

Impacts of an electricity audit on the total and on-peak consumption of residential households: Findings from a pilot study in Waterloo, Ontario, Canada

May 2020

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Acknowledgements

This research was made possible through the support of the Elora Environment Centre, the Faculty of Environment (University of Waterloo), Reep Green Solutions, and Waterloo North Hydro. The authors are grateful for the strong support of these partners. The authors also thank Air Miles for their contribution to participant remuneration. Moreover, the authors thank the 17 participating households for their time and cooperation. This research has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB 30139 and REB 30599). The authors thank the Office of Research at the University of Waterloo for their support. Finally, the authors are responsible for the contents of the report.

Suggested citation

Andrea Bale, Julia Hawthornthwaite, Brian Lyn, Gord Stephen, Danielle Tobert, and Ian H. Rowlands, Impacts of an electricity audit on the total and on-peak consumption of residential households: Findings from a pilot study in Waterloo, Ontario, Canada (Waterloo, ON: University of Waterloo, UWSpace), <https://hdl.handle.net/10012/20759>, May 2020.

Abstract

Against a backdrop of aging infrastructure, growing electricity demand, and local and global concerns over a changing climate, electricity conservation and management has become a top priority in Ontario, Canada. The present study investigated the potential of an electricity audit to reduce total electricity consumption and shift on-peak consumption among 17 residential consumers. Three months following the electricity audit, the sample achieved average total reductions of 9.4% and on-peak reductions of 17.2%. Three years after the audit, total consumption was reduced by 15.6% and on-peak consumption was reduced by 15.5%, on average. A variety of psychological variables and external influences were factored into the consumption analysis, including attitudes, knowledge, weather, control household data, technical upgrades, sociodemographic changes, and social dynamics, to explore their role in the observed consumption changes. Overall, we suggest that the electricity audit, at least indirectly, impacted the consumption behaviour of many households in the sample through increased awareness and understanding. Moreover, we found that exploring each variable in isolation led to an incomplete understanding of its potential impacts, and that applying these lenses or perspectives in sequence helped to contextualize the observed consumption changes in a more robust way. Future work is needed to disentangle the complex interplay of factors influencing electricity consumption, and to differentiate between individual and household-level contributions.

1. Introduction

Climate change is one of the most pressing challenges facing society, with implications on local and global scales. Many countries around the world have made commitments to implement strong climate change adaptation and mitigation strategies, focusing on major sectors like transportation, industry, and energy production and consumption (UNFCCC, 2018).

The electricity supply system in Ontario (Canada) is made up numerous generating stations, utilizing different fuel types. In March 2020, the relative shares of installed energy capacity on the province's transmission system for nuclear, gas/oil, hydropower, and wind were 34%, 29%, 23%, and 12% respectively (IESO, 2020a). The nuclear power stations, however, are the workhorses of the system, meeting 67% of province-wide demand in 2019; hydropower was the second largest-contributor at 27% (IESO, 2020a). Full details are provided in Table 1, below.

Noteworthy, as well, is that Ontario's total demand for electricity was relatively flat during the 2000s and 2010s: from 2000 to 2010 to 2019, it fell by 3.5% and almost 5%, respectively (from 147 TWh in 2000 to 142 TWh in 2010 to 135 TWh in 2019). Moreover, during these two decades, the year with the highest year-long demand was 2005 (157 TWh), and 19 of the 20 highest 'peak hours', were during the 2000s, with all of the top 10 being in either 2005 or 2006 (IESO, 2020d). This context is important, particularly since this report's empirical research covers much of this 20-year period.

Table 1 Ontario electricity data

Resource	Installed capacity – transmission system (MW, March 2020)	Installed capacity – distribution system (MW, December 2019)	Energy output (TWh, 2019)
Nuclear	13,009	0	90.4
Hydropower	9,065	280	36.4
Wind	4,486	591	11.0
Gas/oil	11,270	276 (Gas)	9.5
Biofuel	295	110 (Bio-energy)	0.4
Solar	478	2,163	0.7
Total	38,603	3,420	135.1

Sources: IESO (2020a, 2020e)

Indeed, in light of these high demand periods of the 2000s – and the optimism associated with the end of the recession in 2009 – there was much focus upon conservation and demand-side management (CDM) during the early 2010s as the cleanest and most cost-effective alternative to new generation capacity (MOE, 2013a). These CDM strategies included more efficient electricity use, behavioural changes to reduce total demand, and load-shifting to reduce peak loads. The province specifically targeted demand response – shifting demand away from peak periods – to meet 10% of peak demand by 2025 (MOE, 2013b). It is worth noting, however, that not only has the past 10 years not seen that anticipated growth in demand, but that the election of a new provincial government in June 2018 has also led to the establishment of a different set of priorities. These include the transition of energy program management to a central body rather than local distribution companies (LDCs), and on-bill electricity rebates for consumers (Government of Ontario, 2019), which place less emphasis on local conservation programs and more emphasis on centralized efficiencies and cost-savings for consumers.

An important target for these CDM strategies is residential consumers, as they account for approximately 30% of the demand for electricity in the province (NRCan, 2018). Moreover, long-term forecasts predict a 10% increase in residential demand for electricity between 2020 and 2040 – from 50 TWh to 55 TWh – due to population growth and increased small appliance and electronic use (IESO, 2020c). It is clear the residential sector is a critical component of future energy management in the province.¹

Innovations in smart meter technology provide such opportunities – and incentives – for residential consumers to better manage their electricity consumption. In Ontario, virtually all residential consumers are equipped with smart meters and have usually paid time-of-use (TOU) rates, with different rates established to reflect the cost of electricity production based on demand throughout the day. Electricity audits are an important tool to help consumers understand their consumption patterns and the benefits that time-of-use pricing can provide.

The present study investigates the impact of an electricity audit on the electricity consumption of 17 households in Ontario, Canada². The next section explores relevant literature that informed the development of the study.

¹ Direct combustion of natural gas in households for space conditioning and water heating services is another contributor, responsible for close to 60% of energy use in Ontario's residential sector (NRCan, 2019).

² This project, when at an earlier stage, was reported upon in Rowlands and Hawthornthwaite (2013).

The third section provides an overview of the methods used in data collection and analysis, followed by the presentation of key results in the fourth section. Finally, the fifth section offers a discussion of the results and provides some concluding remarks and areas for future exploration.

2. Literature Review

2.1. Smart Meters and Time-of-Use Pricing

In April 2004, the Ontario government announced plans to deploy smart electricity meters across the province as part of its large-scale conservation initiative (MOE, 2014). Covering nearly all residential and small-business consumers, close to five million smart meters have now been installed across Ontario (IESO, 2020b). Smart meters provide consumers with information about when and how much electricity they are consuming, which is communicated to consumers on monthly or bi-monthly electricity bills and is also made available in near real-time online by many local distribution companies. The installation of smart meters also allowed the province to introduce TOU pricing, which provides an incentive to shift electricity use to periods of lower demand. This pricing structure was introduced in 2006, and to date, over 90% of residential ratepayers are charged this way (MOE, 2014). In all cases, consumers pay the lowest rates after 7pm and before 7am on weekdays, and throughout the weekend days and holidays. During summer months (May to October), consumers pay the highest prices between 11am and 5pm, and during winter months (November to April) between 7–11am and 5–7pm (OEB, 2018).

Researchers, however, have found that the rollout of smart meters and TOU pricing has had limited impact on peak and total demand among Ontario residential consumers. The 2015-16 Energy Conservation Progress Report, released by the Environmental Commissioner of Ontario, found peak reductions of only 0.7% over a four-year period. Similarly, the Annual Report of the Auditor General of Ontario (2016) found the time-of-use pricing model has had limited impact on peak reductions (MOE, 2016). Other researchers have found similarly low levels of peak load shifting (Newsham & Bowker, 2010; Rowlands & Furst, 2011; Faruqui et al., 2014). Evidently, the availability of near-real-time consumption data and TOU pricing incentives do not seem to be sufficient motivators to encourage large-scale shifts or reductions in demand.

2.2. Barriers to Conservation and Load-Shifting

The literature on energy programs designed to encourage energy conservation and/or load-shifting, broadly, suggests that their limited – or mixed – success may be attributed to a number of barriers. Stern (2007) divides these barriers into three categories: (1) financial/transactional, (2) behavioural/motivational, and (3) informational. Financial or transactional barriers refer to high upfront costs and slow payback periods of efficiency investments, whether perceived or actual (Wilson & Dowlatabadi, 2007). Behavioural or motivational barriers refer to factors such as convenience, established routines or practices, and level of interest (Hamilton & Killip, 2009). Informational barriers refer not only to the availability of information, but other factors such as accessibility and consistency with one's existing knowledge or priorities as well (Brown et al., 1998).

The informational barrier is particularly important to explore within the context of smart meters and TOU pricing. An independent consulting firm identified a communication and information barrier as a key component of the limited success of Ontario's TOU pricing program (BEworks, 2014), which is consistent with findings from

related research (Dütschke & Paetz, 2013). Literature from behavioural and environmental psychology helps to navigate how these findings can be addressed.

Behavioural and environmental psychologists argue that energy programs must provide personalized or tailored information to the consumer. Tailored information helps to reduce the 'overload' of information by only providing content that is relevant to the recipient (Abrahamse, Steg, Vlek, & Rottengatter, 2005; Murphy, 2014). In this way, an individual can spend less time discerning what information is contextually applicable and more time processing the information received. In the context of TOU pricing, consumers may have difficulty conceptualizing what tangible benefits they may experience by actively shifting or reducing discretionary loads, or how they might go about implementing those changes in ways that are simple and convenient in their own lives. In addition, information must be provided by a trustworthy, credible source (Coltrane, Archer, & Aronson, 1986; Darby, 1999; Berry, 2010). Information provided by sources perceived to be biased or unreliable is more easily disregarded, especially if it conflicts with existing knowledge. Moreover, information must be provided in a way that is captivating and motivating in order to gain involvement from consumers (Stern, 1999). Fischer (2008) argues that one way to engage individuals is by providing a range of choices or options to gain involvement in the discussion and decision-making process, thereby increasing the likelihood of effective information transfer. In the context of TOU pricing, underscoring the opportunities and choices consumers have may reframe the program and encourage participation among residential consumers.

2.3. Overcoming Barriers with Energy Audits

One intervention that combines these attributes is an energy audit. Energy audits are performed by energy advisors, who complete a comprehensive assessment of the energy systems in a house to identify specific areas for improvement (Gamtessa & Ryan, 2007; Palmer, Walls, Gordon, & Gerarden, 2013). Electricity audits, similarly, involve an assessment of electricity-consuming appliances and devices in a home to identify electricity-saving opportunities.

A review of the energy audit literature suggests the relationship between audits and energy-related behaviours is mixed. Hirst, Berry, and Soderstrom (1981) examined the relationship between energy audits and the installation of energy-efficiency measures. Across six energy audit programs in the US, they found 40-50% of audit recipients installed energy-efficiency measures, compared to 30% in a larger sample of control households. More recently, Ingle, Moezzi, Lutzenhiser, and Diamond (2012) found a positive relationship between an energy audit and investments in equipment and appliances in a group that received personalized audit recommendations compared to a group that received generic, standard recommendations. Similarly, Scott et al. (2016) found that audits helped to catalyze energy-efficiency upgrades among households with little prior knowledge of energy-efficiency opportunities. However, Murphy (2014) surveyed a large group of Dutch homeowners and found no significant difference between those receiving an audit and those not receiving an audit on the installation of energy-efficiency measures. McDougall, Claxton, and Ritchie (1983) also found little impact of the ENER\$AVE program on subsequent investments in conservation.

Beyond reported behaviour changes, other researchers have examined the relationship between attitudes, knowledge (or cognitions), and proenvironmental behaviours with respect to energy audits. Within the audit literature, Hirst and Grady (1982-83) studied attitudes toward conservation and other energy issues among audit recipients and a control group, finding little difference between the two. On the other hand, Boomsma,

Goodhew, Goodhew, and Pahl (2016) looked at the perceived risks and benefits of draftproofing among groups who received a tailored thermal imaging report, a non-tailored thermal imaging report, or a text-only report. The authors found that, two weeks after receiving the report, those who received the tailored thermal imaging report had stronger attitudes about the benefits and risks of draftproofing their home and had greater intentions to implement changes than the other two groups. Similarly, Scott et al. (2016) noted a greater sense of empowerment and increased knowledge among audit recipients, which was correlated with conservation and energy-efficient behaviours. However, Abrahamse et al. (2005) broadly caution that proenvironmental behaviours are not necessarily correlated with proenvironmental attitudes or knowledge, and that more research is needed to disentangle the relationship among these variables.

It is important to note that the studies above all rely upon self-reported data on the part of the homeowner, or the individual(s) meant to undergo a change as a result of the audit. There are a number of potential problems that arise from reliance on self-reported data alone. For example, it is argued that self-reported data may be influenced by social desirability, whereby participants respond in ways they think will be viewed more favourably by those conducting the study (see, for example, Luyben (1982)). Additionally, energy-efficiency gains in one area (e.g. turning off the lights) may be offset by increased consumption in another area through a rebound effect, leading to increases in total consumption (Berkhout, Muskens, & Velthuisen, 2000). Therefore, relying only on self-reported changes to energy systems and appliances may generate misleading results (van Dam, Bakker, & van Hal, 2010).

Departing from self-reported data collection, other researchers have focused on the relationship between energy audits and energy or electricity consumption, though the prevalence of such studies was limited in the literature. Cluett and Amann (2016) argue that programs that are not run by utility companies have difficulty accessing data, though changes in software tools are allowing increased access to near real-time data. Winnett, Love, and Kidd (1982-83) examined biweekly electricity consumption for two months following an audit and found average electricity savings of 20% across 40 households compared to baseline and a control group. Similarly, Hirst and Goetz (1985) estimated annual electricity savings of 3,100-3,300 kilowatt hours for households that received a free electricity audit. Benders et al. (2006) developed a web-based audit and found energy savings of 8.5% over the study period. However, these researchers cautioned that their study duration (five months) was too short to draw any conclusions on long-term energy use; other researchers echo this sentiment (e.g. Abrahamse et al., 2005; van Dam et al., 2010; Hargreaves, Nye, & Burgess, 2013).

2.4. Determinants of Electricity Consumption

While consumption data provide a precise, measurable indicator, these data alone are limited in their ability to explain whether – and in what ways – audits (or other energy interventions) have an impact on consumption. In the context of electricity consumption, there are a number of complex variables that can be important determinants of electricity consumption.

