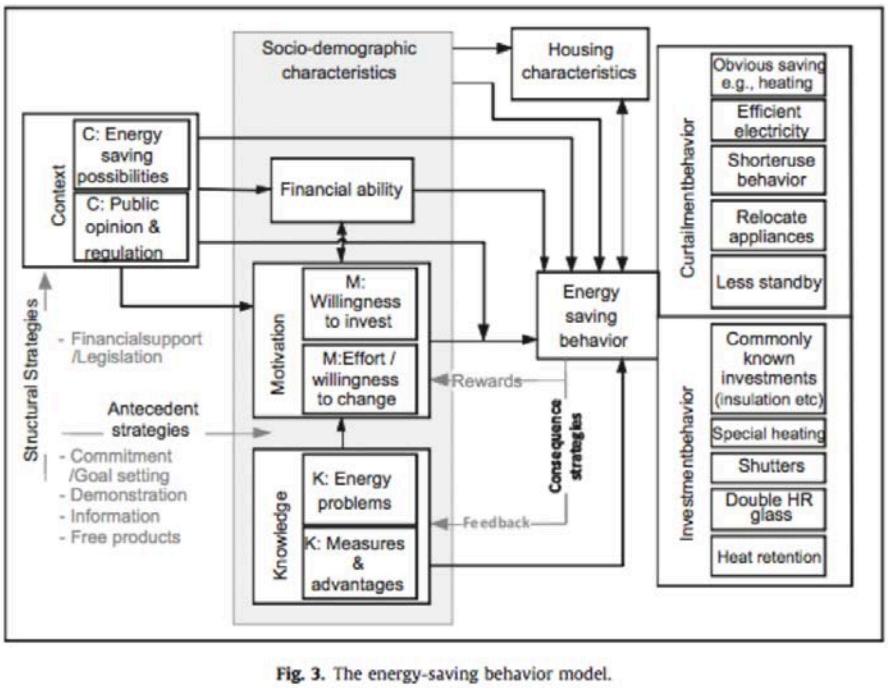

Figure 7: The energy-saving behaviour model (Han et al., 2013).

To conserve energy, home occupants must know how behaviour and energy use interrelate and must be motivated to conserve (Wilson & Dowlatabadi, 2007). Social psychologists emphasized the importance of information as feedback. For example vivid and targeted, personalized, or otherwise tailored information are the most effective approaches to display information that will resonate with a person. This social-psychological approach will be of particular focus throughout this major research paper.

3.1.4.1 Pro-Environmental Behaviours

Stern et al. (2000), value-belief-norm (VBN) theory was developed to explicitly explain pro-environmental behaviour. The values that people hold are indicative of how they see themselves in relation to the environment (Abrahamse & Steg, 2011). Thus, people with a stronger concern for the environment will be more aware of the environmental impact associated with their behaviour and actions. Feelings of moral obligation are assumed to be positively related to willingness to act pro-environmentally (Abrahamse & Steg, 2011).

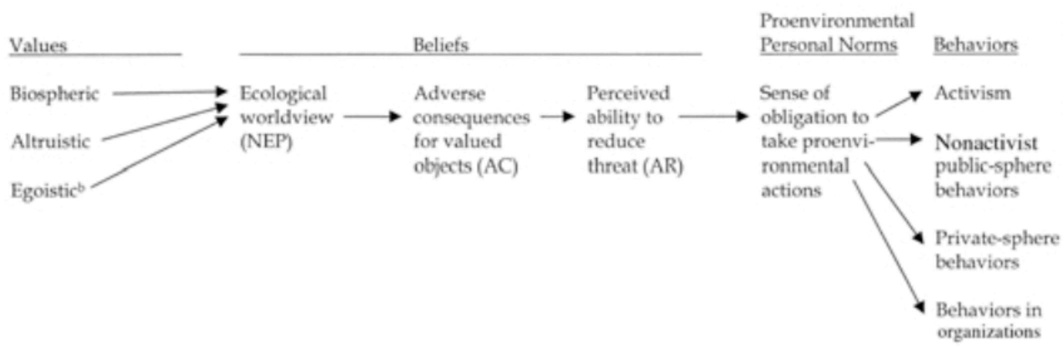

Fig. 1. A schematic representation of variables in the VBN theory of environmentalism[a]
[a]Arrows represent postulated direct effects. Direct effects may also be observed on variables more than one level downstream from a causal variable.
[b]Empirically, measures of egoistic values have been negatively correlated with indicators of environmentalism.

Figure 8: Value-Belief-Norm Theory (Stern, 2000).

In addition, behaviour-specific personal norms and other social-psychological factors (e.g., perceived personal costs and benefits of action, beliefs about the efficacy of particular actions) may affect particular pro-environmental behaviors (Stern, 2000). A study by Abrahamse and Steg (2011) evaluated the effectiveness of the VBN theory, and found that it is important to enhance households' perceived possibilities to conserve energy and to emphasize that households will not experience discomfort or a loss by conserving energy.

3.2 Chapter in Review

Understanding how individuals make decisions is important for policy makers and intervention designers concerned with the impact of human behaviour on energy use and the environment (Wilson & Dowlatabadi, 2007). The range of behaviour models that have been discussed stem from different academic disciplines such as economics, psychology, sociology and social and environmental psychology. Economists typically apply a rational decision model as a fundamental axiom of human behaviour. Psychologists, in contrast, argue that consumers' decisions deviate from the ideals of preference maximization (Sanstad & Howarth, 1998), and attitudes are main determinants of behaviour. Cognitive psychologists have identified mental barriers to behaviour change that are characterized into common tendencies of human behaviour. Sociological theories of energy behaviour also reject theories of rational behaviour, as they believe that energy behaviours are habitual, based on routines and some decisions are made unconsciously that have been fabricated into one's lifestyle and society (Shove, 2010). Social and environmental psychology decision models involve the interaction between human cognitive factors and social contexts.

Energy behaviours are undoubtedly complex, and are shaped by many factors at both an individual and societal level. Current energy conservation policies and programs in Ontario follow the rational economic approach to influencing behaviour, an approach where several behavioural gaps have been identified through the social sciences and offers an explanation as to why these policies and programs are falling short on meeting their long-term targets. To design effective public policy, the social, cognitive and personal forces, in addition to the economic realities must be understood (Yates & Aronson, 1983).

4.0 CHANGING BEHAVIOUR THROUGH BEHAVIOURAL INTERVENTIONS

This chapter will review the behavioural tools that can be used in energy conservation programs, alternatively to the traditional rational economic tools that are currently used by the Ontario government. Behaviour change theories support the use of behavioural interventions that have been designed under the principles of cognitive psychology findings. This chapter will provide an overview of behavioural interventions, but will have particular focus on a specific intervention called feedback. Behaviour change interventions can be defined as coordinated sets of activities designed to change specified behaviour patterns (Michie et al., 2011). Behavioural interventions may be aimed at voluntary behaviour change, by targeting an individual's perceptions, preferences and abilities (Abrahamse et al., 2005). Interventions within the realm of social and environmental psychology predominantly focus on voluntary behaviour change, rather than changing contextual factors, which may also determine households' behavioural decisions (Abrahamse et al., 2005). As indicated previously, understanding human behaviour can inform and enhance behavioural interventions and their effectiveness in stimulating energy conservation. Considering findings from cognitive psychology such as simplification strategies, normative influences, and framing communication can better direct the design of interventions and behaviour change programs.

Household energy interventions have been structured under two categories: antecedent interventions and consequence interventions. The antecedent interventions that will be discussed in this chapter are: commitments, goal setting, and information; and the consequence interventions that will be discussed are: feedback and rewards. Figure 9 below shows the different types and subtypes of interventions that were identified in a literature review by Han et al. (2013).

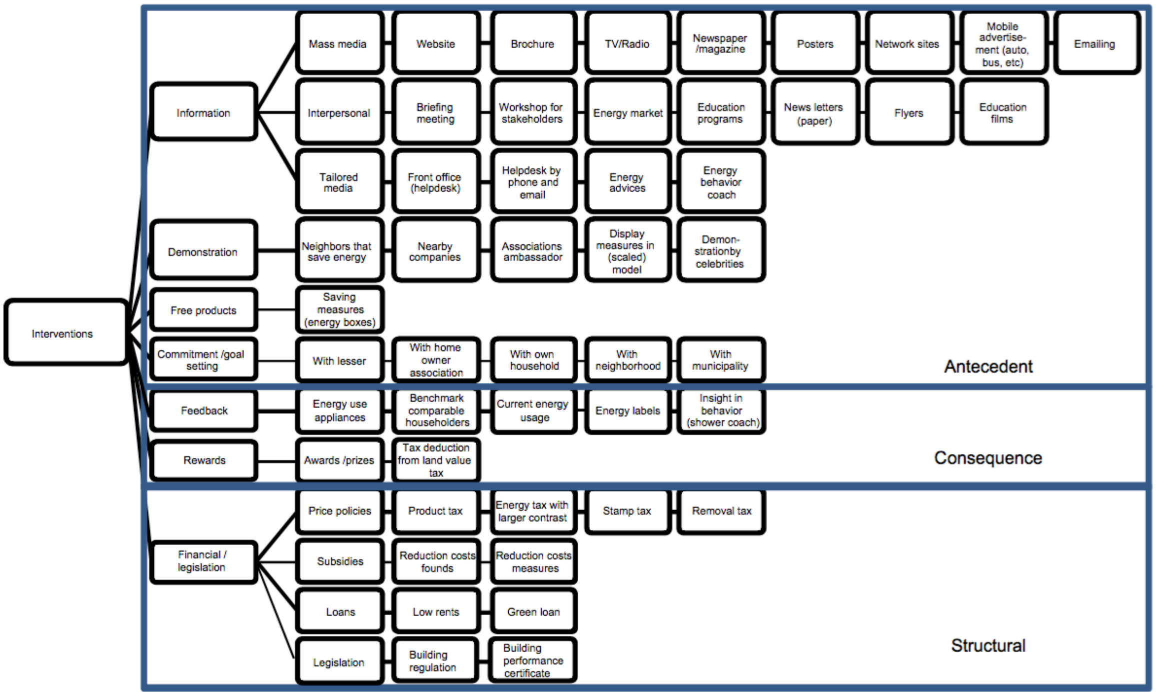

Figure 9: Tree structure of all possible interventions. (Han et al., 2013).

Figure 9 groups interventions into three main types: antecedent, consequence and structural. Structural interventions will not be discussed, as this paper focuses on non-price based behaviour programs.

4.1 Types of Interventions

Antecedent interventions are assumed to influence one or more determinants prior to the performance of environmentally significant behaviours (Abrahamse et al., 2005). That is, interventions (i.e. information) are aimed at influencing underlying behavioural determinants (i.e. knowledge), which in turn are believed to influence behaviour (Abrahamse et al., 2005). Antecedent interventions thus attempt to focus, motivate, educate, facilitate or constrain the individual towards making a desired behavioural action (Wilson et al., 2013). Alternatively, consequence strategies are based on the assumption that the presence of positive or negative consequences will influence behaviour (Abrahamse et al., 2005). Consequence and antecedent interventions can be coupled or paired together to enhance its effectiveness to modify behaviour.

4.1.2 Antecedent Interventions

Commitment and goal-setting are antecedent interventions that cognitively influence behaviour through social norms and intrinsic rewards. A commitment is an oral or written pledge or promise to change behaviour, such as committing to conserve energy by a targeted amount. The commitment can activate a personal norm by pledging to oneself, or the commitment can activate a social norm by being made public (Abrahamse et al., 2005). The Ontario Power Authority (OPA) utilized a commitment strategy through the 'Power Pledge' campaign, which captured the participation of over 133,000 Ontario residents who made a commitment to save energy. Many of the results of the OPA's (2010) Power Pledge campaign were commitments to make an effort to conserve energy, purchase energy efficient items, and to take action to reduce consumption. However, it is unknown if Power Pledge participants followed through with their commitment and actually implemented what they said they were going to do. Goal-setting interventions may provide more binding behaviours and avoid the intention-action gap. Goal-setting entails giving households a reference point, for instance to save 5% or 15% energy (Abrahamse et al., 2005). Harding and Hsiaw (2014) analysed the Citizens Utility Board (CUB) of Illinois' program for residential users that offered three savings plans to users: 5%, 10% and 15% annual electricity savings labeled as "No Cost," "Low Cost" and "Home Investment" plans, reflecting the extent to which a household may need to make further purchases (i.e. energy efficient appliances) to save energy. The CUB program is coupled with three other behavioural interventions: monthly feedback, information and a points-reward system. When evaluating the effectiveness of the goal-setting CUB program, it was found that consumers that selected realistic goals achieved the most substantial savings of 11% on average, where in contrast consumers choosing no goals saved about 1.5% and those that chose over-optimistic goals saved only 1% (Harding & Hsiaw, 2014). Setting realistic goals is does not cause a cognitive overload, compared to over-optimistic goals. Lessons from chapter three also indicate that satisficing influences motivation to conserve energy, as people are more likely to act on a behaviour that requires the least amount of effort and is socially rewarding.

4.1.2.1 Information

Information is another form of an antecedent intervention, as it is delivered to provide information about energy-related problems or specific solutions such as energy-saving measures that households can adopt (Abrahamse et al., 2005). Providing information about energy conservation serves to expand a user's knowledge and awareness of different ways in which they can reduce their energy consumption. The way in which information is delivered crucially impacts it's ability to be effective. For example, information that is provided in an overbearing, impersonal, incomprehensive or unattractive manner will not stimulate interest or expand human knowledge. Social psychologists suggest that the way users interact with information sources, their trust in the sources and confirming or conflicting information that comes from their peers also impacts its effectiveness (Stern, 1992). The rational economic theory views information linearly, in the sense that information generates knowledge, knowledge shapes attitudes and attitudes lead to behaviour (Karatasou et al., 2014). However, as previously discovered in chapter three, the relationship between attitudes and behaviour is not direct. It has been found that information alone tends to result in higher knowledge levels, but not necessarily in changes of behaviour or reduced energy consumption (Nilsson et al., 2014). Instead, information in combination with commitment and goal-setting have been found to produce environmentally responsible behaviour (Nilsson et al., 2014).

Abrahamse et al. (2005) identified various formats of the ways in which public policy and programs can convey information about energy conservation to households, including: workshops, mass media campaigns and tailored information through home energy audits. An analysis of the effectiveness of energy conservation workshops held for the general public indicated that in comparison of the workshop attendees and non-attendees, very few differences were observed in the adoption of energy-saving measures (Geller, 1981). However, the workshops did raise individual levels of concern for the then energy crisis and increased optimism that individuals can effect substantial reductions in energy consumption (Geller, 1981). Mass media campaigns typically generate similar results, in that they raise awareness and may have a positive influence on attitudes about energy, but are also critiqued to experience the attitude-action gap.

Tailored information is highly personalized and specific information, which advantageously provides participants with relevant information only, rather than receiving an overload of general information that may not apply to their household (Abrahamse et al., 2005). Tailored information in the realm of household energy use typically appears through home energy audits. A home energy audit assesses how much energy a home consumes and evaluates the measures that can be taken to make the home more energy efficient (Department of Energy, n.d.). The energy-saving measures that home energy audits produce involve efficiency purchasing and behavioural curtailment measures. Gonzales et al. (1988) conducted a study on the Residential Conservation Service Home Audit Program, which was designed to encourage homeowners to make capital investments to conserve energy and was largely unsuccessful, as only a small portion of homeowners requested audits. Gonzales et al. (1988) conducted a quasi-experiment to determine if training auditors to use social-psychological principles, such as vivid information, during the audits could improve the program. The results of the auditor training to use social-psychological cues when conducting an energy audit were that households in the trained-auditor group reported a significantly greater likelihood of making the recommended changes than households in the control group. However, no difference in actual energy use was found.

4.1.3 Consequence Interventions

Feedback and rewards are consequence interventions that influence behaviour through the immediate reward or consequence of behaviour. Rewards can be intrinsic (acting altruistically) or extrinsic (financial) and are used to motivate people to behave in a specific way. The effects of incentives are criticised for being short-lived and/or inconsistent, resulting in behaviour reverting back to baseline levels upon the removal of reward (Frederiks et al., 2015).