Kavousian, Rajagopal, and Fischer (2013) found that weather, appliances and other physical characteristics, and occupancy and occupant patterns/habits were all significant determinants of residential electricity usage. Abrahamse and Steg (2009) also found that other sociodemographic variables, such as household income, household size, age of occupants, and psychological variables, such as attitudes, knowledge, and behaviours, were all important determinants of consumption. In particular, sociodemographic variables were more strongly

linked with determining baseline energy use, whereas psychological variables were associated with changes in energy use. Similarly, Das, Richman, and Brown (2018) observed that education level and income were positively correlated to the adoption of energy-efficiency measures. Moreover, Abrahamse and Steg (2011) underscored the importance of including both sociodemographic and psychological variables in energy studies. Wilson and Dowlatabadi (2007) also discussed the importance of external conditions to which all householders are subject, such as electricity prices or social norms, as well as social dynamics and broader social systems, as potentially significant contributors to electricity consumption patterns.

Taken together, energy studies would be strengthened by combining self-reported changes (including behavioural, attitudinal, knowledge, technical, social) with actual consumption data over an extended period of time. The present study seeks to add to the literature by examining changes in electricity consumption data over multiple years within the context of key determinants of consumption (weather, environmental factors, technical stock, sociodemographics, and social dynamics) to more holistically explore the impacts of the electricity audit on electricity consumption patterns.

3. Methods

3.1. Project Partners

The Electricity Audit Impact Study (EAIS) was developed as a partnership among four stakeholder groups: a local electricity distribution company (Waterloo North Hydro), two local environmental charities (Elora Environment Centre and Reep Green Solutions), and an academic institution (University of Waterloo). Waterloo North Hydro was responsible for participant recruitment and preparing electricity consumption data for participating households in the study. The Elora Environment Centre and Reep Green Solutions were responsible for developing and delivering electricity audits to 17 Waterloo North Hydro customers. Following the electricity audits, the University of Waterloo was responsible for developing and delivering a series of surveys and interviews, and for analyzing electricity consumption data provided by the utility.

3.2. Recruitment and Baseline Survey

A representative from Waterloo North Hydro sent a recruitment email to 75 households that had previously participated in a prior energy conservation program, randomly selected from a pool of 120 households. Participants were selected on a first-come-first-served basis with no exclusion criteria. The recruitment strategy resulted in a sample of 17 self-selected participants. Based on the sample size and self-selection bias, the results of the present study are not generalizable to larger populations. However, this was not the intention of this research study and thus a representative sample was not deemed necessary.

The 17 participating households completed a baseline survey between 4 March 2012 and 12 March 2012, which was distributed by a Waterloo North Hydro representative prior to the electricity audit. All 17 electricity audits were subsequently booked by Reep Green Solutions and completed by the Elora Environment Centre.

3.3. Audit Intervention

Electricity audits were performed on 17 households between 12 March 2012 and 18 April 2012. All electricity audits were performed by the same Certified Energy Advisor. The electricity audits lasted approximately one and

a half hours and included an inventory of all electricity-consuming devices in the home. Participants were encouraged to follow the advisor around during the audit to ask questions and learn more about their home's electricity use, though this was not mandatory. After the walk-through, the advisor briefly reviewed the findings of the audit on a portable tablet to outline any areas where electricity conservation was possible.

An electricity audit report was emailed to each participant one week after the audit. The report included a list of recommendations, including three or four 'key' recommendations. Recommendations were broken down into discrete changes (e.g. one-time appliance purchases) and continuous changes (e.g. shifting laundry time).

3.4. Electricity Consumption Data

Electricity consumption data provided by Waterloo North Hydro for the 17 participating households were for a period of one year before the beginning of the study period (April 2011 to March 2012) and for three years following the study period (March 2012 to June 2015). The hourly consumption data – that is, collected by smart meters – were transformed to monthly electricity consumption data. The data were adjusted to ensure the same number of weekend and weekdays in each comparator month. Baseline total and on-peak consumption was calculated using data from April 2011 to March 2012. Short-term changes in total and on-peak consumption were calculated by comparing data from April 2012 to June 2012 (3 months post-audit) to baseline (April 2011 to June 2011). Long-term changes in total and on-peak consumption were calculated by comparing data from July 2012 to June 2015 (3 years post-audit) to baseline (July 2011 to June 2012).

3.5. Self-Reported Data

3.5.1. Surveys

Baseline self-reported data were collected through an online survey before the audit. Participants were emailed a second online survey approximately one and a half weeks following the audit, and a third online survey three months after the audit, to measure short-term changes following the audit. The survey questions are included in Appendix A. As remuneration for participation in all three surveys, participants were given a 100 AirMiles Reward Bonus Card upon completion of the third survey.

The first (baseline) survey collected information about the household including demographic characteristics, existing electricity saving behaviours, and knowledge and attitudes towards electricity conservation. The second survey included the same electricity behaviour, knowledge, and attitudes questions from the baseline survey to determine any immediate impacts from the audit. The third survey followed up on responses from the first and second surveys to determine if planned behaviour changes had occurred and been sustained over the short-term.

The same 17 households were sent an email invitation to complete a follow-up survey online approximately three and a half years after the audit to measure long-term changes to demographic characteristics and appliances. The follow-up survey investigated the longer-term impacts of the audit such as changes in appliances and explored other factors that may have affected electricity consumption (e.g. additional family members, extended periods of absence, etc.). The follow-up survey questions are included in Appendix A.

3.5.2. Interviews

As part of the follow-up survey sent three-and-a-half years after the audit, participants were also invited to participate in a short telephone interview. Interviews were conducted four to six months after the follow-up survey by a graduate student researcher. These interviews were semi-structured and consisted of 20 questions, on average. The questions inquired about changes to electricity-related practices as a result of the audit (e.g. one-off changes, daily practices, purchasing decisions), and any changes to awareness and understanding of their electricity consumption because of the audit. As well, homeowners were probed about notable changes in their consumption data after the audit that could not be accounted for based on results from the surveys. All interviews were conducted over the telephone, and were tape recorded and transcribed for subsequent analysis. The six interviews lasted between 14 minutes and 46 minutes, with a median interview time of 20 minutes and an average interview time of 23 minutes. Again, the interviewees were self-selected and thus are not representative of the research sample or any larger populations. The interview questions are included in Appendix A.

3.6. Overview of Dataset

All 17 households completed the first three surveys and consented to providing their electricity consumption data. Eleven of these households also completed the follow-up survey, and six of those 11 also participated in the follow-up interview. To our knowledge, the same individuals occupied each of the 17 houses over the four-year period, as we confirmed that the billing name at the address was the same.

3.7. Data Analysis

The primary objective of the present study was to determine changes to total and on-peak electricity consumption following an electricity audit. Electricity consumption data were analyzed over the short-term (approximately three months) and long-term (approximately three years) to determine total and on-peak consumption changes for each of the 17 households. The short-term data were then compared against the first three sets of survey responses, and the long-term data were examined under four different lenses – or perspectives – to determine whether factors other than the electricity audit were likely responsible for the observed changes.

3.7.1. Weather

To explore the impacts of weather, weather data were collected from the Kitchener/Waterloo weather station managed by Environment Canada (latitude 43.46°N, longitude 80.38°W) (Government of Canada, 2019). Heating degree days were calculated for each day, and then summed. For each individual day, the mean temperature was calculated; if it was below 18°C, then the difference (from 18°C) was the value, while if the mean temperature for that day was above 18°C, then there would be zero heating degree days. This indicator is generally used to estimate the heating requirements of buildings. Similarly, cooling degree days were calculated for each day, and then summed. For each individual day, the mean temperature was calculated; if it was above 18°C, then the difference (from 18°C) was the value, while if the mean temperature for that day was below 18°C, then there would be zero cooling degree days. This indicator is generally used to estimate the air-conditioning requirements of buildings.

3.7.2. Control Household Data

To explore external ‘environmental’ factors, consumption data for 50 randomly-selected households in Waterloo North Hydro service territory were collected for the entire time-period of the study as a control; apart from the audit, these 67 households (the 17 participating households plus these 50 households) were subject to the same environmental factors. The 50 randomly-selected households’ consumption data were compared to the consumption of the 17 households in the study using a fixed effect regression (‘difference-in-difference’) approach to compute three sets of values:

1. Hourly correction values applied to all households (both participants and controls), to correct for factors influencing electricity consumption in a single hour across the entire population (weather, electricity prices, etc.).
2. Household correction values applied over all hours of the observation period, to correct for factors influencing average electricity consumption in a single household across all time (dwelling size, number of occupants, etc.).
3. Household-level correction values applied to hours occurring after the audit took place, capturing changes in average electricity consumption in a given household *after the audit*.

3.7.3. Renovations and Technical Changes

To explore the role of renovations and/or appliance changes on electricity consumption, households were asked to identify any renovation activity or major appliance upgrades following the audit, including the approximate date of the change. These changes were then compared to the observed changes in consumption to identify any notable correlations.

3.7.4. Sociodemographic Changes

To explore the role of sociodemographic variables on consumption, the initial and follow-up surveys contained the same sets of questions related to education, income, household size, and occupancy patterns to determine key changes over time. These changes were then compared to the observed changes in consumption to identify any notable correlations.

3.7.5. Social Dynamics

To explore the role of social dynamics and familial relations among household members on consumption patterns, the follow-up interviews probed dynamics within the household, and how those dynamics changed following the audit, whether directly or indirectly.

4. Results

The results are presented in three parts: Baseline, Short-Term Impacts, and Long-Term Impacts. Each section will present (changes to) total and on-peak electricity consumption, followed by additional insights collected from the surveys and interviews, where applicable. The Long-Term Impacts will be explored using a number of lenses to help explain the long-term patterns in electricity consumption over the three years.

4.1. Demographic Characteristics

Table 2 provides a summary of key demographic characteristics for the 17 households in the sample. All houses in the study were owner-occupied. All but one respondent resided in a detached house; one resided in a semi-detached house. The average house size for the sample was between 1,500 and 2,000 square feet. All but two houses had a finished basement, and all houses were heated by natural gas.

On average, the number of household members was 2.9, which is slightly higher than the provincial average of 2.6 (StatsCan, 2017b). Five households in the sample had at least one child under the age of 18, and four households included members over 65 years of age.

The median household income (before taxes) was CAD\$110,000-\$119,999, which is higher than the median of CAD\$77,530 in Waterloo Region, Ontario (StatsCan, 2017a). Further, 13 households had some form of post-secondary education as their household's highest level of educational attainment, including eight Bachelor's degrees, four Master's degrees and one degree in medicine, dentistry, veterinary medicine, or optometry. An additional three households had a high school diploma, and one household had no degree, diploma or certificate.

4.2. Audit Reports

Households were provided with a report of electricity-saving opportunities. These recommendations were divided into two categories: discrete (i.e. one-time) and continuous (i.e. over time) actions. Households received, on average, eight electricity-saving recommendations, with a minimum of three and a maximum of 14. A subset of recommendations was identified as 'key', with an average of three, a minimum of two and a maximum of four. The most frequent recommendations overall were making upgrades to home lighting, installing power bars to reduce phantom loads, and reducing use of the furnace fan. Other common recommendations included load-shifting appliance use to off-peak times and reducing the use of small appliances when possible.

4.3. Baseline

4.3.1. Electricity Consumption

Figure 1 presents the average total monthly electricity consumption for the baseline period of April 2011 to March 2012. The data suggest that 11 out of 17 households had a total monthly consumption less than the provincial average of 750 kWh per month (OEB, 2016). The average monthly consumption for the research sample as a whole was 703 kWh.

Figure 1 Average total monthly electricity consumption for baseline period (April 2011-March 2012), with provincial monthly average consumption for comparison (n=17)

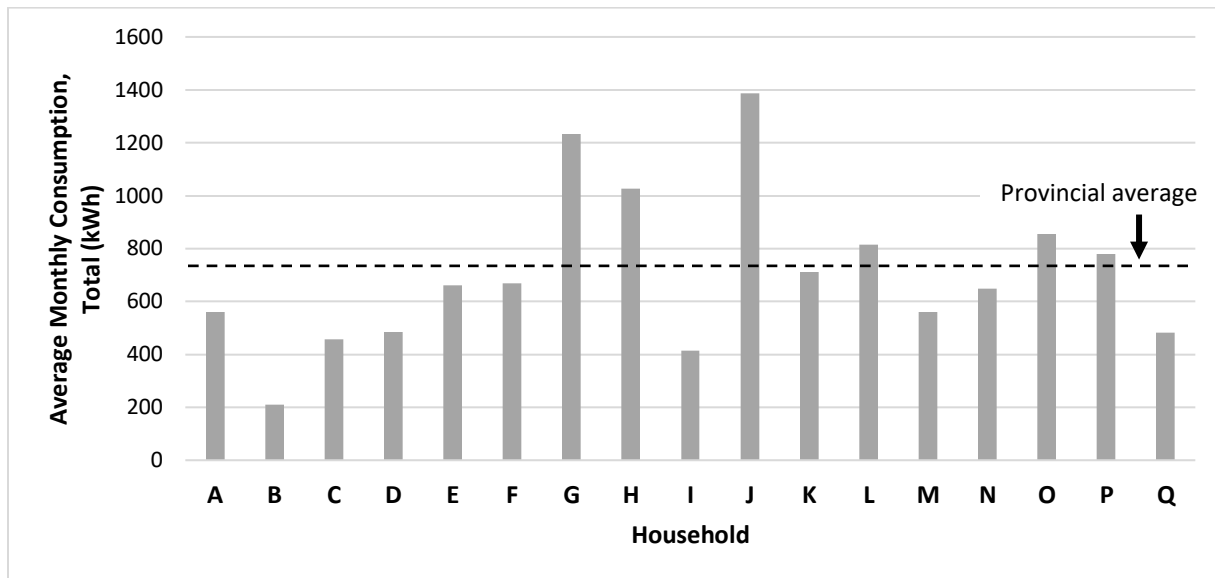
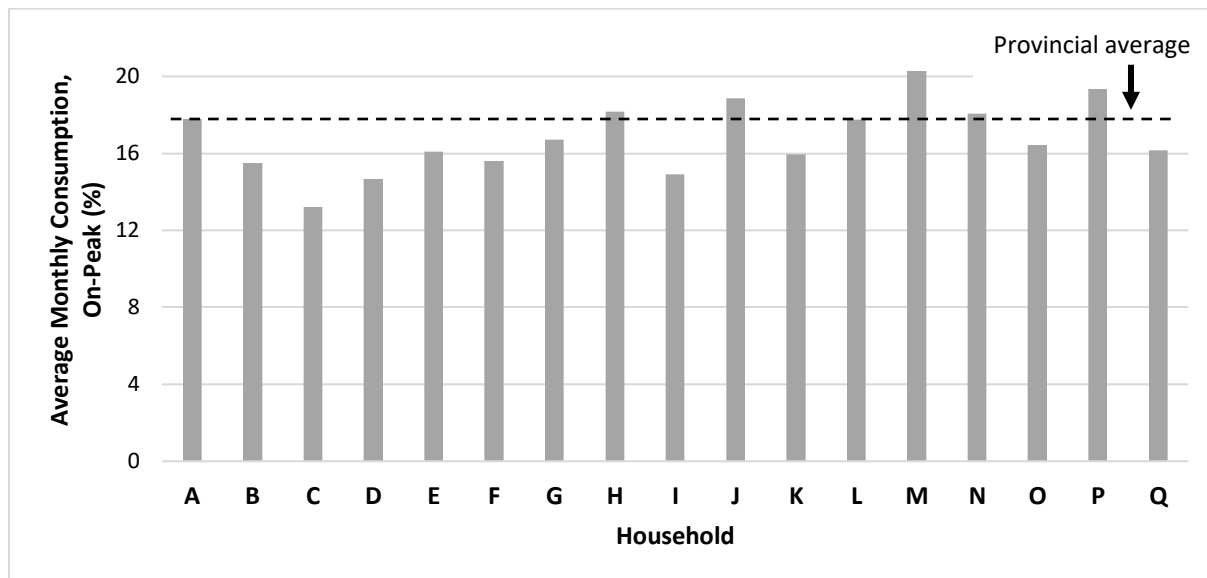


Figure 2 presents the average on-peak monthly electricity consumption for the baseline period of April 2011 to March 2012. The data suggest that 12 out of 17 households used less electricity during on-peak periods than the provincial average of 18% (OEB, 2016). The average share of on-peak consumption for the research sample as a whole was 16.8%.

Table 2 Baseline demographic characteristics for research sample (n=17)

Household	Household Size	House Type	House Size (ft ²)	Children Under 6	Children 6-18	Adults 65+	Education	Income	Occupation
A	3	Detached	3000-3500			3	Master's degree	\$150k+	Retired
B	2	Detached	2000-2500				Bachelor's degree	\$50-60k	Retired
C	2	Detached	2500-3000				Degree in medicine, dentistry, veterinary medicine or optometry	\$150k+	Working
D	3	Semi-detached	1000-1500				Bachelor's degree		Working
E	4	Detached	2000-2500	2			Master's degree	\$100-110k	Maternity leave
F	2	Detached	2000-2500				Master's degree		Working
G	2	Detached	2000-2500				High school certificate		Retired
H	2	Detached	3000-3500			1	Bachelor's degree	\$120-130k	Retired
I	2	Detached	1500-2000				High school certificate		Working
J	5	Detached	2500-3000	2	1		Bachelor's degree	\$110-120k	Working
K	2	Detached	2000-2500				No certificate, diploma or degree	\$70-80k	Working
L	4	Detached	2000-2500		2		Master's degree	\$140-150k	Self-employed
M	2	Detached	1500-2000			2	Bachelor's degree	\$60-70k	Retired
N	3	Detached	1500-2000				High school certificate	\$60-70k	Working
O	4	Detached	2000-2500		2		Bachelor's degree	\$140-150k	Working
P	4	Detached	2500-3000		1	1	Bachelor's degree	\$80-90k	Working
Q	3	Detached	2000-2500		2		Bachelor's degree	\$30-40k	Medical leave

Figure 2 Average on-peak monthly electricity consumption (%) for the baseline period (April 2011-March 2012), with provincial monthly average for comparison (n=17)



4.3.2. Major Appliances

On the first survey, households provided a baseline inventory of the major electricity-consuming devices in the house. The results indicate that the majority of households in the sample owned a furnace (n=17), clothes washer (n=17), refrigerator (n=17, with seven noting multiple), stove/oven (n=17, with two noting multiple), dryer (n=16), central air conditioner (n=15), dishwasher (n=14), and standalone freezer (n=14). Four households also indicated a pool heater and hot tub in use, with two households operating a pool pump.

4.3.3. Attitudes, Behaviours, and Cognitions

Attitudes

On the first survey, all households agreed – to varying degrees – that they would like to reduce the environmental impact of their electricity consumption. All households also agreed they would like to learn more about the electricity consumed by devices in their home.

Behaviours

On the first survey, households were given a list of 11 discussion topics related to electricity use and asked to report how many were discussed among household members. Households reported discussing an average of 5.5 topics with household members, with a minimum of three and a maximum of 11. The three most frequently discussed topics were turning the lights off when leaving a room, TOU rates, and adjusting thermostat settings to be more efficient. The three least frequently discussed topics were the

environmental aspects of electricity use, the pros and cons of efficient appliances, and upgrading the furnace to a higher efficiency model.

Households were also asked to rate their level of agreement with statements related to electricity conservation behaviours. All households agreed – to varying degrees – that they were making an effort to conserve or reduce electricity consumption, generally, and trying to reduce consumption during on-peak periods in particular. Fewer households agreed that they had actively researched tips or strategies to conserve electricity.

Cognitions (Knowledge)

On the first survey, households were asked to rate their awareness of how many kilowatt hours (kWhs) they consumed over one month, and the associated electricity costs with this consumption. The results suggest that the majority were aware of how much it cost to use electricity each month, though only about one-half of households were aware of how many kWhs were used each month.

The majority of households displayed agreement – to varying degrees – that they were aware of actions they could take to reduce their monthly consumption.

4.4. Short-Term Changes

4.4.1. Electricity Consumption

Figure 3 presents short-term changes in total electricity consumption for three months following the electricity audit, compared to the same period the previous year. Thirteen out of 17 households experienced overall electricity consumption reductions, with an average reduction of 9.4% for the sample as a whole (median: 7.5%, largest reduction: 56.1%, largest increase: 30.2%).

Figure 3 Short-term changes in total electricity consumption from April-June 2012, compared to baseline (April-June 2011) (n=17)

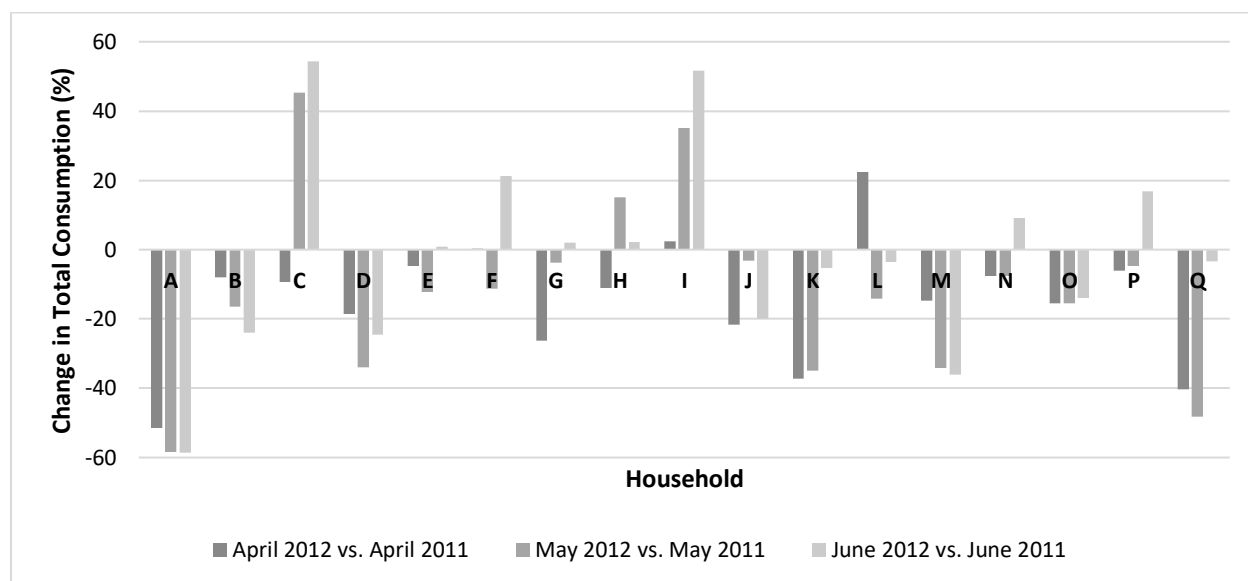
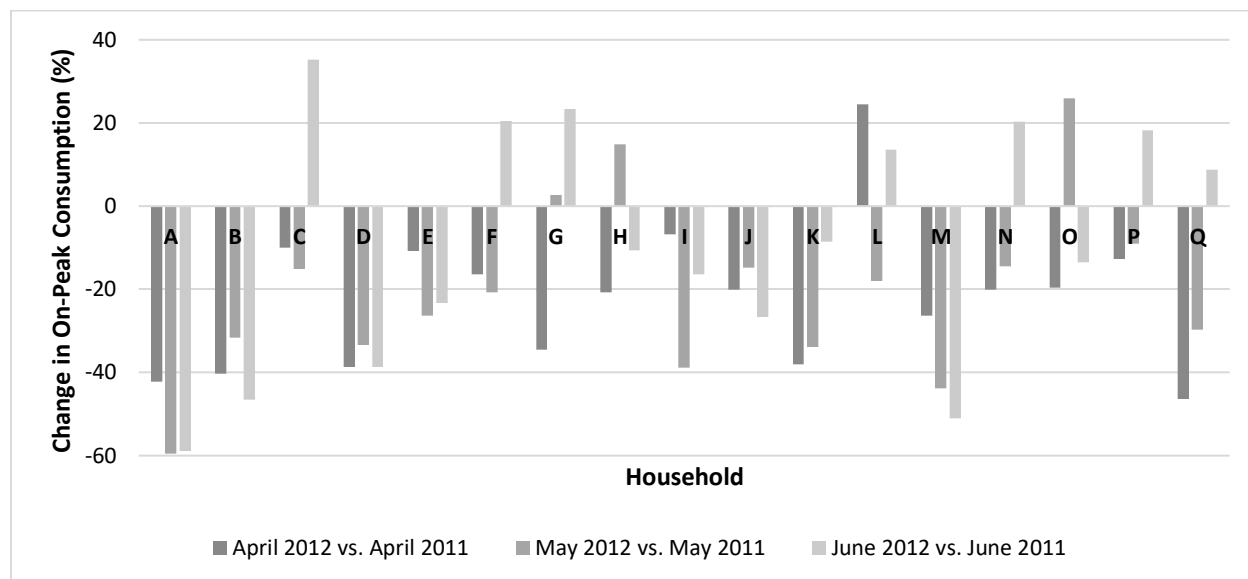


Figure 4 presents short-term changes in on-peak electricity consumption for three months following the electricity audit. Fifteen out of 17 households experienced reductions to their on-peak consumption over the three months, with an average of 17.2% (median: 16.5%, largest reduction: 58.9%, largest increase: 13.6%).

Figure 4 Short-term changes in on-peak electricity consumption from April-June 2012, compared to baseline (April-June 2011) (n=17)



4.4.2. Weather

Figures 5a and 5b present the heating and cooling degree days for the short-term baseline period (April to June 2011) and the three months following the audit intervention (April to June 2012).

Figure 5a Heating degree days for short-term baseline (April-June 2011) and short-term impact period (April-June 2012)

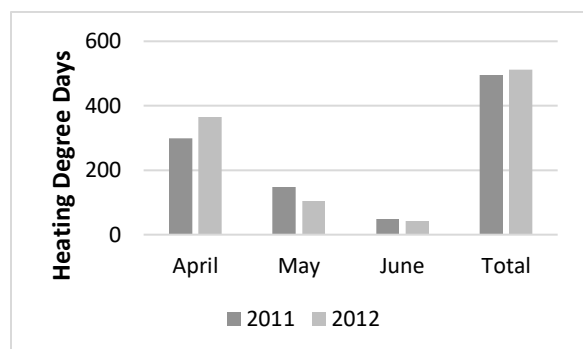
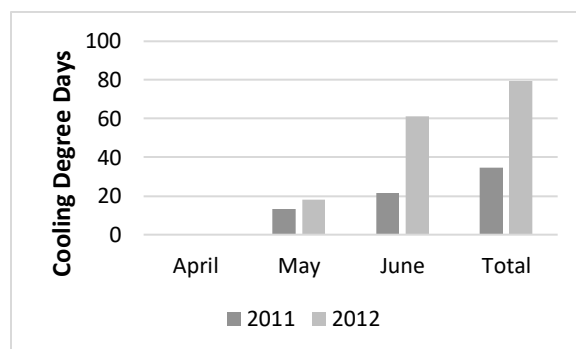


Figure 5b Cooling degree days for short-term baseline (April-June 2011) and short-term impact period (April-June 2012)



The data suggest that the number of heating degree days during the baseline period and short-term study period of April to June 2011 and 2012, respectively, were approximately equivalent. Alternatively, the number of cooling degree days in the baseline period totaled less than half of that in the short-term study period.

4.4.3. Attitudes, Behaviours, and Cognitions

Attitudes

On the short-term follow-up survey, households did not indicate a notable change in their desire to reduce the environmental impact of their electricity consumption. However, the majority of households, on balance, were less interested to learn about the electricity consumption of their home's appliances compared to the baseline survey.

Behaviours

As on the first survey, households were provided with the same list of electricity-related discussion topics and asked to indicate how many had been talked about in the home. The average number of discussion topics increased to 6.5 (from 5.5), with ten households discussing more topics, five households discussing fewer, and two households discussing the same amount. The three most frequent discussion topics showed one difference, with unplugging unused appliances surpassing TOU rates. The least frequently discussed topics remained the same.

Households were also asked the same questions about engaging in electricity conservation behaviours. Notably, 13 households more strongly agreed that they had actively researched tips to conserve electricity than on the baseline survey. There was no change in the level of agreement toward making an effort to conserve electricity and reduce peak loads.

In relation to the audit recommendations, participants indicated that, on average, 48% of total recommendations had been implemented three months after the audit (min: 0%, max: 86%), and 69% of 'key' recommendations had been implemented (min: 0%, max: 100%).

Cognitions (Knowledge)

While many households were already aware of how much their electricity cost each month, nearly one-half of participants indicated a stronger awareness of electricity costs after the audit. Additionally, the majority of households indicated a higher awareness of their monthly kWh consumption. All respondents also indicated a stronger awareness of actions they could take to reduce their monthly consumption.