Feedback consists of giving information about energy consumption or energy savings. Feedback can influence behaviour because households can associate certain outcomes, such as energy savings, with their behaviour (Abrahamse et al., 2005). Typical feedback systems take one of two forms: direct feedback is provided in real time (or near real time) at the point of use, while indirect feedback is provided after consumption occurs. A distinction is made between continuous feedback, in most cases using a monitor or display showing the current consumption; and daily, weekly or monthly feedback, where participants are given information via the mail or the internet (Nilsson, et al., 2014).

Indirect feedback refers to information that has been processed (typically by the utility company) before reaching the end user (AEEA, 2014). Standard bills are a traditional source of feedback to households and are provided on a monthly basis. An example of the integration of the social-psychological concept of descriptive social norms in indirect feedback is most commonly presented through OPower. OPower partnered with utilities in the United States to send home energy use reports to residential electricity and natural gas consumers. The home energy reports consists of social comparisons, as it compares a household's recent energy use to that of their neighbours with similar home characteristics. The social comparisons are based on research (Cialdini et al., 2004) that showed that descriptive social norms are better at reducing energy use than appeals to saving the environment and to social responsibility, despite the fact that many households claim that social norms have little influence on their behaviour (Allcott & Mullainathan, 2010). The OPower programs are perhaps the most widely-implemented example of a behavioural non-price approach (Allcott & Rogers, 2014).

Direct feedback systems, also called real-time or near-real-time feedback systems, provide energy information to consumers directly, typically from a meter or through a separate display monitor or software application (AEEA, 2014). These systems have the ability to show instantaneous electricity consumption along with the cost per hour at a pre-programmed rate (AEEA, 2014). "Real-time plus" systems also typically disaggregate consumption information by end use, which can offer additional benefits to utilities by providing them with highly granulated data sets to inform better targeted efficiency recommendations (AEEA, 2014). Disaggregated information also aids consumers in identifying which appliances are consuming the most power in their house, providing guidance for energy-saving behaviours (AEEA, 2014). Studies on direct feedback show that there is considerable untapped potential for learning and for fuel conservation from direct display panels or smart meters, more accessible and informative than standard domestic meter (Darby, 2006). Giving people clear feedback on their consumption and improving the visibility and comprehensibility of energy supply and consumption is an effective strategy to change their behaviour. The impact that direct feedback has on energy conservation behaviour will be of focus in the subsequent chapter and is recommended as one of the main behavioural policy tools that should be implemented in the residential sector.

4.2 CASE STUDY: CHANGING BEHAVIOUR THROUGH FEEDBACK

This section will focus on direct feedback and will determine its effectiveness based on findings from meta-analyses from studies that conducted research trials in households. The study of feedback and its impact on residential energy consumption is dated back to the 1970s through hypothesis testing and experimentation. The research produced during this decade, was intrinsically motivated due to the energy crisis, to study energy conservation techniques particularly in the residential sector. Feedback research has been largely grouped into two eras, the 'Energy Crisis Era' and the 'Climate Change Era'. Early feedback researchers were motivated by the concept of energy invisibility, "appliances run, the air conditioning cycles, hot water is used, the furnace runs and the homeowner has no way of determining what amounts of energy are being used by these devices" (Seligman & Darley, 1976). Principle feedback studies realized that feedback had measurable effects, the consistency and frequency of feedback deliberately impacted the success of the intervention and feedback can be implemented in combination with other interventions (Seligman & Darley, 1976, McClelland & Cook, 1979; Becker, 1978).

This section will describe the way in which energy is 'invisible' to households, provide an overview of feedback and describe the main findings from early studies, evaluate the effectiveness of feedback from many factors including energy savings, modes, design, motivation, combination with other interventions, changes to behaviour. This section will then look at the characteristics of feedback participants, behavioural insights in policy that impact feedback programs and study limitations.

4.2.1 Problem Statement: Energy Invisibility

Energy use in households is often described amongst social-psychology researchers as 'invisible'. It is ascribed that energy is invisible in two main ways, first that electricity in particular is an invisible and abstract force entering the household via often hidden wires, and second, that most energy consuming behaviours are part of inconspicuous routines and habits making it difficult for people to connect specific behaviours to the energy that they consume (Burgess & Nye, 2008). Most people have only a vague idea of how much energy they are using for different purposes and what sort of difference they could make by changing day-to-day behaviour or investing in efficiency measures (Darby, 2006). Households currently have no means to judge energy use other than their monthly utility bill. Unfortunately this does not readily provide insight as to how or where the energy is being used. Energy bills are ineffective in reducing or altering household energy behaviour, as they do not convey information in an effective way that resonates with users, does not occur frequently enough to induce change and does not provide a detailed breakdown of energy consumption for users to understand where to direct conservation behaviours. A standard utility bill in Ontario typically provides the balance of the bill owed, the meter reading dates, metered usage in kilowatt-hours and electricity use charges per time of use (on peak, off-peak and mid-peak). As previously mentioned in chapter two of this major research paper, energy literacy in Ontario is low, thus residents may not associate much meaning with utility bills presented in kilowatt hours.

A study by Pierce et al. (2010) found in their survey data that although 80.5% of respondents personally paid their monthly bills, only 25.8% claimed to be "very sure" of roughly how much they paid each month and 24.1% "had no idea" or were "just guessing". The survey results also revealed that 83.8% of participants had no idea how much one kWh of electricity costs, and were even more uncertain of the amount of energy consumed by individual appliances (Pierce et al., 2010). A grocery store without prices on individual items, where shoppers are only presented with one total bill at the cash register, is a metaphor used by Kempton and Montgomery (1982) to describe the invisibility of household energy use. In many ways this example provides parallels to energy use, as users are mostly unaware of the amount of energy being used per appliance and only receive a vague indication when they are presented with their monthly utility bill.

Many routine energy-related actions simply go unnoticed. The majority of everyday interactions appear to be performed without the conscious consideration of energy (Pierce et al., 2010). Shove (2003) describes energy invisibility through a sociological lens and describes that energy consuming behaviours are part of inconspicuous routines and habits which makes it difficult for people to connect specific behaviours to the energy that they consume. Studies that ask consumers to keep diary records of their routines (i.e. cleaning, washing, door opening, refrigerator use) report that people are surprised by the frequency of these actions and that the self-monitoring causes them to "catch themselves" in the act of using energy (Lutzenheiser, 1993). Kempton et al. (1985) revealed that household energy conservation actions also lack transparency, as people typically overestimate energy use for lights, a visible end use, and underestimate savings for water heating and other less visible ends.

Typically, energy use becomes visible to households when they are presented with some type of shock, either through an outage, energy shortage or expensive energy bills. According to a US consulting firm study completed in 2013, most consumers interact with their utility provider on an average of just nine minutes per year (Accenture, 2013). Figure 11 below shows that majority of people have limited or no interaction with their local utility company.

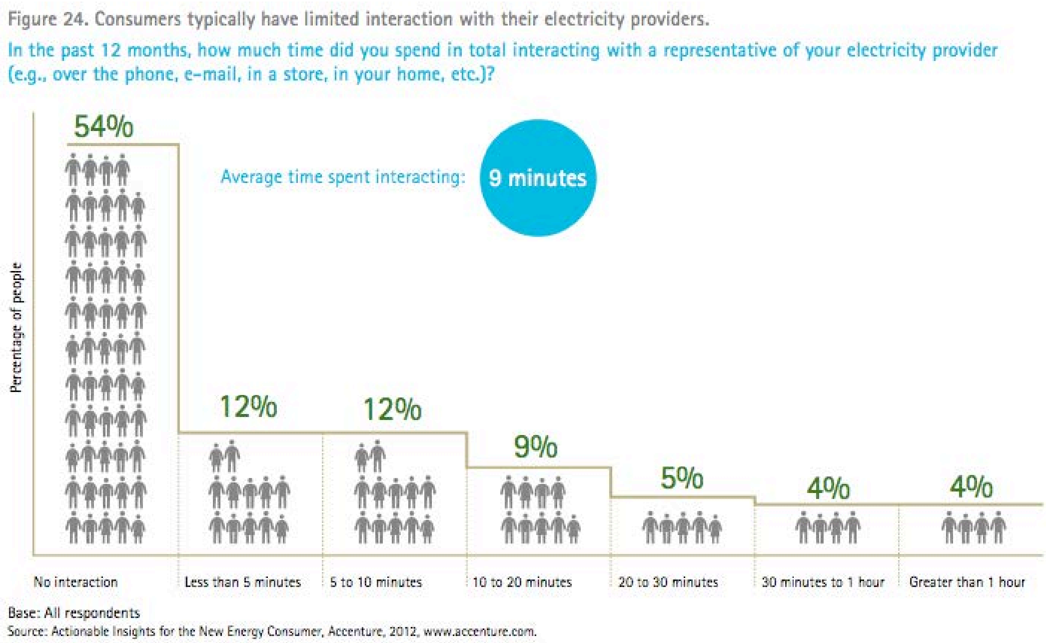

Figure 11: Consumers typically have limited interaction with their electricity providers. (Accenture, 2013).