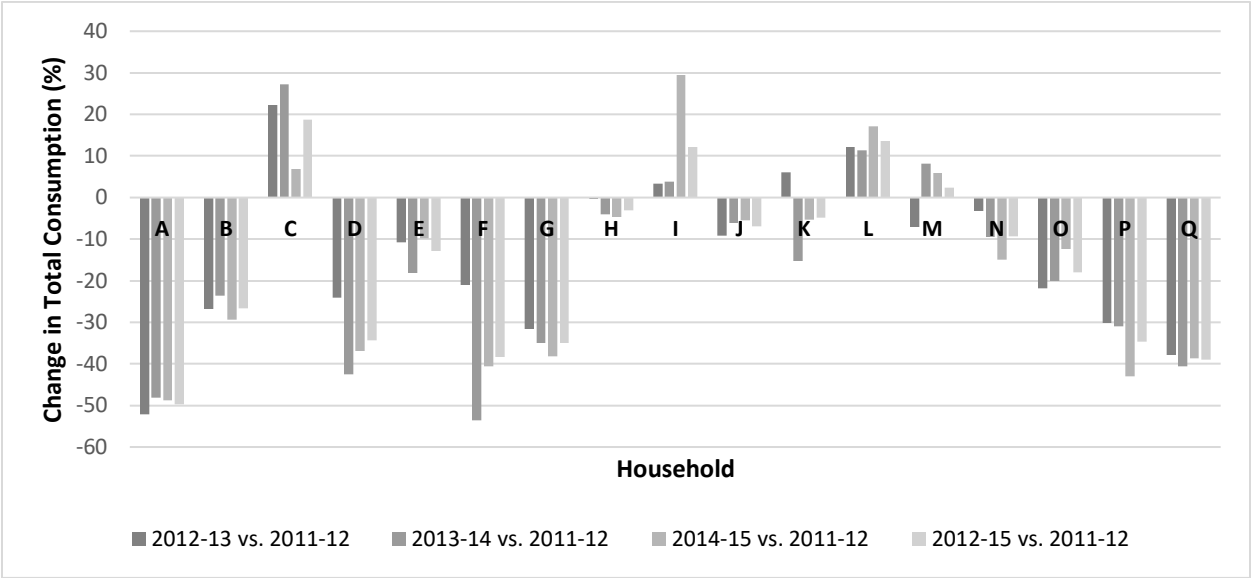
4.5. Long-Term Changes

4.5.1. Long-Term Changes to Consumption

Figure 6 presents long-term trends in total electricity consumption for three years following the electricity audit. The data reveal that, on average, the sample as a whole reduced their electricity consumption by 15.6% over the three years (median: 12.9%, largest reduction: 49.7%, largest increase: 18.7%), with 12 households sustaining electricity reductions and five households demonstrating increases in consumption over the three impact years. Notably, six households reduced their electricity consumption by more than one-third (34%) over the three impact years.

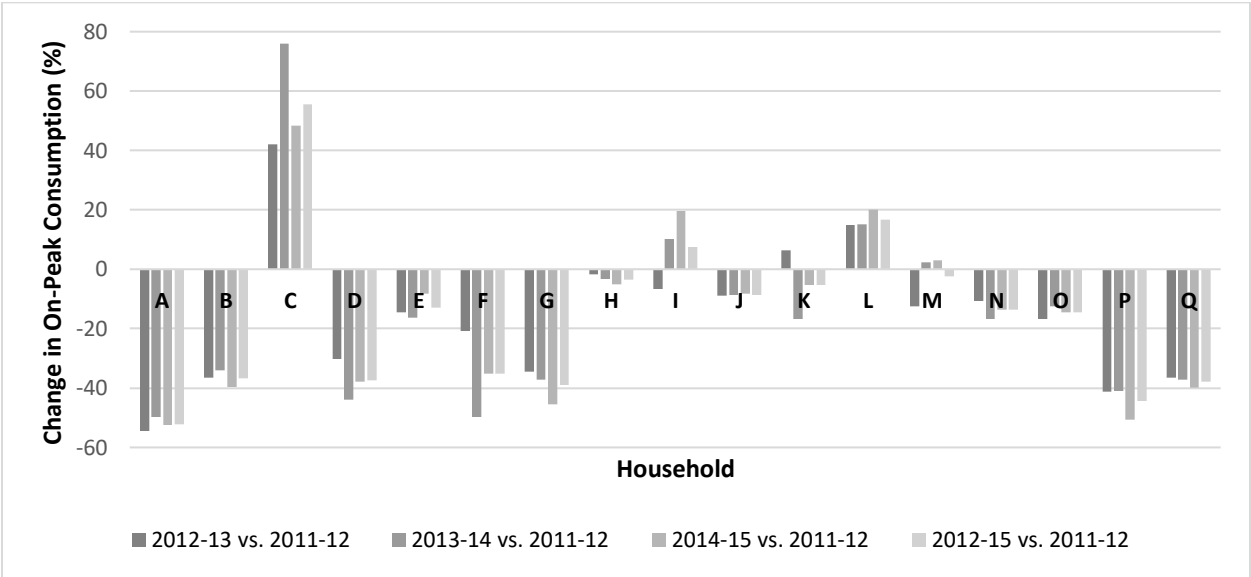
Figure 7 presents long-term trends in on-peak electricity consumption for three years following the audit. The data show that the sample as a whole, on average, reduced their on-peak electricity consumption by 15.5% over the three impact years (median: 13.7%, largest reduction: 52.2%, largest increase: 55.5%), including 14 households that sustained reductions in on-peak consumption and three households that saw increases in their on-peak consumption.

Figure 6 Total electricity consumption trends for three impacts years (2012-2015) compared to baseline (2011-12) (n=17)



Note: For each 'impact year', the duration is July to June.

Figure 7 On-peak electricity consumption trends for three impact years (2012-15) compared to baseline (2011-12) (n=17)



Note: For each 'impact year', the duration is July to June.

4.5.2. Comparison to Control Group

Table 3 presents household-level correction values – based on data from 50 control households – for three impact years after the audit, along with actual consumption data for the 17 households. The data indicate that 11 households continue to be considered overall ‘conservers’ – that is, reduced their consumption – and four continue to be considered overall ‘consumers’ – that is, increased their consumption; two households, however, have mixed results, whereby they earlier seemed to be ‘conservers’ but can now be considered ‘consumers’.

Turning to on-peak consumption, Table 4 presents household-level correction values alongside consumption data as well. Similar to total consumption, the data indicate that 11 households continue to be considered ‘load-shifters’ and three do not; three households, however, have mixed results, whereby they seemed to be ‘load-shifters’ based on actual consumption data, but not when looking at changes relative to the control group.

Table 3 Average total impacts compared to baseline via change relative to control group (CRC) method vs. raw observed change (ROC)

Household	Post-audit change in first year (%)		Post-audit change in second year (%)		Post-audit change in third year (%)		Post-audit change overall (%)	
	CRC	ROC	CRC	ROC	CRC	ROC	CRC	ROC
A	-57.6	-52.1	-52.7	-52.1	-52.0	-48.7	-54.2	-49.7
B	-37.6	-26.8	-29.3	-26.8	-32.3	-29.3	-31.6	-26.6
C	22.0	22.2	30.2	22.2	17.1	6.8	20.9	18.7
D	-17.6	-24.1	-38.9	-24.1	-30.6	-36.9	-28.8	-34.4
E	-16.5	-10.8	-22.9	-10.8	-9.5	-9.8	-15.5	-12.9
F	-27.9	-21	-59.2	-21	-48.9	-40.6	-44.1	-38.3
G	-34.3	-31.6	-36.3	-31.6	-37.4	-38.2	-35.2	-34.9
H	8.1	-0.3	6.2	-0.3	7.6	-4.7	7.4	-3
I	2.1	3.3	13.7	3.3	43.2	29.4	18.6	12.2
J	-9.4	-9.1	-4.9	-9.1	-3.1	-5.5	-6.3	-6.9
K	15.6	6.1	-5.2	6.1	12.5	-5.3	4.8	-4.8
L	8.4	12.2	9.9	12.2	14.6	17.1	10.0	13.6
M	-9.2	-7.1	15.7	-7.1	16.9	5.9	5.0	2.3
N	-2.8	-3.2	-9.8	-3.2	-13.3	-15	-7.6	-9.3
O	-27.3	-21.8	-23.4	-21.8	-16.9	-12.3	-22.3	-18
P	-26.9	-30.2	-24.2	-30.2	-35.0	-43	-28.1	-34.7
Q	-35.4	-37.8	-36.6	-37.8	-35.5	-38.7	-35.8	-39

Table 4 Average on-peak impacts compared to baseline via change relative to control group (CRC) method vs. raw observed change (ROC)

Household	Post-audit change in first year (%)		Post-audit change in second year (%)		Post-audit change in third year (%)		Post-audit change overall (%)	
	CRC	ROC	CRC	ROC	CRC	ROC	CRC	ROC
A	-59.5	-54.5	-54.5	-49.7	-54.1	-52.5	-55.4	-52.2
B	-49.7	-36.5	-45.7	-34	-43.5	-39.6	-44.8	-36.7
C	2.7	42.1	23.4	75.9	13.3	48.3	9.4	55.5
D	-27.9	-30.3	-42.0	-44	-32.3	-37.9	-33.6	-37.4
E	-26.5	-14.4	-28.0	-16.3	-14.2	-8.3	-23.2	-13
F	-26.2	-20.8	-59.2	-49.7	-44.5	-35.1	-42.4	-35.2
G	-39.2	-34.4	-39.2	-37.2	-43.2	-45.5	-39.5	-39
H	10.1	-1.8	9.3	-3.3	12.0	-5.1	10.4	-3.4
I	-15.9	-6.6	2.8	10.1	19.9	19.5	0.5	7.6
J	-0.5	-8.9	0.6	-8.7	5.9	-8.2	1.6	-8.6
K	5.3	6.4	-14.4	-16.7	8.6	-5.2	-3.4	-5.2
L	12.8	14.9	14.0	15.1	21.9	20.1	14.9	16.7
M	8.1	-12.6	36.3	2.3	46.9	3	26.6	-2.4
N	-5.2	-10.6	-15.4	-16.8	-10.6	-13.7	-9.4	-13.7
O	-23.2	-16.8	-17.4	-12.4	-18.0	-14.4	-20.0	-14.5
P	-24.7	-41.2	-22.6	-41.1	-31.9	-50.6	-25.4	-44.3
Q	-40.0	-36.6	-40.6	-37.2	-38.7	-39.8	-39.2	-37.9

4.6. Explanatory Lenses

This section will explore long-term consumption changes in the context of four different lenses to identify any connections or correlations that exist between electricity consumption patterns and changes in weather, renovations and technical changes, social characteristic changes, and social dynamics.

4.6.1. Weather

Figures 8a and 8b present the heating and cooling degree days for the baseline period (2011-12) and three impact years (2012-13, 2013-14, 2014-15).

The data reveal that, compared to the baseline period, there were a greater number of heating degree days in each of the three impact years. Conversely, the number of cooling degree days were lower in each of the three impact years compared to the baseline period.

Figure 8a Heating degree days for baseline period (2011-12) and three impact years (2012-13, 2013-14, 2014-15)

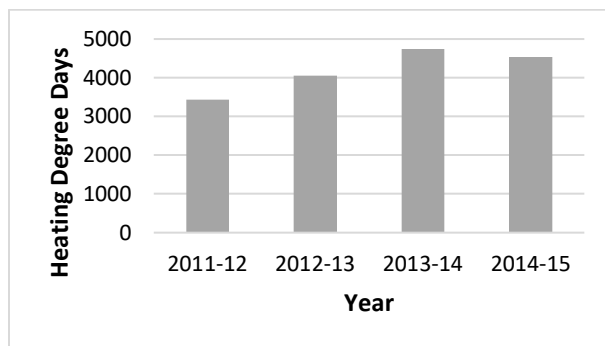
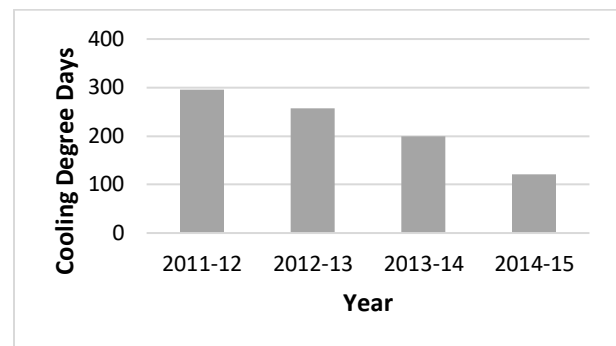


Figure 8b Cooling degree days for baseline period (2011-12) and three impact years (2012-13, 2013-14, 2014-15)



4.6.2. Renovations and Technical Changes

The results from the follow-up surveys and interviews related to renovations or changes to major appliances are presented below. Table 5 summarizes the reported renovations and technical changes alongside the long-term changes in consumption.

Renovations

On the follow-up survey, households were asked to indicate whether their house had undergone any major renovations following the audit. Four out of 11 households indicated that renovation work had occurred during this time frame, including Household C (recreation room updated: December 2013, ensuite bathroom updated: June 2015), Household E (solar panels added: 2014), Household J (basement windows/office updated: 2015), and Household K (deck added: 2014).

Major Appliances

Households were also asked to indicate whether they had upgraded and/or replaced any major appliances following the audit. Nine out of 11 households indicated that they had completed at least one appliance upgrade and/or replacement since the audit, including three households that upgraded more than one. Stoves and dishwashers were replaced most frequently (n=3), followed by clothes washers, clothes dryers, and central air conditioning (n=2), and refrigerators and pool heaters (n=1). Additionally, one household noted one more refrigerator in use and one household indicated one less refrigerator in use.

4.6.3. Social Characteristic Changes

This section presents survey data related to sociodemographic changes, including the number of household members, annual household income, employment and educational attainment, and periods that the household was occupied. These variables are compared to consumption changes in Table 6.

Household Composition

Households were asked whether there were any changes to the number of people living in the house on a regular basis following the audit. Household C reported one additional member (a new baby welcomed in February 2013, changing the household size from two to three), and Household K reported

one additional member (elderly mother moved in during July 2014, moving the household size from two to three).

Table 5 Summary of Renovations and Technical Changes for research sample (n=11)

Household	Total Consumption Change (%)	On-Peak Consumption Change (%)	Reported Renovations	Reported Appliance Changes
A	-49.7	-52.2		Stove/oven (Nov 2014)
B	-26.6	-36.7		Stove/oven (Mar 2015)
C	18.7	55.5	Recreation room (Dec 2013), bathroom (Jun 2015)	Clothes washer (Jan 2014)
E	-12.9	-37.4	Solar panels* (2014)	Refrigerator (2013)
G	-34.9	-13		Refrigerator use (2→1)
H	-3.0	-35.2		Central AC (2013)
I	12.2	-39		Dishwasher (2012), pool heater and filter (Jul 2015)
J	-6.9	-3.4	Basement windows/office (2015)	Central AC (Jun 2014), dishwasher (Nov 2014), clothes dryer (Jun 2015)
K	-4.8	7.6	Deck (2014)	Clothes washer (May 2013), clothes dryer (May 2013), stove/oven (Feb 2016), refrigerator use (1→2)
L	13.6	-8.6		
M	2.3	-5.2		Dishwasher (Feb 2015)

*Installed under a microFIT contract and metered separately, so no direct impact on electricity consumption.

Household Annual Income

Households were asked to report their annual household income before taxes on the initial and follow-up surveys. Four households (B, E, H, and M) saw increases in their annual household income from 2012 to 2015, while two households (K and L) saw decreases in their annual household income from 2012 to 2015. Three households (G, I, and J) did not report incomes on both surveys.

Employment and Educational Attainment

Households were asked to indicate their employment status and highest level of educational attainment on the initial and follow-up surveys. Household E indicated a return to work from maternity leave, and Household K indicated a change from working to retirement. In terms of educational attainment, Household A advanced from a Master's degree to an earned doctorate degree, Household G completed a university certificate from a high school certificate, and Household K obtained a high school certificate.

Time of Day House is Occupied During Week

Households were asked to indicate the times of day that their home was occupied during the week (Monday to Friday), under the categories of "Morning", "Afternoon", and "Evening" on the initial and follow-up surveys. The surveys indicated that the majority of households were occupied by at least one

member during the morning, afternoon, and evening. Two households indicated changes from 2012 to 2015: Household C noted that the household was occupied during mornings and afternoons two weekdays during the summer, and Household E reported a change from only being home during evenings to one member being home during the mornings and afternoons.

Vacations and Periods of Absence

Households were asked whether the house had been unoccupied for one week or more since the audit. Six households (A, B, C, G, H, and M) reported that their house had been unoccupied for at least a week within the time period, with reports offering varying levels of detail.

4.6.4. Social Dynamics

This section presents findings from the six follow-up interviews related to social dynamics within households. Two key themes were identified that help to contextualize the impacts of the audit and the observed changes in consumption: awareness and understanding and family dynamics.

Awareness and Understanding

The majority of households who participated in an interview (B, C, E, J, and L) indicated that the electricity audit had influenced their awareness and understanding of their household consumption, particularly with respect to individual appliances. Several of the participants recalled the portable plug-load meter used by the advisor and how the breakdown of individual appliances' usages was important for their awareness of the electricity consumption for particular appliances. Several households (C, E, and L) also noted that, before the audit, they were unaware of the phantom power draw of particular appliances when not in use, which subsequently led to greater efforts to unplug appliances when not in use.

The impact on awareness also extended to the purchasing decisions of new appliances, though in an indirect way. The majority of households (B, C, E, J, and L) indicated that the audit had an indirect impact on major appliance purchases following the audit and will continue to have an impact on future appliance purchases. These households indicated that they were more aware of the energy-efficiency ratings of potential appliances, and that these ratings had played and would play a greater role in the decision-making process going forward.

Family Dynamics

All households (B, C, E, J, K, and L) discussed the importance of family dynamics in their ability to conserve or shift electricity use. For example, four households (C, E, J, and L) had children under the age of 18, which seemed to present different challenges and different levels of expected responsibility for each household. Household J noted that the younger children did not understand the concept of electricity conservation, while the older child had started to engage in activities that require electricity, such as a personal laptop for school. Similarly, Household C had welcomed a new child which changed the household's overall and time-of-use consumption patterns.

While the other two households did not have children living at home, inconsistent support from adult members posed similar challenges to conservation or load-shifting. Households B and K noted a lack of engagement and cooperation from all family members, and resistance to energy-efficient upgrades. For

example, Household K discussed the dissatisfaction with new, energy-efficient lighting, and the use of additional lights to compensate.

Beyond relationships between family members, other household dynamics were identified as challenges to conservation, such as working from home. Household J noted that one family member works from home, so load-shifting activities to off-peak hours was a challenge. The on-peak consumption for Household J was also likely increased by the fact that their occupation required that multiple computers were running continuously throughout the day. Conversely, Household E did not note any challenges with working from home.

While many households identified barriers to conservation, others noted the ways in which family dynamics enabled conservation. For example, Household B discussed their household's preference for fresh food, so the couple empties and unplugs their refrigerator during periods of absence. This behaviour was not prompted by the audit, though the audit helped to emphasize the importance of electricity conservation when the house is empty.

5. Discussion

5.1. Impacts on Electricity Consumption

The main objective of the present study was to examine the impacts of an electricity audit on the electricity consumption of 17 residential consumers. Three months after the audit, the research sample achieved an average total reduction of 9% and on-peak reduction of 17%. These results are in line with the findings of other researchers, who observed savings in the range of 8-20% (Winnett, Love, & Kidd, 1982-83; Benders et al., 2006). Three years after the audit, these reductions were sustained for the sample as a whole; the research sample reduced their total and on-peak consumption by nearly 16%, on average.

To analyse the observed changes in consumption, we compared the consumption data of our research group to a control group and explored four different sets of variables that are known to be associated with electricity consumption: weather, technical changes and/or renovations, sociodemographic changes, and social dynamics. We will discuss each of these in turn, drawing connections between variables as appropriate, followed by a broader reflection on the dataset as a whole.

We caution that the research sample is not representative of any larger populations. The research sample was more educated and had a higher median income than Waterloo Region as a whole, characteristics which have both been associated with 'greener' groups in the population (Fawcett & Killip, 2014). Other researchers have also found that households with more education were better able to use information related to TOU pricing to reduce consumption (Di Cosmo, O'Hara, & Devitt, 2017). These findings seem to be supported by baseline consumption data that were below the provincial average for approximately two-thirds of the sample.

Table 6 Summary of social characteristic changes for research sample (n=11)**Note: Blanks mean that information was not provided.*

Household	Consumption Change (%)	Composition	Income	Employment	Educational Attainment	Time of Day Home	Vacation / Periods of Absence (summarized here)
A	-49.7		No change		Masters to PhD		Two weeks annually
B	-26.6		Increase				One-three weeks annually
C	18.7	2 to 3 members (child)	No change			Only evenings to morning/afternoon two summer weekdays and evenings	Annual vacations, about three weeks a year (varies)
E	-12.9	4 to 5 members (child)	Increase	Maternity leave to working		Only evenings to morning/afternoon and evenings	
G	-34.9				High school certificate to university certificate		One week
H	-3.0	1/2 to 2/2 members 65+	Increase				Three weeks
I	12.2	1/2 members now 65+					
J	-6.9	3 children now 6-18 range					
K	-4.8	2 to 3 members (elderly mother)	Decrease	Working to retirement	No certificate to high school certificate		
L	13.6	1/2 children now 19-64 range	Decrease				
M	2.3		Decrease				One week

5.2. Exploring the Observed Changes

5.2.1. Short-Term Changes

Heating and cooling degree days were examined to investigate whether seasonal weather patterns may have contributed to observed changes in short-term consumption. We observed more than twice as many cooling degree days in the first three months after the audit (April to June 2012) compared to baseline (April to June 2011), with 80.9 days and 34.8 days, respectively. If weather were a significant contributor to the average overall savings of 9% in our research sample, we assume that the number of cooling degree days would have been lower in the first three months after the audit. We speculate that the observed savings were not strongly impacted by changes in weather in the short-term.

We did not specifically investigate technical changes or renovation activity within the first three months after the audit, though results from the follow-up survey three-and-a-half years after the audit did not suggest any notable changes during this time for the 11 households that provided responses.

Within the context of sociodemographic changes and social dynamics, the initial surveys highlighted changes to attitudes, behaviours, and cognitions following the audit that may help to explain the observed changes in short-term consumption. Many households noted more electricity-related discussions with family members, especially around phantom power, and more active research into tips and strategies to conserve and shift consumption away from peak periods. Equipping household members with specific, actionable recommendations may have helped to reduce consumption over the short-term. Many households also noted a greater sense of awareness of appliance-specific consumption, total monthly consumption, and associated costs. In this way, we speculate that households were more mindful when using particular appliances and were able to draw associations between specific consumption patterns and monthly electricity bills. This is consistent with findings from Scott et al. (2016) who found that audits helped to increase knowledge and empower homeowners to take part in efficiency and conservation behaviours.

In terms of audit recommendations, we see that nearly one-half of all recommendations, and nearly 70% of key recommendations, had been implemented three months after the audit. This proportion seems to be higher than that of related studies (e.g., Hirst et al., 1981). The most frequent key recommendations included lighting upgrades, installing power bars, and reducing use of the furnace fan, all of which are known to be large contributors to total electricity use (e.g. Toronto Hydro, 2018) and are relatively simple upgrades to make. Since nearly three-quarters of these key recommendations were implemented, we would expect to see notable reductions across the sample as a whole. Homeowners noted upfront cost, payback, and convenience as reasons for not implementing other audit recommendations, and some noted that these actions would be implemented over time. This is consistent with findings from Gamtessa (2013) who found that retrofit costs and cost savings were the main determinants behind retrofit decisions.

5.2.2. Long-Term Changes

Environmental factors that influence society as a whole, such as electricity prices, public education campaigns, and social attitudes or norms, were explored by comparing total and on-peak consumption data to that of 50 randomly-selected control households. This approach determined consistency between our observed findings and expected findings based on the control group for the majority of the

research sample. We interpret this finding to mean that observed changes in consumption were not largely attributable to environmental factors to which all householders would have been subject.

The first variable we explored was weather as a potentially significant determinant of long-term changes in electricity consumption. Once again, heating and cooling degree days were examined to investigate whether seasonal weather patterns may have contributed to observed changes. Focusing on cooling degree days, we saw that the number of cooling degree days was lower in each of the three impact years compared to the baseline. We speculate that some of the reductions in the first, second, and third impact years may be attributable to those years' relatively cooler summers and reduced need for air-conditioning (and therefore lower demand for electricity). This is supported by Kavousian et al. (2013) who found that cooling degree days were a strong indicator of total consumption. Therefore, it may be reasonable to assume that the observed changes in electricity consumption were attributable – at least in part – to seasonal weather patterns.

The second variable we explored was technical changes. The timing of renovations and major appliance changes were compared to the consumption data to identify possible correlations in consumption patterns for the 11 households that completed the follow-up survey. For some households, changes in appliances help to explain some of the observed changes in consumption. For instance, Household G indicated one refrigerator in use on the 2015 survey, compared to two refrigerators in use on the 2012 survey. Thus, at least part of the 35% decline in electricity consumption may be attributable to the fact that only one refrigerator was now being used. Indeed, studies have shown that refrigerators are one of the largest electricity consuming appliances in the home, and that secondary refrigerators are often older and less efficient models (Kavousian et al., 2013). Similarly, Households A and B indicated an upgrade to their stove/oven; at least part of their electricity reductions – 50% and 26% respectively – may be attributed to the appliance upgrade, as we assume it was replaced with a more energy-efficient model. Findings from the follow-up interviews with six households suggest that the audit played a role in the purchasing decision-making process. Thus, we speculate that the audit contributed, at least indirectly, to some of the electricity reductions via appliance upgrades.

On the other end of the spectrum, some households that noted appliance upgrades also demonstrated increases in electricity consumption, such as Households C, I, and M. In the middle, Households J and K provide interesting cases, as these households each upgraded three appliances but saw only modest reductions in total consumption, though Household K also noted an additional refrigerator in use and a deck renovation. Overall, upgrades to major appliances and renovation activity did not necessarily correlate with reductions in electricity consumption and conversely, large reductions in consumption were not necessarily associated with the replacement of multiple appliances. Thus, we speculate that the audit may have contributed, at least indirectly, to some of the observed consumption changes, but not all.

The third set of variables that was explored were sociodemographics. These were compared with the initial and follow-up surveys for 11 households and with consumption changes to identify any correlations. The three largest observed reductions – across Households A, B, and G – did not seem to be obviously explained by (changes in) sociodemographic variables, at least not entirely. Households A, B, and G ranged greatly in terms of total household income and educational attainment, though all three households were home to retired individuals. This is consistent with findings from Kavousian et al. (2013) who found households with members aged over 55 recorded lower consumption levels. However, Households H, M, and K, which also noted retired individuals at home, did not achieve drastic

reductions, which suggests a more complex interplay among sociodemographic and/or other variables. Households A, B, and G also noted periods of absence for longer than one week, which correlated with decreased consumption during those periods. Therefore, we recommend that studies take vacation and/or other absences into account when analyzing long-term consumption data to ensure that observed decreases in consumption are attributed correctly.

The largest observed increase in consumption seems to be more clearly explained by sociodemographic changes. Household C's consumption increased by nearly 56% compared to baseline, and noted that the family welcomed a new child along with an increase in the numbers of days home during the summer. This is not surprising, as stage of family life is an important predictor of energy consumption, associated with highest consumption during child-rearing years (Frederiks, Stenner, & Hobman, 2015). However, Household E also welcomed a new baby but was able to achieve reductions of about 13%, suggesting that other factors were at play to achieve reductions despite an additional household member. Additionally, Households I and L, which also had increases in consumption, do not have such obvious correlations with sociodemographic changes. Changes to the number of household members in Household K and the age of household members in Household J (specifically, children entering into teenage years) may logically be predicted to correlate with increases in total consumption, as supported by Thøgersen and Grønhøj (2010). However, these households demonstrated modest overall reductions across the three impact years. In these cases, we speculate that the audit – or some other set of factors – had some mediating impact on consumption, as these households sustained electricity reductions despite increases to the number and intensity of electricity users. Overall, we find that specific sociodemographic variables did not singularly explain the observed changes in consumption, consistent with findings from other researchers (e.g., Abrahamse & Steg, 2009; Abrahamse & Steg, 2011). Rather, we speculate that a number of these related variables interacted with one another, and potentially other categories of variables, to lead to the observed changes in consumption.

Social dynamics were the fourth variable we explored during the follow-up interviews. One of the key findings from the six interviews was the role of family dynamics as both a barrier to, and enabler of, conservation efforts; family dynamics also helped to contextualize some of the sociodemographic changes identified in the surveys. As Household J noted, growing children more frequently engaged in electricity-consuming activities (e.g. showers, laptop), though the family was seeking to address these challenges with conservation education within the family as a means to offset those increases. In a related study, Grønhøj and Thøgersen (2011) found that households with teenagers were better able to demonstrate electricity savings following the installation of an energy feedback device in the home, partly due to the establishment of household norms. Alternatively, other households were able to frame conservation and efficiency as co-benefits to existing household norms and preferences. For example, Household B (with reductions of nearly 37%) discussed the couple's preference for fresh food as a motivator to empty and unplug their refrigerator during longer periods of absence. Another key finding was the influence of the audit on awareness and understanding of consumption, and how that helped to shape social practices around appliance use. Some households mentioned unplugging appliances when not in use more frequently to avoid phantom loads, as well as generally being more aware of the consumption of individual appliances. Again, this is consistent with findings from Scott et al. (2016), who talked about the influence of energy audits on knowledge and empowerment to engage in energy-conscious decision-making.

5.3. Exploring the Impact of the Audit

The initial surveys provided some insight into the mechanisms by which the audit may have influenced consumption. Many households noted more electricity-related discussions with family members, especially related to unplugging unused appliances. Many households also noted they had actively researched tips to conserve or shift electricity consumption and had a stronger awareness of specific actions they could take after the audit. Nearly one-half of households also indicated a stronger awareness of electricity costs and monthly kilowatt-hour consumption following the audit. Taken together, we speculate that engaging family members through discussions, researching tips and strategies, and having a greater awareness of appliance-specific consumption and monthly usage and costs were all important variables in the short-term reductions after the audit.