The concept of energy invisibility contributes in a critical way to energy consumption, as users are unequipped and unable to effectively conserve or alter their energy use. A transparent energy monitoring system should mediate the relationship between daily activities and energy use in such a way that 'invisible' energy use becomes connected to a more considered frame of consciousness (Burgess & Nye, 2008). This can be accomplished through feedback, as it is considered an important dimension of behaviour change and has been used to influence behaviour in a wide variety of fields including education, public health and organizational behaviour (Karlin et al., 2015). Feedback in the energy domain has received an increasing amount of attention in recent years because of changes in sensing technology and energy infrastructure that allow for energy information to be collected, processed and sent back to consumers quickly, cheaply and often in real-time (Karlin et al., 2015).

4.2.2. Feedback Effectiveness

This section will describe feedback program effectiveness through energy savings, modes of feedback, design implications, motivation, combination with other interventions and behaviour changes. A large number of feedback studies have been undertaken, with most assigning households to various treatment and control groups, whose conservation behaviour and consumption are closely monitored (Lutzenheiser, 1994). Meta-analyses of feedback studies in regards to its effect on energy conservation have been completed by Karlin et al. (2015), Ehrhardt-Martinez et al. (2010), Fischer (2008) and Darby (2006). Cumulatively, these four meta-analyses have reviewed over one hundred and fifty feedback studies that span from Canada, the United States, Europe, Australia and Japan, over the past four decades. The findings from these meta-analyses will be reviewed to determine the effectiveness of feedback as they provide comprehensive results across a multitude of studies.

4.2.2.1 Household Energy Savings

Feedback, on average, have reduced individual household electricity consumption between 4% to 12% (Ehrhardt-Martinez et al., 2010), 1.1% to over 20% (Fischer, 2008), 5% to 15% for direct feedback (Darby, 2006) and Karlin et al. (2015) support average savings of 8% to 12%. Savings from feedback will always vary according to the technology under consideration; the social context under which the study takes place; and the quality of the study conducted will affect the recorded outcomes (Darby, 2006). Fischer's (2008) evaluation of feedback studies, found the types of feedback that were most effective across studies are designed to provide computerized feedback that display information per the user's choice (i.e. consumption over time, comparisons, environmental impact or energy-saving tips), designs that use an interactive element to engage households, detailed appliance-specific breakdowns and designs that give feedback very often (daily or more). Karlin et al. (2015) found similar results, in that studies with feedback that used the least engaging medium (a utility bill) reported the lowest average effect size, whereas studies with feedback that used the most engaging and interactive medium (computer) had the highest effect size. Ehrhardt- Martinez et al. (2010) found that past studies suggest that daily/weekly feedback and real-time plus feedback (plus meaning disaggregated data) tend to generate the highest savings per household. It is estimated that if feedback is broadly implemented throughout the United States using well-designed programs, the residential sector could provide the equivalent of 100 billion kilowatt-hours of electricity savings annually by 2030 (Ehrhardt-Martinez et al., 2010)

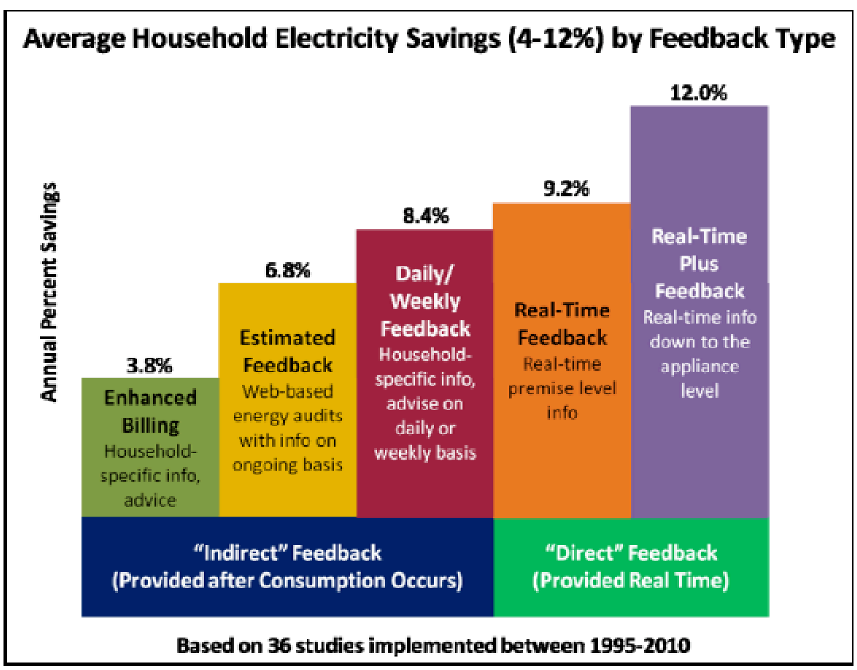

Figure 10: Average household electricity savings (4-12%) by feedback type. (Ehrdhardt-Martinez et al., 2010).

4.2.2.2 Feedback in combination with other interventions

Feedback-induced energy savings and overall rates of household participation are malleable and can be enhanced through the use of motivational elements such as the use of goal setting, commitments, competitions and social norms (Ehrhardt-Martinez, 2010). Karlin et al. (2015) found that the effect of combining feedback with goal and incentive interventions was significant and that they had higher effect sizes than studies that used feedback alone. Fischer (2008) also supports that feedback is more effective in combination with other instruments such as financial incentives, information, goal setting and personal commitments.

4.2.3 Impact of Feedback on Behaviour

In a social-psychological sense, feedback is more likely to be effective in changing behaviour, depending on the format in which feedback is provided and whether people understand the information, believe that they are capable of making a difference and are motivated to take action. Achieving maximum feedback-related savings will require an approach that combines useful technologies with well-designed programs that successfully inform, engage, empower and motivate people (Ehrhardt-Martinez et al., 2010). Positive environmental attitudes as well as interests in and understanding of feedback displays, appear to be important factors in motivating the households to use the monitors and engage in electricity saving behaviour (Nilsson et al., 2014).

A crucial way in which feedback induces human behaviour change is through the immediate reward or consequence of behaviour, which reinforces that the conservation efforts are either effective or ineffective. As derived in Han et al. (2013) energy-saving behaviour model that was previously discussed in chapter three, reward and consequence feed into motivation and knowledge, which leads to energy saving behaviours. People continue with behaviours that are rewarded, and these rewards are essential to ensuring the repetition of desirable behaviour (Nilsson et al., 2014). The behavioural reward in the household energy context would be a reduced amount of consumption leading to lower energy bills. This may allude as to why higher energy savings are typically realized with continuous direct feedback, compared to indirect non-continuous feedback. Fischer (2008) suggests that feedback is more effective, the more directly after an action that it is given. This is justified, as rapid feedback would improve the link between action and effect, and therefore, increase consciousness about the action's consequences (Fischer, 2008).