The follow-up interviews provided valuable insight into the causes of the long-term consumption changes that the follow-up survey was unable to capture. While the survey categorized the household as a single unit, the in-depth interviews revealed the importance of household dynamics and individual members within the household. The follow-up interviews also offered clarifications to inconsistencies or anomalies in the survey data, and provided more detail on some of the technical and sociodemographic changes. For example, Household K indicated a deck renovation on the follow-up survey. This data point alone does not necessarily suggest increased consumption, though this household noted that their renovation prompted more frequent social gatherings at their home, which were associated with additional consumption. Nevertheless, this household sustained modest reductions in consumption over three years. We speculate that the electricity audit may have contributed, at least in part, to developing strategies that helped this household manage consumption despite developments that contributed to increased usage.

Ultimately, we found that exploring each variable in isolation painted an incomplete picture of the impacts of the electricity audit, and no single variable (or set of variables) was able to fully explain – nor was entirely independent of – the observed changes in consumption. Rather, we see that applying each of these lenses in sequence helps to offer possible explanations and contextualize the observed changes in a more comprehensive way.

5.4. Limitations

In addition to the small sample size, one limitation of this study is the self-selection bias. Participating households in the study may have already had a propensity toward electricity conservation or efficiency, which may have made them more likely to reduce their electricity consumption following an electricity audit than the broader population. Households that participated in the follow-up interviews may have been among the most engaged with electricity conservation in the research sample, which could have further impacted results. Additionally, nearly two-thirds of the sample already consumed less electricity, on average, than the provincial average (OEB, 2016). To address some of these limitations, future research could focus on obtaining a larger sample size to better represent the entire population and reduce the impact of outliers in calculations.

Another limitation relates to the self-reported data collection from only one household member. As evidenced in the present study and other related works (e.g. Grønhøj & Thøgersen, 2011), interactions between family members has an important role to play in total household consumption, and these nuances can be lost when focusing on survey or interview responses from only one ‘representative’.

Future work could focus on meeting with all members of a household to better understand the complexity of electricity-related behaviours and norms, and how those might be impacted by audits or other energy interventions.

5.5. Conclusions and Future Research

In conclusion, we find that an electricity audit seems to play at least an indirect role in reducing electricity consumption. Households indicated that the audit increased their awareness of appliance-specific consumption and helped to strengthen their understanding of specific actions they could take to manage consumption. However, a myriad of external factors, including weather, environmental factors, technical upgrades, sociodemographic variables, and social dynamics, seemed to play an important role in total consumption and the ability to shift loads away from peak periods. The latter of these variables – particularly technical upgrades and social dynamics – may very well have been impacted by the audit. Future research should focus on a greater understanding of the impact of audits on the complex interplay of variables that influence decision-making, norms and practices, and how that differs on familial and individual scales within a household.

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Appendix A

Electricity Audit Impact Study

Page #1

 Dear Waterloo North Hydro Customer,

My name is Ian Rowlands and I am a professor in the Department of Environment and Resource Studies at the University of Waterloo. A student, Julia Hawthornthwaite, and I are excited to invite you to participate in a project we call the 'Electricity Audit Impact Study'. This project is being conducted in partnership with Waterloo North Hydro, REEP Green Solutions and the Elora Environment Centre. Julia's involvement in this study is helping her complete the requirements for her undergraduate thesis. This project is looking to recruit 20 homeowners in the Waterloo area who are willing to have an electricity audit completed on their home. To help us evaluate the impact of the audit we are also asking homeowners to complete three web-based surveys as part of the study. This letter details the study and what your involvement would entail if you decide to take part.

Study Overview

We are investigating ways to encourage electricity conservation, both in terms of overall usage and peak demand. Historically, electrical energy consumption has been a relatively 'unknown process' – you consumed electricity at a single, prescribed rate and you often did not know how much you were consuming until your bill arrived in the mail. Now, with the introduction of smart meters, time-of-use pricing and other conservation incentives, homeowners have more opportunities to manage their energy consumption.

This project arose out of the partners' respective interests in electricity research. The partners – who have collaborated before in the past – share a common interest in advancing energy sustainability while pursuing specific goals: Waterloo North Hydro has obligations to advance electricity conservation and demand management in our community; REEP Green Solutions and the Elora Environment Centre are particularly interested in community engagement for a sustainable future; and as researchers, we are looking for ways to advance our understanding of the interaction between homeowners and their electricity usage.

The specific roles of each partner in this project are as follows: Waterloo North Hydro has recruited you – one of their customers – to participate in this study; collectively, REEP Green Solutions and the Elora Environment Centre have developed the electricity audit, will conduct the electricity audit, and will generate the electricity audit report for you; and the University of Waterloo researchers will evaluate the impact of the electricity audit in relation to the homeowner's electricity behavior, attitudes, and knowledge.

By participating in this project, we believe you will gain valuable information about electricity usage in your home. If you find the suggestions helpful, and decide to engage in electricity saving behaviour you may see electricity savings reflected on your monthly electric bill. However, these savings may or may not be seen in all cases. This is one of the objectives of the project and will be reported as part of the study results. At the end of the study, you will be asked if you would like a copy of the results. The results are expected to be available in October 2012.

What you will be asked to do?

As a participant in this project, you will be asked to be present at your home during the time of the audit. It is recommended that you follow the Certified Energy Advisor (Advisor) around your home as he/she conducts the audit so that the Advisor can ask you questions about your electricity usage/appliances/etc. The Advisor will take an inventory of everything in your home that uses electricity. This is also a good opportunity for you to gain a better understanding of what an electricity audit entails, and to ask the Advisor questions throughout the process. During the inventory, if applicable, the Advisor will discuss electricity upgrade suggestions as they arise.

The audit will take approximately one to one and a half hours of your time after which the Advisor will review the audit results with you, which could take an additional five to fifteen minutes. In total, the time the Advisor spends at your home could be approximately two hours. The Advisor will walk you through the findings of the audit on a portable tablet while at your home and outline any areas where you may be able to conserve electricity. You are encouraged to ask the Advisor questions if you wish. The Advisor will also e-mail you an electronic copy of the audit report for your household within one week of the audit. If you would prefer a paper copy of the report please contact the REEP office at 519-744-9799. To be able to conduct a comprehensive evaluation of these electricity audits, your home audit report and the information collected to complete the audit as prepared by REEP, will be shared with the researchers from the University of Waterloo. This would include an inventory of your home's major appliances and their electricity usage.

This project also involves asking you to complete three surveys. The first survey is to be completed before the audit is conducted. This survey will ask questions about the number and type of appliances you have in your home such as furnace, dryer, dishwasher, etc. The survey also asks questions such as "In what year did you purchase your home?", and "What do you think consumes the most electricity in your home?" In the first survey, you will also be asked to provide demographic information, such as the number of individuals who live in your home. This information will assist in determining whether particular kinds of households are affected by electricity audits in particular ways and to establish a baseline for measuring any changes in electricity usage as a result of the audit.

The second survey is to be completed within one and half weeks after the audit has been completed. This survey will ask for your feedback on the audit process, for example, "What part of the audit did you find most helpful?"

The third and final survey is to be completed approximately three months following the audit. The third survey will ask you about any electricity saving behaviours you may have engaged in as a result of the audit. It is anticipated that each survey should take you no longer than 20 minutes to complete.

Each of the surveys will be available through a secure website called Fluidsurveys.com with computer servers located in Canada. Your data will be removed from the Fluidsurveys.com website within five business days of your completion of the survey. If you prefer not to complete the surveys on the web, please contact one of the researchers and we will make arrangements to provide you with another method of participation.

Should you decide to participate in this research project, you will be asked to complete the consent form below. Following that, you will be directed to the first of the three surveys. After you complete the first survey, you will, within a few days, be contacted by REEP Green Solutions to arrange a mutually-convenient date and time to conduct the audit. After the audit is completed, you will receive an email from us, the University of Waterloo researchers, asking you to complete the second survey. Approximately three months after that, you will receive another email, asking you to complete the third survey.

As part of our evaluation to assess the impact of the audit on electricity usage over time, we would like your permission to analyze your home's electricity consumption data. We are looking to analyze these data dating back two years (to January 2010) and up to and including data collected until July 2012. REEP Green Solutions, and the Elora Environment Centre, who jointly conduct the audits will also use some of the electricity data collected. Your home's electricity consumption data recorded prior to the audit (dating back to January 2010) will help in conducting the audit and allow the Advisor to provide specific recommendations to you for possible electricity savings. You will be asked in the Consent Form below to allow Waterloo North Hydro to provide the project partners, REEP Green Solutions, the Elora Environment Centre, and the University of Waterloo researchers to have access to your home's electricity consumption data as outlined above.

Participation in this study

Participation in this study is voluntary. You may decline to answer any questions that you do not wish to answer and you can withdraw your participation at any time by contacting the researcher, Dr. Ian Rowlands, or Jeff Quint from Waterloo North Hydro. We expect that up to 20 homeowners will participate in this study. Eligible participants will be selected on a 'first come, first served' basis.

Confidentiality

All personal information collected during the course of this research project is confidential and will not be shared or distributed to any third parties. Only the partners involved in this project will have access to the information and data collected. No individual or household will be personally identified in any way in any written reports, presentations or publications arising from this project. Your name, address or Waterloo North Hydro account number will not be used to identify your data or quotations from the surveys; instead, we will refer to you and your data as 'Household A' (for example). The web site used for the surveys is programmed to collect responses alone and will not collect any additional information such as machine identifiers. The data collected from this study will be maintained on a password-protected computer database in a restricted access area of the university. As well, the data will be electronically archived after completion of the study and maintained for two years and then erased by both the researchers and REEP Green Solutions.

Benefits and risks of participation

We hope one of the benefits you will receive from participating in this study will be a better understanding of the electricity usage of certain appliances in your home and an understanding of overall electricity use in your home. You may also see electricity savings

as a result of your participation in this study reflected on your monthly electric bill; however, these savings may or may not be seen in all cases. There are no known or anticipated risks from participating in this study.

Remuneration

As a thank you for participating in this study, Waterloo North Hydro is pleased to offer you a 100 AirMiles Reward Miles Bonus Card after you complete the third survey. Following the completion of the third survey in this study, Waterloo North Hydro will arrange for the AirMiles Reward Miles to be mailed to your home address.

Further information

To request further information on how to obtain a copy of the study results, or if you are interested in learning more about this area of research, please contact Dr. Ian Rowlands or Julia Hawthornthwaite (contact details below).

Concerns about participation

This study has been reviewed and received ethics clearance through the Office of Research Ethics at the University of Waterloo. However, the final decision about participation is yours. If you have any comments or concerns resulting from your participation in this study, please contact Dr. Susan Sykes, Director, Office of Research Ethics at 519-888-4567 Ext. 36005 or ssykes@uwaterloo.ca.

Sincerely Yours,

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CONSENT TO PARTICIPATE

By completing this online consent form, you are not waiving your legal rights or releasing the project team or involved institution(s) from their legal and professional responsibilities.

I agree to take part in a research study being conducted by Dr. Ian Rowlands and Julia Hawthornthwaite in the Department of Environment and Resource Studies at the University of Waterloo. This research project is being conducted in partnership with Waterloo North Hydro, REEP Green Solutions, and the Elora Environment Centre.

I have made this decision based on the information I have read in the Information Letter. All the procedures, and any risks and benefits have been explained to me. I have had the opportunity to ask any questions and to receive any additional details I wanted about the study. If I have questions later about the study, I can contact one of the researchers or Waterloo North Hydro.

I was informed that I may withdraw from the study at any time without penalty by telling one of the researchers or Waterloo North Hydro.

I am aware that excerpts from the surveys may be included in publications, papers, or reports to come from this research, with the understanding that the quotations will be anonymous.

This project has been reviewed by, and received ethics clearance through, the Office of Research Ethics at the University of Waterloo. I am aware that I may contact Dr. Susan Sykes, Director, Office of Research Ethics at 519-888-4567, ext. 36005 or ssykes@uwaterloo.ca if I have any concerns or questions resulting from my involvement in this study.

 With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

☐ Yes

☐ No

 I agree to the use of anonymous quotations in any thesis or publication that comes of this research.

☐ Yes

☐ No

 Participant name (acts as your electronic signature on this Consent Form):

 Today's date

 CONSENT FORM: ELECTRICAL CONSUMPTION INFORMATION - WATERLOO NORTH HYDRO.

 Your name:

 The last 4 digits of your Waterloo North Hydro account number:

 Your e-mail address:

 Your telephone number:

 Your address (street name and number, city, postal code):

 I agree that WATERLOO NORTH HYDRO can provide the researchers with my electricity consumption data, and that the researchers may share these data with REEP Green Solutions and the Elora Environment Centre for the purposes of this research project

☐ Yes

☐ No

 I am the account holder with Waterloo North Hydro.

If the Participant is NOT the account holder with Waterloo North Hydro, then the account holder must agree to all of the above, and also must agree that the person named above lives in their household and that they allow the named Participant to represent them and their Waterloo North Hydro account in this study.

☐ Yes

☐ No

 I agree, as the account holder of the Waterloo North Hydro account for this household that the Participant named above has my permission to represent my account in this study and to take part in this study

☐ Yes

☐ No

 Waterloo North Hydro account holder name:

 Please click the 'Next' button below to begin the first survey. The survey needs to be completed no later than March 9, 2012. Once you have completed the first survey, REEP will contact you by telephone to arrange a mutually convenient time to schedule the audit. Thank you for your participation in this study!

 PART A: HOUSE CHARACTERISTICS

 A1. What is the size of your home (not including any unfinished basement)?

- ☐ Less than 1000 square feet
- ☐ 1000 - 1499 square feet
- ☐ 1500 - 1999 square feet
- ☐ 1500 - 1999 square feet
- ☐ 2000 - 2499 square feet
- ☐ 2500 - 2999 square feet
- ☐ 3000 - 3499 square feet
- ☐ More than 3500 square feet

 A2. Does your home have a finished basement?

- ☐ Yes
- ☐ No

 A3. What type of home do you currently live in?

- ☐ Apartment
- ☐ Townhouse
- ☐ Semi-detached one story
- ☐ Semi-detached two or more story
- ☐ Detached one story
- ☐ Detached two or more story
- ☐ Detached side-split or back-split
- ☐ Condominium
- ☐ Other, please specify: _____

 A4. What is the main source of energy used for heating your home

main source means greater than 50% of your total energy use

- ☐ Natural Gas
- ☐ Electricity
- ☐ Oil
- ☐ Wood
- ☐ Other, please specify: _____

☒ A5. From the list below, please identify which energy consuming devices you have in your home and how many of each that you currently use (e.g. Fridge: 3)

(If an appliance is shared within a building – e.g., furnace or shared laundry machines – please leave it blank.)

- ☐ Furnace _____
- ☐ Air conditioner _____
- ☐ Clothes washer _____
- ☐ Clothes dryer _____
- ☐ Fridge _____
- ☐ Stove/Oven _____
- ☐ Dishwasher _____
- ☐ Microwave _____
- ☐ Stand alone freezer _____
- ☐ Television _____
- ☐ Personal computer _____
- ☐ Hot tub _____
- ☐ Pool pump _____
- ☐ Pool heater _____
- ☐ Heat recovery ventilator _____

☐ Space heater _____

☐ Dehumidifier _____

☐ Humidifier _____

☐ Entertainment Centre (a unit containing sound and television systems, e.g. stereo, television, speakers, etc.)

☐ Please list any other high-consuming electricity items your house uses (e.g. woodworking tools, pottery equipment, backyard pond pump, etc.) and how many are in use _____

 A6. Have you changed from using a gas appliance to an electric appliance in the last year?

☐ Yes

☐ No

 A7. If Yes, please indicate which appliance has made this change and in what month of the year the change was made? If No, please skip this question.

(The box has unlimited text space. Please write as much as you wish.)

e.g. " Stove-May. " Please use space as needed.

 A8. Have you changed from using an electric appliance to a gas appliance in the last year?

☐ Yes

☐ No

 A9. If Yes, please indicate which appliance has made this change and in what month of the year the change was made? If No, please skip this question.

(The box has unlimited text space. Please write as much as you wish.)

e.g. "Stove - May" Please use space as needed.

PART B: ELECTRICITY AWARENESS

 B1. Please indicate how you perceive your level of awareness with regards to the following.

	Strongly Agree	Agree	Somewh at Agree	Niether Agree nor Disagree	Somewh at Disagree	Disagree	Strongly Disagree	Don't Know
a) I am aware of how much electricity is used by my home each month (in kilowatt hours)	☐	☐	☐	☐	☐	☐	☐	☐
b) I am aware of how much money it costs to use electricity in my home each month	☐	☐	☐	☐	☐	☐	☐	☐
c) I am aware of what I can do to reduce the amount of electricity I consume in an average month	☐	☐	☐	☐	☐	☐	☐	☐

 B2. Please list the top 3 items in your home that you think consume the most electricity (It does not matter in which order you place them. Just list the top 3).

 B3. In which month out of the year do you think you consume the most electricity?

 B4. In which month out of the year do you think you consume the least electricity?

 B5. Are you aware of time-of-use rates and how they apply to the electricity consumption in your home?

- ☐ Yes
☐ No

 B6. Do you know what phantom power is?

- ☐ Yes
☐ No

 B7. Which of the following do you discuss with members of your household (please check all that apply)?

- ☐ Electricity prices
☐ Electricity bills
☐ Environmental aspects of electricity use
☐ Electricity conservation around your household
☐ Turning off lights when leaving a room
☐ Unplugging appliances when they are not in use
☐ Time-of-use rates
☐ Purchasing energy-efficient appliances

- ☐ The pros and cons of energy-efficient appliances
- ☐ Upgrading your furnace to a higher efficiency model
- ☐ Adjusting the thermostat to attempt to use energy efficiently

☒ B8. From which of the following sources do you receive information regarding electricity (please check all that apply)?

- ☐ Waterloo North Hydro bills/letters/e-mails
- ☐ Waterloo North Hydro website
- ☐ A utility company website other than Waterloo North Hydro
- ☐ General websites about electricity
- ☐ Government websites
- ☐ Not-for-profit websites
- ☐ Friends and/or family
- ☐ Social media sites (e.g. Facebook, Twitter, YouTube, Flickr, Tumblr, Pintrest etc)
- ☐ Blog
- ☐ Television
- ☐ Radio
- ☐ Other, please specify: _____

PART C: ELECTRICITY ATTITUDES

 C1. To what extent do the following statements describe your attitudes towards electricity management in your home? (Please indicate one response for each statement in the table below.)

[illegible]

 C2. Are you motivated to conserve electricity?

- ☐ Yes
- ☐ No

 C3. If yes, which of the following motivate you to conserve electricity? (check all that apply). (The box below has unlimited text space. Please write as much as you wish.)

- ☐ Saving money
- ☐ Increasing comfort through, for example, eliminating or reducing drafts
- ☐ Addressing environmental/sustainability concerns
- ☐ Other, please specify:

 C4. Please indicate what best describes your opinion of Ontario's current electricity prices:

Electricity prices in Ontario

 C5. What barriers (if any) do you feel prevent you from decreasing your electricity consumption? For example: convenience, cost, time.

(The box has unlimited text space. Please write as much as you wish.)

If you experience no barriers, please write 'None'.

 C6. Why are you interested in participating in the 'Electricity Audit Impact Study'?

(The box has unlimited text space. Please write as much as you wish.)

 PART D: ELECTRICITY BEHAVIOURS

 D1. Please identify and describe three behaviours you could do around your home -- but are presently not doing around your home -- that may help contribute to a reduction in your home's electricity use. (These boxes have unlimited text space. Please write as much as you wish.)

- 1: _____
- 2: _____
- 3: _____

☒ D2. Which of the following have you done in your home in the past year? (Please check all that apply).

- ☐ Purchased energy saving appliances
- ☐ Purchased and used power bars
- ☐ Purchased a high efficiency furnace
- ☐ Disposed of old/inefficient major appliances
- ☐ Adjusted when you used electricity based on time-of-use rates (i.e. peak price periods)
- ☐ Set lights on timers
- ☐ Turned lights off when exiting a room
- ☐ Unplugged appliances when they are not in use
- ☐ Improved the weatherization of your home (caulking, weather stripping, insulating, repairing windows)
- ☐ Adjusted the thermostat to attempt to use energy efficiently (e.g. lower at night and when house is not occupied)
- ☐ Purchased a high efficiency hot water heater
- ☐ Installed an electricity/energy smart meter
- ☐ Other, please specify: _____

 D3. How do you usually set the temperature on your thermostat?

- ☐ Program it for different temperatures for different times of the day
- ☐ Manually set it for different temperatures at different times of the day
- ☐ Set it seasonally and leave it
- ☐ Other, please specify: _____

PART E: HOUSEHOLD DYNAMICS

☒ E1. During the week (Monday through Friday), at what time of the day is your house generally occupied by members of your household?

- ☐ Morning
☐ Afternoon
☐ Evening
☐ A combination of the above. Please specify: _____

☒ E2. Please select which of the following have occurred in the last year in your household (please check all that apply). In the boxes beside the activity, please provide details about the activity (e.g., the kind of major renovation, when and who moved in/out, the change in appliance inventory, the period the house was unoccupied):

- ☐ Major home renovations _____
☐ An additional person living regularly in your house (e.g., birth of a child, new boarder, child at post-secondary education returns home, parents move in, etc) _____
☐ A reduction in the number of people regularly living your house (e.g., child moves out, boarder moves on, etc.) _____
☐ Purchased major appliance(s) that replaced an existing one(s) _____
☐ Purchased major appliance(s) where you didn't have one before (e.g. purchasing a chest freezer for the first time) _____
☐ Discarded major appliance(s) without purchasing a replacement (e.g. got rid of an old fridge) _____
☐ House unoccupied for one week or more (please indicate the month) _____

☒ E3. Please select which of the following you anticipate to occur in your home over the next 6 months (please check all that apply). In the boxes beside the activity, please provide details about the activity (e.g., the kind of major renovation, when and who will move in/out, the change in appliance inventory, the period the house will be unoccupied):

- ☐ Major home renovations _____
☐ An additional person living regularly in your house (e.g., birth of a child, new boarder, child at post-secondary education returns home, parents move in, etc) _____
☐ A reduction in the number of people regularly living your house (e.g., child moves out, boarder moves on, etc.) _____
☐ Purchase major appliance(s) that replaced an existing one(s) _____
☐ Purchase major appliance(s) where you didn't have one before (e.g. purchasing a chest freezer for the first time) _____
☐ Discard major appliance(s) without purchasing a replacement (e.g. will get rid of an old fridge) _____
☐ House unoccupied for one week or more (please indicate the planned month) _____

 PART F: DEMOGRAPHIC INFORMATION

In this section, we ask for some demographic information regarding yourself and your household. This information will assist us in determining whether particular kinds of households are affected by electricity audits in particular ways. As a reminder, please note that all information obtained in these surveys during the course of this research project is confidential and will not be shared or distributed to any third parties. Only the partners involved in this project will have access to these survey responses and we will immediately remove your personal identification from the data itself. No individual will be personally identified in any way in any written reports, presentations or publications arising from this research.

 F1. Are you a homeowner or a tenant?

- ☐ Homeowner
☐ Tenant
☐ Other, please specify: _____

 F2. In what year was your house constructed? (check only one)

- ☐ Before 1950
☐ 1950 - 1969
☐ 1970 - 1979
☐ 1980 - 1989
☐ 1990 - 1995
☐ 1996 - 2000
☐ 2001 - 2004
☐ 2005 - 2008
☐ After 2008

 F3. How long have you lived in your current home?

 F4. How long do you plan to live in your current home?

(Please provide your best estimate of the year. If you do not know, please write "I don't know".)

 F5. How many people live in your home?

 F6. How many children under the age of 6 live in your home?

 F7. How many children between the ages of 6 and 18 years live in your home?

 F8. How many people over the age of 65 live in your home?

 F9. In what year were you born?

 F10. Please indicate your gender.

- ☐ Male
☐ Female
☐ Prefer not to say

 F11. Are you currently:

- ☐ In school?
- ☐ Working?
- ☐ Retired?
- ☐ Homemaker?
- ☐ Volunteering?
- ☐ Unemployed?
- ☐ Other, please specify: _____

 F12. What is the highest earned certificate, diploma or degree of any individual in your household?

- ☐ No certificate, diploma or degree
- ☐ High school certificate or equivalent
- ☐ Apprenticeship or trades certificate or diploma
- ☐ College, CEGEP or other non-university certificate or diploma
- ☐ University certificate or diploma below bachelor level
- ☐ Bachelor's degree
- ☐ Degree in medicine, dentistry, veterinary medicine or optometry
- ☐ Master's degree
- ☐ Earned doctorate
- ☐ Other, please specify: _____

 F13. What was your total household income (before taxes) last year?

- ☐ Under \$30,000
- ☐ \$30,000 - \$39,000
- ☐ \$40,000 - \$49,000
- ☐ \$50,000 - \$59,000
- ☐ \$60,000 - \$69,000
- ☐ \$70,000 - \$79,000
- ☐ \$80,000 - \$89,000
- ☐ \$90,000 - \$99,999
- ☐ \$100,000 - \$109,999
- ☐ \$110,000 - \$119,999
- ☐ \$120,000 - \$129,999
- ☐ \$130,000 - \$139,999
- ☐ \$140,000 - \$149,999
- ☐ \$150,000 and over
- ☐ I don't know

 Thank you for completing the first survey in the Electricity Audit Impact Study. REEP Green Solutions will contact you shortly by telephone to arrange your household's electricity audit at a mutually convenient time. When the audit is completed, you will receive an e-mail from us (the researchers) with a link to the second survey. Thank you again for your time and participation in this study! If you have any questions about the survey or the study in general, please contact Dr. Ian Rowlands (contact details below).

Ian Rowlands (Supervisor)
Professor, Environment and Resource Studies
University of Waterloo
irowlands@uwaterloo.ca
Tel: 519-888-4567 ext. 32574

Electricity Audit Impact Study- Survey 2

 Welcome to the second survey in the Electricity Audit Impact Study. REEP Green Solutions completed a home electricity audit for you within the past two to three weeks. We are now interested in your feedback. Please make sure you review your audit report before completing this survey.

You will notice that some of the questions you see here are the same as questions in the previous survey; this is to see if your awareness or behaviours related to electricity use have changed as a result of the electricity audit. It is anticipated that this survey should take you no longer than 15 minutes to complete.

PART A: ELECTRICITY ATTITUDES

 A1. To what extent do the following statements describe your attitudes towards electricity use. (Please indicate one response for each statement in the table below.)

[illegible]

PART B: AUDIT KNOWLEDGE, BEHAVIOURS AND ATTITUDES

 B1. To what extent do the following statements describe your attitudes towards the electricity audit you received from REEP Green Solutions. (Please indicate one response for each statement in the table below)

[illegible]

 B2. Please describe the electricity saving and/or conservation suggestions you received from the Advisor, and provide details as to your understanding of their level of difficulty to achieve.

(The box has unlimited text space. Please write as much as you wish.)

 B3. I plan to undertake all or some of the activities suggested to me by the Advisor:

- ☐ Yes, all.
☐ Yes, some.
☐ No

 B4. If you answered yes to the above question, which activities do you plan to undertake? If you answered no, please describe why you do not plan to undertake some or all of the activities suggested to you by the Advisor:

(The box has unlimited text space. Please write as much as you wish.)

 B5. Did the Advisor suggest a range of activities you could do to decrease your electricity consumption (for example, a few that were relatively easy to achieve, one medium difficulty activity, and a few that required a major investment either in time or cost?). If the Advisor provided a range, was it helpful? If the Advisor did not provide a range, would you have liked one? Please use the comment box below:

- ☐ Yes
☐ No



Your comments in response to B5:

 B6. Did you enjoy the audit experience?

- ☐ Yes
☐ No

 B7. If you did enjoy the audit experience, why? And if you did not enjoy the audit experience, why not?

(The box has unlimited text space. Please write as much as you wish.)

 B8. Would you recommend the audit to a friend?

- ☐ Yes
☐ No

 B9. Were you satisfied with the presentation of the audit results (in the report format, which was e-mailed to you after receiving the audit)?

- ☐ Yes
☐ No

 B10. If no, please let us know another way you would have preferred the results to be displayed:

(The box has unlimited text space. Please write as much as you wish.)

 PART C: ELECTRICITY AWARENESS

 C1. Please list the top 3 items in your home that you think consume the most electricity (It does not matter in which order you place them. Just list the top 3).

 C2. In which month out of the year do you think you consume the most electricity?

 C3. In which month out of the year do you think you consume the least electricity?

 C4. Please indicate what best describes your opinion of Ontario's current electricity prices.

	Much too high	High	Acceptable /Appropriate	Low	Much too low	No opinion	Don't know
Electricity prices in Ontario	☐	☐	☐	☐	☐	☐	☐

 C5. What barriers (if any) do you feel prevent you from decreasing your electricity consumption?

(The box has unlimited text space. Please write as much as you wish.)

 C6. Are you aware of time-of-use rates and how they apply to the electricity consumption in your home?

- ☐ Yes
☐ No

 C7. Do you know what phantom power is?

- ☐ Yes
☐ No

 PART D: ELECTRICITY BEHAVIOURS

 D1. Please identify and describe three behaviours you could do around your home -- but are presently not doing around your home -- that may help contribute to a reduction in your home's electricity use.

(These boxes have unlimited text space. Please write as much as you wish.)