Many feedback studies have found through qualitative methods that feedback has affected participant's behaviour through increased levels of energy literacy, and improved attitudes towards conservation. Schwartz et al. (2013) conducted semi-structured interviews with participating households to understand what and how people learned through interaction with feedback displays. The impacts that were sustained from learning about their household energy consumption resulted in a change of routines (i.e. drying clothes manually rather than using the dryer), rearrangement of existing devices (i.e. using power strips to merge devices together for shut off), and choice of appliances (increased awareness led to influencing of future buying decisions).

Feedback devices can help householders to identify particularly wasteful appliances or behaviours and use them less or replace them and also cause spill-over effects to act pro-environmentally in other aspects of their lives (Hargreaves et al., 2013). Feedback supports intrinsic behaviour controls which causes individuals to develop new habits (Darby, 2006). Targeting the timing of persistence and habituation can play an important role in designing behavioural interventions (Allcott & Rogers, 2014). As previously discussed, the majority of everyday household interactions are performed without the conscious consideration of energy (Pierce et al., 2010).

4.2.4 Design Implications

4.2.4.1 Frequency

The frequency of how often feedback is recited back to users is associated with different levels of effectiveness. Feedback can be provided monthly, weekly, daily or in near real-time intervals. Fischer (2008) suggests that feedback is more effective, the more directly after an action that it is given. This is justified, as quick feedback would improve the link between action and effect, and therefore, increase consciousness about the action's consequences (Fischer 2008). As noted, less frequent feedback studies were found to be more effective for energy conservation in space heating, while instantaneous feedback is more effective to induce conservation behaviour for smaller end uses.

Karlin et al. (2015) note that there is some confusion associated with the term frequency in feedback studies. Feedback studies define frequency according to how often energy information is updated; however, from a theoretical standing, frequency refers to how often users receive the feedback (Karlin et al., 2015). Karlin et al. (2015) found that more frequent or continuous feedback may only be accessed occasionally, despite the higher frequency in which it is delivered. Specifically with direct feedback, the information either via computer, tablet or monitor must be 'pulled' (Karlin et al., 2015), by the user, which means that even though energy data may be updated continuously, users may not access that data as frequently as the data can be provided.

4.2.4.2 Language and Presentation of Information

The language and key performance indicators that are used to convey energy feedback information to households impacts the effectiveness of behaviour change. The meta-analyses often distinguish feedback studies by granularity between feedback studies delivered at the appliance or whole-home level. Appliance-specific or disaggregated data has its benefits as it enhances the household learning process. Disaggregated feedback may help with task-learning processes and is hypothesized to positively moderate the effects of energy feedback (Karlin et al., 2015). Ehrhardt-Martinez et al. (2010) categorizes appliance-specific or disaggregated energy use as real-time plus feedback, and found that disaggregated feedback generates the largest amount of savings compared to other feedback types. Fischer (2008) also classifies feedback designs that provide detailed, appliance specific breakdowns as more effective means of energy conservation. Tailored feedback is needed that is based on detailed documentation of the households' energy consumption and adapted to the household members needs that combines different types of information in order to develop relevant strategies for energy savings (Nilsson et al., 2014). This aligns with cognitive psychology findings presented in chapter three of this paper, that framing messages are more likely to resonate with consumers.

In terms of how information should be presented, Fischer (2008) found that households' reactions to graphical designs depend on the exact choice of diagram or chart type, labels, scale, symbols and wording of the explanation. Feedback devices should take into consideration cognitive psychology findings (discussed in chapter 3) that find information to be more effectively conveyed when it is vivid and personalized, simple, and uses images.

Figure 11: The Energy Detective versus Bidgely Homebeat feedback displays.

As displayed above, early studies of feedback utilized The Energy Detective in the experimentation of feedback displays on home energy consumption. Since this time, feedback displays have changed considerably to present vivid information, as pictured with Bidgely's Homebeat. The use of vivid data charts and tables is especially effective for feedback to display comparisons between historical household energy consumption, social comparisons, appliance comparisons and so forth. Schwartz et al. (2013) living lab feedback study suggests that feedback design should display horizontal and vertical comparisons to show the relationship and make connections between activities that involves the use of multiple appliances.

4.2.4.3 Content

The presence of a comparison (historic, goal based, or social) is hypothesized to positively moderate the effectiveness of feedback (Karlin et al., 2015). Energy consumption information is generally thought to be more meaningful when situated in either a historical or comparative context, providing consumers with information about how their current levels of consumption compare to either past consumption or to other households (Ehrnhardt-Martinez, 2010). Karlin et al. (2015) found that goal comparisons are considered to be the most effective and that social comparisons and historical comparisons did not impact behaviour as effectively.

This negates Darby (2006) finding that historic feedback is likely to be more popular than comparative feedback. Hargreaves et al. (2010) found that comparisons were more effective in relaying feedback information than any other unit of measurement (i.e. kWh or CO_2 emissions). Fischer (2008) finds that households prefer clear labeling and explanation of labels, acronyms and technical terms; clear indication of the various components of electricity prices; and information to be supported by graphic presentations which are also clearly labeled. Translating energy use into alternative units may also not be as effective if they correspond to very small amounts. Varying levels of households' energy literacy should be taken into account when designing the language of feedback devices (Schwartz et al., 2013). Hargreaves et al. (2010) found that there was little interest in absolute measures of consumption, and that people found fuel tank symbols on the monitors to be engaging.

4.2.5 Characteristics of feedback participants

Hargreaves et al. (2010) conducted a qualitative field study of how householders interact with feedback over a one year 'Visible Energy Trial' study. His findings suggest that feedback monitors were used differently by different members of households and that there appeared to be a single dominant user of the monitor. Interviews with participants of Hargreaves et al. (2010) study indicated that the placement and location of feedback monitors and the aesthetics of feedback monitors are crucial to the frequency of its use by members of the household.

In a broad sense, two of the meta-analyses reviewed suggest that high-energy users and single-family homes are the target market for direct energy feedback systems. Socio-demographic factors such as income, level of education and work status have been measured in feedback studies, but have not been directly attributed as a cause of energy consumption.

Currently, the main demographic of home energy management systems includes single-family homes with large energy use patterns that enable cost-effective automation, although multi-dwelling installations are also beginning to occur with some frequency (Ehrhardt-Martinez et al., 2010). Darby (2006) indicates that high-energy users may respond more than low energy users to direct feedback.

Age is an important factor in energy use, as comfort preferences and habits may impact thermostat settings, frequency and lengths of showers and the number of used appliances. The age of residents may also inform the strength of habits, since habitual behaviour is likely to be repeated when outcomes are satisfactory, and such habitual behaviours are commonly observable in the elderly (Han et al., 2013). Abrahamse and Steg (2009) also note that the household size and composition, as well as the number of people living in the same home impacts energy use due to the frequency of activities such as showering, dishwashing, clothes washing etc.

4.2.5.1 Barriers and motivations

This section will identify the factors that motivate and challenge households in using a feedback device. Nilsson et al. (2014) conducted a two-part study that analyzed the effects of visual feedback via in-home displays and the motives and barriers in using feedback displays. While this study did not find significant electricity savings from participants (which is believed to be due to the random selection of participants, as opposed to other studies where participants were initially motivated to participate in the study), this study indicates important barriers and motivations for reducing energy consumption. For people without an interest in saving energy, it can be difficult to understand the relationship between behaviour and consumption or behaviour, consumption and costs (Nilsson et al., 2014).

In a social-psychological sense, feedback is more likely to be effective in changing behaviour, depending on the way feedback is provided and whether people understand the information, believe that they are capable of making a difference and are motivated to take action. Achieving maximum feedback-related savings will require an approach that combines useful technologies with well-designed programs that successfully inform, engage, empower and motivate people (Ehrhardt-Martinez et al., 2010). Positive environmental attitudes as well as interests in and understanding of feedback displays, appear to be important factors in motivating the households to use the monitors and engage in electricity saving behaviour (Nilsson et al., 2014). Table 4 below describes Nilsson et al. (2014) findings of barriers and motivational factors to using a feedback device.

Table 4: Barriers and motivational factors of using a feedback device. (Nilsson et al., 2014).

Themes and sub-themes.

Theme	Sub-theme
Barriers	a Consuming low levels of energy b Habits c Difficulty in understanding the display d Difficulty in understanding the relationship between behaviour and consumption e Low awareness of how much energy can be used without extra charge
Motivational factors	a Curiosity and interest b Cost considerations c Altruistic/environmental concerns

Similarly, in Hargreaves et al. (2010) 'Visible Energy Trial', found that the reasons people gave for participating in the trial were critical in shaping what they expected from the monitors, how they used them and how they evaluated their effectiveness. Qualitative feedback studies have found that participants were motivated to reduce energy consumption due to economic and financial considerations, altruistic and environmental reasons, curiosity and interest in the use of feedback technology to learn more about their energy consumption

(Nilsson, 2013; Hargreaves et al., 2010). Without an implicit or explicit motivation to conserve, information provided to an energy user about how well they perform is useless and could potentially be counterproductive (Fischer, 2008).

4.2.6 Study Limitations

There are several notable research gaps associated with feedback studies. The first being, that many studies and project use rather small sample sizes, whereas studies should cover a representative sample of households (Fischer, 2008). Wood and Newborough (2003) analysis of feedback studies suggests that the Hawthorne effect could have played a large part in generating reductions in energy consumption. The Hawthorne effect is used to describe study participants that act differently than they normally would, due to their awareness of being observed. Vine et al. (2013) acknowledge several research gaps in regards to residential energy feedback studies, including the following effects of feedback on: consumers in different demographic groups; appliance purchasing decisions; duration of changed behaviour; and the divergence of cost-benefit calculations for feedback. Additionally, Pierce et al. (2010) note significant challenges and remaining inquiries and surprisingly, little is known about what specific behaviours do or do not result in the savings reported in feedback studies. Often, authors indicate the total percentage of energy saved during their study, but do not provide details of which household behaviours are responsible for the savings.

The duration and persistence of savings from behaviour-based programs are often in question. Persistent effects of feedback would be more likely if feedback is given over a longer time, to allow time for feedback to support intrinsic behavioural controls and allow for new habits to form (Fischer, 2008; Darby, 2006). Darby (2006) suggests that a new type of behaviour formed over a three-month period or longer seems likely to persist, but continued feedback is needed to help maintain the change and encourage other changes. As seen in Figure 12 below, Karlin et al. (2015) contests this rule of thumb, and finds that users heavily engage with feedback after an initial learning phase, and then interaction with the feedback device diminishes and energy conservation decreases.

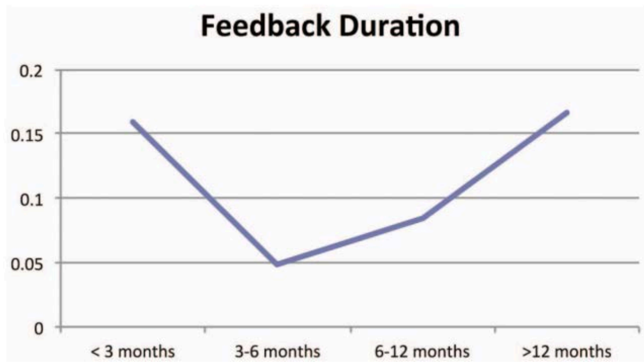

Figure 2. Feedback duration (*x*-axis) as moderator of feedback effectiveness (*y*-axis). See the online article for the color version of this figure.

Figure 12: Feedback duration (Karlin et al., 2015).

However, Karlin (2015) also notes that feedback provided for longer time periods may allow habits to be created and maintained, which may lead to a rebound in effect size. Hargreaves et al. (2013) conducted the first in-depth qualitative study to explore how householders use feedback monitor and how this usage changes over a 12-month period. In support of Karlin et al. (2015) feedback effect duration findings, Hargreaves et al. (2013) study found that after the initial burst of saving energy, the monitors appeared unable to motivate further steps to reduce consumption levels. It is suggested that more research focus on the duration of user interaction with feedback technologies over time.

While the studies that were reviewed in this section went into detail about how information should be displayed and the language that should be used in the design of a feedback device, an area for further research could be a study that investigates the impact of targeted messaging for different roles in the household. For example, an experimental study could investigate how targeted messages may impact the behaviours of a male and female differently. Ethnic, gender and cultural considerations in the design of a feedback tool would be of value to feedback research and for feedback designers to maximize the probability of pro-environmental behaviour change.

4.3 Chapter in Review

This chapter was presented in two parts, first, it reviewed the behavioural interventions that have been studied and evaluated in intervention literature aimed at household energy conservation. Secondly, it presented direct feedback as a case study to influencing household energy conservation. Understanding human behaviour can inform and enhance behavioural interventions and their effectiveness in stimulating energy conservation. The interventions discussed in this chapter have cognitive psychology elements incorporated into their design, which is not comprised in rational economic tools. A review of the antecedent and consequence interventions, examples and lessons learned are provided in Table 5 below.

Table 5: A review of behavioural interventions and key lessons learned

Intervention	Lesson
Commitment	• Successful for improving public attitudes toward conserving energy, however does not necessarily result in energy savings • Importance of social norms i.e. social pressure of others making a commitment
Goal Setting	• Small goals are not as effective, perceived not to be worth the effort • Realistic goals achieve the most savings • More powerful of an intervention when coupled with other behavioural interventions, such as feedback, information and rewards
Workshops	• Successfully raise awareness about energy issues and improve attitudes about energy conservation • Did not result in energy savings
Mass Media Campaigns	• Effective short-term policy tool • Context-dependent • Resulted in energy savings
Energy Audits	• Energy audits were more successful when coupled with tailored information • Households were more likely to implement recommended efficiency retrofits and upgrades when auditors undergone social-psychological training such as

	framing, vivid information and loss aversion
In-direct Feedback	• Behaviour change through tapping into social norms
Direct Feedback	• Context, scale, timing of use, synergies with other forms of information and timing influence the effectiveness of feedback • More likely to result in energy savings when combined with other behavioural interventions
Rewards	• Effective to change behaviour in the short-term, but do not have lasting savings • More successful when combined with other behavioural interventions

The concept of energy invisibility contributes in a critical way to energy consumption and leaves users unequipped and unable to effectively conserve or alter their energy use. Feedback provides people with information about their energy use and consumption habits that can be used to reinforce and/or modify future conservation actions. The meta-analyses have also indicated key considerations to amplify the effectiveness of feedback programs:

Table 6: Key considerations for the effectiveness of feedback programs

Feedback Modes	▪ Computerized feedback that displays information per the users choice (i.e. consumption over time, comparisons, environmental impact or energy savings tips)
Design	▪ Designs should use an interactive element to engage households
Display of information	▪ Detailed appliance-specific breakdowns ▪ Tailored feedback is needed that is based on detailed documentation of the households energy consumption and adapted to the households members needs ▪ Information is most effectively conveyed when it is vivid, personalized, simplistic and uses images. ▪ The use of vivid data charts and tables is especially effective for feedback to display comparisons between historical household energy consumption, social comparisons, appliance comparisons and so forth
Comparisons	▪ Energy consumption information is more meaningful when situated in either a historical or comparative context, providing consumers with information about how their current levels of consumption compare to past consumption or other households
Language	▪ Households prefer clear labelling and explanation of labels, acronyms and technical terms, clear indication of various components of electricity prices and information to be supported by graphic presentations which are also clearly labeled ▪ Varying levels of households energy literacy should be taken into account when designing the language of feedback devices

Frequency of messaging	▪ Real-time plus feedback generates the highest amount of savings
Persistence and duration of savings	▪ The persistence of savings from feedback is contested, as some studies indicate that feedback given over a longer time will allow for new habits to form, and others indicate that users engage with feedback after an initial learning phase, and then spend less and less time interacting with the device
Combination with other interventions	▪ Feedback is generally more effective when in combination with antecedent interventions such as goal setting, commitment and information.

5.0 DISCUSSION: OPPORTUNITIES FOR ONTARIO

The central idea behind behaviour change theory is that individuals do not always act rationally, as assumed in traditional economic models of human decision-making. Insights from the social sciences matter for energy conservation, as they explain why people may fail to conserve energy or adopt more efficient technologies. For example, the economic model does not consider the cognitive mechanisms that prevent humans from acting rationally. Behaviour change theories recognize that curtailment and efficiency behaviours involve human choices and cognitive decision-making process, in which the rational model ignores. Traditional economic and social science models are compared and contrasted as government policies and utility conservation programs in Ontario are largely modeled based on the rational economic model. Therefore, it is suggested that applying insights from the social sciences can largely enhance these programs and policies.

Behavioural insights that would be specifically applicable to enhancing energy policy and programs in Ontario are to make individuals more aware of their energy habits by making their household energy use 'visible' through feedback mechanisms. Feedback enhances the ability to provide targeted information, as human behaviour is not homogeneous. The format of information and communications has a drastic effect on behaviour, as information that is simple, vivid and emotionally charged is more likely to reduce cognitive tendencies that act as a barrier to behaviour change. Unnecessary complexity and overload should be avoided by framing messages in a clear, concise and comprehensible format. Social norms are an important facet to human behaviour, as social comparisons and evaluation of one's past performance makes energy saving practices more desirable. These psychological elements are addressed through providing direct feedback to households and result in reduced energy consumption and increased energy knowledge.

As identified in chapter three, behaviours are undoubtedly complex and impacted by several intrinsic and extrinsic factors. While behaviour change theories and models of decision making cannot predict with absolute certainty the way in which an individual will respond to a specific policy or program, they can better direct the design of programs and tools to increase the likelihood to influence behaviours such as energy conservation. The purpose of policy directives such as the LTEP or incentive programs such as SaveONenergy is to encourage individuals to behave in a manner that will result in energy savings. These policies and programs operate under the axiom that information and incentives will ultimately result in a changed behaviour. However, as described in the background section of this research paper, just over half of Ontario's LDCs met their energy reduction targets. This alludes to the fact that the rational approach is not effective for the majority of Ontario's population, and perhaps there is room for behaviour change programs to assist LDCs and the Ontario government in meeting it's energy conservation targets. The following sections will review the opportunities that the Ontario government has to integrate behaviour-based program into energy conservation policy and program design.

5.1 Policy and program opportunities

The Ministry of Energy is planning to release an updated LTEP in 2017. The LTEP update provides the opportunity for the Province to commit to other strategies such as behaviour-based programs, in addition to economic, technical driven approaches to conservation. The LTEP (2013) commits to the Green Button Initiative, to give consumers access to their energy data and the ability to connect to mobile and web-based applications to analyze and manage their energy use. Green Button enabled data provides a direct opportunity for the deployment of a feedback program in Ontario, as the 'download and connect my data' features allows utility customers to download their utility data and then share their data with web-based solution providers.

Figure 13: Ontario's Green Button Initiative. Ministry of Energy (2016).

The Green Button was initiated through a White House call to action in 2011 to develop a tool that will enable consumers access to their own energy usage data. Ontario's Green Button initiative launched in 2012 and is the first jurisdiction in Canada that has adopted the standard (Green Button, n.d.). Insofar, ten electricity utilities have implemented Green Button 'download my data (DMD)' and London Hydro has implemented pilots for DMD and 'connect my data (CMD)' (Green Button, n.d.). The LTEP (2013) commits to the Green Button Initiative, to provide consumers with the ability to connect to mobile and web-based applications to analyze and manage their energy use. Since 2013, the Green Button initiative is yet to make traction in Ontario's residential sector on a large-scale. Currently, only two utilities, London Hydro and Hydro One, allow electricity customers to participate in CMD, which allows customers to connect their utility data with Green Button apps.

Households are able to download their utility data through Ontario's smart grid. The smart grid is a modern power grid that supports bidirectional communication between energy providers and consumers for fine-grained metering, control and feedback (Aman et al., 2013). Smart meters connect households to the smart grid and allow for enhanced energy efficiency and manageability of resources. Hydro One, one of Ontario's largest utilities, has installed more than 1.3 million smart meters and has met the provincial government's target of having a smart meter in every home and small business by 2010 (Hydro One, n.d.). Cloud computing and mobile platforms have made it possible to perform large-scale analytics on sensor data and offer advanced real-time feedback to consumers (Aman et al., 2013). The LTEP update can push forward energy innovation by committing to near real-time energy data access for the residential sector, such as the Green Button initiative.

5.1.1 Behavioural working groups

There has been a growing policy interest to incorporate behavioural research into policy design. For example, behaviour-based working groups have been established in government that are dedicated to enhance the research and development of behaviour-based energy programs. In the United States, the State and Local Energy Efficiency Action Network (SEE Action) is a network of state, local leaders and experts facilitated by the US Department of Energy and the Environmental Protection Agency (EPA) that is composed of eight working groups to advance local efficiency policies and programs. The Customer Information and

Behavior Working Group focuses on reducing energy consumption through behaviour-based energy efficiency programs and strategies (SEE Action, n.d.). The Customer Information and Behavior Working Group offers information resources to support state policymakers, utilities, regulators and other decision makers deploying customer energy information and feedback strategies to improve residential energy consumption behaviour and achieve deeper energy savings (SEE Action, 2012). The ACEEE is researching ways that users can change their behaviour to save energy through the Behavior and Human Dimensions Program. The Behavior and Human Dimensions Program is a laboratory where behaviour change programs are tested and tools for program developers are created (ACEEE, n.d.).

The United Kingdom (UK) is considered to be another leader in the production of research and publications in the realm of behaviour change and energy use. The Department of Climate Change (DECC) has worked with researchers to contribute to the knowledge of behaviour change programs and energy conservation. The Department for Environment, Food and Rural Affairs (DEFRA) in the UK has developed a '4 E' framework of four elements (enable, engage, exemplify and encourage) that should underpin behaviour change policies. It is believed that these elements ensure that a mix of interventions is employed to create the right conditions for behaviour change, including addressing motivations and barriers (UK Parliamentary Office of Science and Technology, 2012).

Alberta has recently established an Energy Efficiency Advisory Panel to make recommendations on the types of energy saving programs that Alberta should pursue. Ontario could consider establishing a working group that is similar in structure to Alberta's Energy Efficiency Advisory Panel, to make recommendations to the Ontario Ministry of Energy on behaviour-based energy programs that could be implemented on a large-scale.

5.2 Benefits of energy conservation from feedback programs

5.2.1 Economic benefits

Residential energy conservation is economically beneficial to utilities, consumers and the economy as a whole. Conservation is Ontario's best, and most cost-effective energy saving option. Conserving electricity is generally less expensive than generating electricity, as it costs less to avoid using kWh of electricity than it costs to produce an additional kWh of electricity (Mallinson, 2013). Between now and 2020 more than 100 new power plants are slated to be built and thousands of kilometres of new transmission lines erected (Dubinsky, 2011). Thus, the costs will be on consumers, as the average household electricity bill is expected to rise to more than $150 (Dubinsky, 2011).

Each year, electricity and natural gas utilities spend billions of dollars on energy conservation programs in an effort to reduce energy use externalities and address other market failures that may reduce investment in energy efficient durable goods (Allcott & Greenstone, 2012). According to the IESO's Annual Verified Results (2015), $12,984,876 was spent on LDC incentive-based energy programs that were offered to the residential sector. Behaviour-based energy programs have the potential to be less costly for utilities to run compared to rebate and incentive-driven programs. While the Green Button has only been rolled out to a small number of utilities, the total cost of a province-wide roll out is unknown. As utilities continue to install advanced meters throughout the residential sector, with the goal of meeting other utility objectives, real-time feedback mechanisms could well become an increasingly viable and cost-effective approach to providing households with useful feedback (Ehrnhardt-Martinez et al., 2010).

Consumers can benefit financially by reducing their household energy consumption, thus reducing costs on their utility bills. Cumulative amounts of energy cost saving can be reached through energy conservation behavioural changes (Ting et al., 2011). Behaviour-based strategies such as feedback, usually incur curtailment behaviours that provide no cost opportunities to reduce household energy consumption, resulting in a low cost to consumers to implement (purchase of applications and/or monitors) and creating savings in utility bills. The cost for a real-time direct feedback program was estimated to be about $0.30/kWh saved for the first year, with expected reductions to $0.07/kWh saved after five years, using a standard discount rate of 5% (AEEA, 2014). The avoided construction of new power plants averts extensive costs to the government and taxpayers. The Darlington nuclear power plant in Ontario was budgeted at $3.4 billion to construct, but ended up costing $15 billion when it was completed in the mid-1980s (David Suzuki Foundation, n.d.). As feedback programs make more traction in Ontario through the roll out of the Green Button initiative, more innovation solution providers will be needed to create web-based applications that can be made available to consumers. This can be a source of job creation and drive innovation in Ontario's economy.

5.2.2 Social benefits

The spill-over effect of household energy conservation to other pro-environmental behaviours is a potential benefit of direct feedback programs. Individuals that begin down a path of reduced energy use with small initial steps become committed to further steps, and those who are making personal changes to protect the environment will demand the same of government and other organizations (Dietz et al., 2013). Hargreaves et al. (2010) study of UK households' interactions with feedback on their domestic energy consumption through in-home displays revealed that environmentally-motivated participants' energy saving behaviours appeared to spill-over beyond the domestic setting, as they were motivated to drive less, bought smaller cars and encouraged their peers to reduce their emissions.

Enhancing energy literacy would be valuable to Ontario, as previously mentioned, a Canada-wide survey indicated that Ontario was among one of the lowest energy literate provinces in the country. Studies have found that direct feedback improves energy literacy amongst users. Van Houwellingen and van Raaij (1989) and Henryson et al. (2000) found that participants showed growing awareness of energy use. Schwartz et al. (2013) found that participants learned about electricity consumption for their home appliances and ascribed meaning to information presented by their energy monitors. Some participants were able to de-aggregate their individual consumption on appliances level and use technical terms such as a 'watt' to explain and compare electricity consumption. Schwartz et al. (2013) observed that participants were able to increase their energy literacy through contextual knowledge of routine and habits, allowing to ascribe behaviour to visual data, learning through comparisons with other appliances, learning by service, learning from the "energy expert" (the family member that followed the energy monitor the closest), and learning in collaboration.

5.2.3. Environmental Benefits

Most of the pressing environmental problems are caused by energy system operations (Lutzenhiser, 1994). By conserving energy, pollution from fossil-fuel energy sources is avoided and environmental degradation is minimized, as the need for the construction of new energy generation sites is diminished. The Ontario electricity supply mix is regarded as "clean", as the province's major source that supplies electricity comes from nuclear power plants and does not emit air pollution or carbon dioxide while operating. Natural gas supplies the majority of Ontario's fuels for heating purposes in the residential sector and to supply electricity from peaker plants during peak demand. In terms of greenhouse gas reductions and environmental benefits, residential feedback programs would be mostly beneficial during peak demand and for fossil-fuel energy sources.

5.3 Challenges and Limitations

Behaviour-based energy programs face some challenges, largely revolving around lack of awareness of the effectiveness these programs by policymakers and utility companies. The traditional approach to energy conservation has been through technology or economics, as opposed to human behaviour. Other issues include measuring and verifying behaviour-attributable energy savings, the persistence of these savings and ensuring that the programs are cost-effective (Energy and Environmental Economics Inc., 2011). There is also a lack of publications and research on the effectiveness of the Green Button initiative in the residential sector, as it is a relatively new standard.

The trend of growing minor appliance stock and non-negotiable practices in households will be a major challenge that faces direct feedback and behaviour-based programs. Residential energy feedback systems must seriously take into account the non-negotiability of everyday practices and the power of habit (Hargreaves et al., 2013). Hargreaves et al. (2013) qualitative study shows how households interact with feedback monitors and found that certain appliances were considered essential and household routines were described as impossible to change as negotiations with other household members to make changes was difficult. What constitutes as non-negotiable behaviours may differ across households. During follow-up interviews, Hargreaves et al. (2013) found that various uses had come to be seen as an unavoidable part of the normal, base level energy consumption. At the same time, these 'normal' levels of energy use continue to rise, as the use of smaller appliances in households are growing and demand for energy-consuming appliances to meet escalating conventions of comfort, cleanliness and convenience (Shove, 2003). As previously described, Natural Resources Canada data shows that minor appliance use has doubled from 1990 to 2010, which offsets the energy savings from major appliances being more energy efficient. It will be challenging for behaviour-based energy programs to change the societal 'need' for more appliances. However, perhaps through enhanced energy literacy, householders will learn to use them more efficiently (i.e. completely cutting the power off and reducing phantom loads).

The Green Button is the antithesis of the traditional utility revenue model and is a perfect fit with the goals being sought through revenue decoupling (Sayogo & Pardo, 2013). Revenue decoupling is a regulatory framework that seeks to break the link between a distributor's revenue recovery and consumer consumption of energy (Ontario Energy Board, 2012). Companies with revenue decoupling have more incentive to adopt Green Button, while those without decoupling will be less eager to do so as it impacts the total surplus revenue of the company. It is in effect recognizing that the distributor is in the business of managing a network, rather than in the business of selling electricity (Sayogo & Pardo, 2013). Currently in Ontario, there have been discussions by the Ontario Energy Board (2012) to redesign the rate structure of LDCs, including revenue decoupling and moving to fixed charges for distributor's revenue. Revenue decoupling is not the only factor that influences Green Button implementation, as Sayogo & Pardo (2013) finds that other economic factors such as energy market structure, competitiveness in the energy market and the cost of Green Button implementation also affects uptake.

5.4 Recommendations

To address the behavioural gap in Ontario's energy conservation policies and programs, five key recommendations will be described below. The evidence to support these recommendations has been provided throughout the entirety of this major research paper.

i. To address the behavioural gap in Ontario's energy conservation policy and programs, government policies and utility programs should incorporate insights from the social sciences in addition to monetary incentives. The use of information as a policy tool should be enhanced through the principles of cognitive psychology;

ii. The Province should prioritize and implement a near real-time direct feedback program (similar to the Green Button initiative) in the residential sector to enhance the public's energy literacy and better direct household curtailment behaviours;

iii. The LTEP update should include a commitment to behaviour-based energy programs in addition to existing incentive programs to meet long term conservation targets;

iv. Ontario should develop a working group that focuses on the research and development of behaviour-based energy programs to educate policymakers and utilities about the effectiveness of behaviour-based programs; and

v. Further research is needed on the impact of ethnic, cultural and gender considerations in the design of a feedback program.

6.0 CONCLUSION

The primary research question that has been addressed through this major research paper was: how can residential feedback programs help Ontario to meet its conservation targets? The need for this research question becomes apparent in review of the Province's approach of attaining a culture of conservation and the projected growth of energy consumption in the residential sector. If energy consumption continues to rise additional resources, infrastructure and investments will be required to meet its demand. In the Annual Energy Conservation Progress Report's review of LDCs current energy conservation performance, just over half met their energy target, but only five met both their energy and peak demand targets. As indicated through the LTEP and CCAP, the Province has steep energy conservation and GHG reduction targets. The residential sector is responsible for 17% of Canada's total energy use by sector and, in 2009, was the second largest consumer of the country's electricity and natural gas supply. The APS (2016) indicated that the residential single-family subsector has considerable technical potential for savings. Thus, making the residential sector an important target area that can contribute to the Province's conservation and GHG targets.

As described in this research paper, Ontario takes a predominantly economic approach to encourage energy conservation in the residential sector. This paper identified a gap in the Province's approach through the presentation of various decision models that identify determinants that influence behaviour and describe how the rational-economic model oversimplifies human behaviour processes and are ineffective in creating lasting behavioural changes. Studies have shown that households in Ontario have low rates of energy literacy, which is caused by a lack of knowledge gained through incentives and efficiency behaviours. In addition to the current traditional policy tools that are intended to shift household behaviour, the Province needs support from behaviour-based energy programs that enhance energy literacy and influence pro-environmental behavioural changes. Behavioural interventions such as direct feedback can reduce residential energy consumption, enhance energy literacy and create a spillover effect to other pro-environmental behaviours. It is recommended that the Province incorporates behavioural insights into the LTEP update, develop a working group to inform policies on the benefits and implementation of behaviour programs and that further research be conducted on feedback and the implications of demographic variables.

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