1: _____

2: _____

3: _____

 Thank you for completing the second survey in the Electricity Audit Impact Study. In three months time you will be sent via e-mail a link to the third and final survey in this study. We thank you for your participation in this research. If you have any questions about this survey or the study in general, please contact Dr. Ian Rowlands (contact details below).

Ian Rowlands (Supervisor)
Professor, Environment and Resource Studies
University of Waterloo
irowlands@uwaterloo.ca
Tel: 519-888-4567 ext. 32574

Electricity Audit Impact Study - Survey 3

Page #1

 Welcome to the third survey in the Electricity Audit Impact Study. It has been three months since you received your audit report from REEP Green Solutions with your home's personalized suggestions for reducing electricity consumption. We are now interested in your feedback in order to understand what activities you have undergone since receiving these suggestions.

You will notice that some of the questions in this survey are the same as questions in the previous two surveys; this is to see if your awareness, knowledge, attitudes or behaviours related to electricity use have changed. It is anticipated that this survey should take you no longer than 25 minutes to complete.

PART A: HOUSE CHARACTERISTICS

 A1. Have you changed from using a gas appliance to an electric appliance since receiving your electricity audit?

- ☐ Yes
☐ No

 A2. If Yes, please indicate which appliance has made this change and in what month of the year the change was made? If No, please skip this question. e.g. "Stove - May"

(The box has unlimited text space. Please write as much as you wish.)

 A3. Have you changed from using an electric appliance to a gas appliance since receiving your electricity audit?

- ☐ Yes
☐ No

 A4. If Yes, please indicate which appliance has made this change and in what month of the year the change was made? If No, please skip this question. e.g. "Stove - May"

(The box has unlimited text space. Please write as much as you wish.)

PART B: ELECTRICITY AWARENESS

 B1. Please indicate how you perceive your level of awareness with regards to the following. (Please indicate one response for each statement in the table below.)

	Strongly Agree	Agree	Somewh at Agree	Neither Agree nor Disagree	Somewh at Disagree	Disagree	Strongly Disagree	Don't Know
a) I am aware of how much electricity is used by my home each month	☐	☐	☐	☐	☐	☐	☐	☐
b) I am aware of how much money it costs to use electricity in my home each month	☐	☐	☐	☐	☐	☐	☐	☐
c) I am aware of what I can do to reduce the amount of electricity I consume in an average month	☐	☐	☐	☐	☐	☐	☐	☐

 B2. Please list the top 3 items in your home that you think consume the most electricity (It does not matter in which order you place them - just list the top 3.)

 B3. In which month out of the year do you think you consume the most electricity?

 B4. In which month out of the year do you think you consume the least electricity?

 B5. Are you aware of time-of-use rates and how they apply to the electricity consumption in your home?

- ☐ Yes
☐ No

 B6. Do you know what phantom power is?

- ☐ Yes
☐ No

 B7. Which of the following do you discuss with members of your household (please check all that apply)?

- ☐ Electricity prices
☐ Electricity bills
☐ Environmental aspects of electricity use
☐ Electricity conservation around your household
☐ Turning off lights when leaving a room
☐ Unplugging appliances when they are not in use
☐ Time-of-use rates
☐ Purchasing energy-efficient appliances

- ☐ The pros and cons of energy-efficient appliances
- ☐ Upgrading your furnace to a higher efficiency model
- ☐ Adjusting the thermostat to attempt to use energy efficiently
- ☐ Other, please specify: _____

☒ B8. From which of the following sources do you receive information regarding electricity (please check all that apply)?

- ☐ Waterloo North Hydro bills/letters/e-mails
- ☐ Waterloo North Hydro website
- ☐ REEP Green Solutions website
- ☐ A utility company website other than Waterloo North Hydro, please specify (optional) _____
- ☐ General websites about electricity, please specify (optional) _____
- ☐ Government websites, please specify (optional) _____
- ☐ Not-for-profit websites, please specify (optional) _____
- ☐ Friends and/or family
- ☐ Social media sites (e.g. Facebook, Twitter, YouTube, Tumblr, Pintrest etc), please specify (optional) _____
- ☐ Blog, please specify (optional) _____
- ☐ Television, please specify (optional) _____
- ☐ Radio, please specify (optional) _____
- ☐ Other, please specify (optional) _____

 PART C: ELECTRICITY ATTITUDES

 C1. To what extent do the following statements describe your attitudes towards electricity use. (Please indicate one response for each statement in the table below.)

	Strongly Agree	Agree	Somewh at Agree	Neither Agree nor Disagree	Somewh at Disagree	Disagree	Strongly Disagree	Don't Know
a) I am currently making an effort to conserve or reduce my electricity consumption at home	☐	☐	☐	☐	☐	☐	☐	☐
b) I try to reduce my electricity usage during 'on-peak' times (times when the price of electricity is highest)	☐	☐	☐	☐	☐	☐	☐	☐
c) I want to reduce the environmental impact associated with electricity usage	☐	☐	☐	☐	☐	☐	☐	☐
d) I would like to learn more about the amount of electricity my home's appliances consume	☐	☐	☐	☐	☐	☐	☐	☐
e) Finding helpful tips for conserving electricity at home is difficult	☐	☐	☐	☐	☐	☐	☐	☐
f) I have researched strategies and tips on how to conserve electricity in my home	☐	☐	☐	☐	☐	☐	☐	☐

 C2. Please indicate what best describes your opinion of Ontario's current electricity prices.

	Much too high	High	Acceptable/ appropriate	Low	Much too low	No opinion
Electricity prices in Ontario	☐	☐	☐	☐	☐	☐

 C3. What barriers or obstacles (if any) do you feel prevent you from decreasing your electricity consumption? For example: convenience, cost, time. If you experience no barriers, please write 'None'.

(The box has unlimited text space. Please write as much as you wish.)

PART D: AUDIT KNOWLEDGE, BEHAVIOURS AND ATTITUDES

 D1. To what extent do the following statements describe your attitudes towards the electricity audit you received from REEP Green Solutions. (Please indicate one response for each statement in the table below.)

	Strongly Agree	Agree	Somewh at Agree	Neither Agree nor Disagree	Somewh at Disagree	Disagree	Strongly Disagree	Don't Know
a) The audit taught me something I did not know about my home's electricity consumption	☐	☐	☐	☐	☐	☐	☐	☐
b) The audit provided me with useful tips on how to decrease my electricity usage	☐	☐	☐	☐	☐	☐	☐	☐
c) The audit report I received was helpful and/or useful	☐	☐	☐	☐	☐	☐	☐	☐
d) The audit report was confusing to understand	☐	☐	☐	☐	☐	☐	☐	☐
e) I have referred back to the audit report as a resource for electricity reduction strategies	☐	☐	☐	☐	☐	☐	☐	☐

 D2. It has been three months since you received your audit report. Is there any other feedback you would like to provide at this time regarding your experience with the audit?

We are trying to understand how the audit can encourage Ontario householders to achieve electricity conservation and reduction goals, so any additional reactions you have are appreciated.

(The box has unlimited text space. Please write as much as you wish.)

 D3. You received an audit report from Don Eaton on March 28 2012. In this report Don gave you 14 electricity saving behaviours you could do around your home. How many would you estimate that you have achieved at this point in time? (Please indicate a number out of 14 in the text box below.)

 D4. In your audit report, Don highlighted four key activities for you on the first page. These four suggestions are listed below in questions D4. a) - d). For each suggestion, you will be asked to answer three questions.

 D4. a) Audit report suggestion: "Turn off your furnace fan. Your home should be comfortable without running the fan continuously. I suggest turning it to "auto" so it will only run when the furnace or the Air conditioning is on. This is a Zero cost measure with a great return on energy savings and money." Please respond to the following questions in relation to the audit report suggestion:

1) Did you make a change in your home in response to this suggestion? If 'yes', what did you do? If 'no', please write 'no'.

2) If 'yes', why did you decide to do this activity? If 'no', why did you not make a change in response to this suggestion?

3) As appropriate, do you plan to continue to follow this suggestion in the future? Why or why not?

(The box has unlimited text space. Please write as much as you wish.)

 D4. b) Audit report suggestion: "Install and use a power bar on the entertainment centre. This is low cost and effective".

Please respond to the following questions in relation to the audit report suggestion:

1) Did you make a change in your home in response to this suggestion? If 'yes', what did you do? If 'no', please write 'no'.

2) If 'yes', why did you decide to do this activity? If 'no', why did you not make a change in response to this suggestion?

3) As appropriate, do you plan to continue to follow this suggestion in the future? Why or why not?

(The box has unlimited text space. Please write as much as you wish.)

 D4. c) Audit report suggestion: "Replace the incandescent bulbs that are frequently used (as indicated in the upgrades)."

Please respond to the following questions in relation to the audit report suggestion:

1) Did you make a change in your home in response to this suggestion? If 'yes', what did you do? If 'no', please write 'no'.

2) If 'yes', why did you decide to do this activity? If 'no', why did you not make a change in response to this suggestion?

3) As appropriate, do you plan to continue to follow this suggestion in the future? Why or why not?

(The box has unlimited text space. Please write as much as you wish.)

 D4. d) Audit report suggestion: "Replace the incandescent bulbs that are not frequently used as needed. I suggest keeping a 27 watt and 13 watt CFL on hand to facilitate the change."

Please respond to the following questions in relation to the audit report suggestion:

1) Did you make a change in your home in response to this suggestion? If 'yes', what did you do? If 'no', please write 'no'.

2) If 'yes', why did you decide to do this activity? If 'no', why did you not make a change in response to this suggestion?

3) As appropriate, do you plan to continue to follow this suggestion in the future? Why or why not?

(The box has unlimited text space. Please write as much as you wish.)

 D5. Have you engaged in any other electricity saving activities since receiving your audit (different from the ones you have discussed in question D4) - that you were not engaging in before? Please describe any behaviours in the text box below.

(The box has unlimited text space. Please write as much as you wish.)

 D6. Are you motivated to conserve electricity into the future?

- ☐ Yes
☐ No

 D7. If you responded "Yes" to D6, which of the following motivate you to conserve electricity into the future? (please check all that apply.)

- ☐ Saving money
☐ Increasing comfort through, for example, eliminating or reducing drafts
☐ Addressing environmental/sustainability concerns
☐ Other, please specify: _____

 D8. Knowing what you know now about the electricity audit, what do you think would be a 'fair' price for homeowners to pay for it? What price would be 'too low', and what price would be 'too high'? Please indicate dollar amounts in the text boxes below.

Too low (\$) _____
Fair (\$) _____
Too high (\$) _____

 PART E: HOUSEHOLD DYNAMICS

 E1. Please select which of the following have occurred in your household since you received the audit from REEP Green Solutions (please check all that apply). In the boxes beside the activity, please provide details about the activity (e.g., the kind of major renovation, when and who moved in/out, the change in appliance inventory, the period the house was unoccupied, etc.):

- ☐ Major home renovations _____
- ☐ An additional person living regularly in your house (e.g., birth of a child, new boarder, child at post-secondary education returns home, parents move in, etc.) _____
- ☐ A reduction in the number of people regularly living your house (e.g., child moves out, boarder moves on, etc.) _____
- ☐ Purchased major appliance(s) that replaced an existing one(s) _____
- ☐ Purchased major appliance(s) where you didn't have one before (e.g. purchasing a chest freezer for the first time.) _____
- ☐ Discarded major appliance(s) without purchasing a replacement (e.g. got rid of an old fridge.) _____
- ☐ House unoccupied for one week or more (please indicate the month.) _____

 Thank you for completing the third and final survey in the Electricity Audit Impact Study. You will receive your Air Miles Bonus Card for 100 Air Miles shortly by mail from Waterloo North Hydro as our thank you for your participation in this study. If you have any questions about the survey or the study in general, please contact Dr. Ian Rowlands (contact details below.) Thank you again for your participation and commitment to this study!

Ian Rowlands (Supervisor) Professor, Environment and Resource Studies University of Waterloo irowlands@uwaterloo.ca Tel: 519-888-4567 ext. 32574

Electricity Audit Impact Study Extension

There are 29 questions in this survey

Consent

[]

Consent to Participate

If you agree to the following statements, please select 'I agree,' below.

By agreeing to the contents of this consent form, you are not waiving your legal rights or releasing the project team or involved institution(s) from their legal and professional responsibilities.

I agree to take part in a research study being conducted by Dr. Ian Rowlands in the Department of Environment and Resource Studies at the University of Waterloo. This research project is being conducted in partnership with Waterloo North Hydro.

I am aware that after agreeing to participate in this research project, my input from a survey I filled out as part of the *Electricity Audit Impact Study* in 2012 will be linked to results of the survey that I complete as a part of this project, as well as to my electricity consumption data between March 2010 and August 2015.

I was informed that I may withdraw from the study at any time without penalty by telling one of the researchers or Waterloo North Hydro.

I am aware that excerpts from the survey and/or interview may be included in publications, papers, or reports to come from this research, with the understanding that the quotations will be anonymous.

I have made this decision based on the information I have read in the Information Email that directed me to this survey. All the procedures, and any risks and benefits have been explained to me. I have had the opportunity to ask any questions and to receive any additional details I wanted about the study. If I have questions later about the study, I can contact one of the researchers or Waterloo North Hydro.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee. However, the final decision about participation is yours. If you have any comments or concerns resulting from your participation in this study, please contact Dr. Maureen Nummelin, Chief Ethics Officer, Office of Research Ethics at 519-888-4567 Ext. 36005 or mnummelin@uwaterloo.ca.

Please choose only one of the following:

- ☐ *I agree*
- ☐ *I do not agree*

[]

Thank you for choosing to participate in our research project. As a part of our analysis, we will be linking your survey responses from our past project with both the information that you fill out here, as well as your electricity consumption data for a period beginning in March 2010 and ending in August 2015.

To do this, we will match your address provided here with the one provided in your past survey response. If you have moved since you completed the last survey (March - May 2012), please indicate this by typing "moved" into the address field, along with your current address.

Please note: we will also use this address data to mail you your \$20.00 gift certificate.

Only answer this question if the following conditions are met:

Answer was 'I agree' at question '1 [D1]' (Consent to Participate If you agree to the following statements, please select 'I agree,' below. By agreeing to the contents of this consent form, you are not waiving your legal rights or releasing the project team or involved institution(s) from their legal and professional responsibilities. I agree to take part in a research study being conducted by Dr. Ian Rowlands in the Department of Environment and Resource Studies at the University of Waterloo. This research project is being conducted in partnership with Waterloo North Hydro. I am aware that after agreeing to participate in this research project, my input from a survey I filled out as part of the Electricity Audit Impact Study in 2012 will be linked to results of the survey that I complete as a part of this project, as well as to my electricity consumption data between March 2010 and August 2015. I was informed that I may withdraw from the study at any time without penalty by telling one of the researchers or Waterloo North Hydro. I am aware that excerpts from the survey and/or interview may be included in publications, papers, or reports to come from this research, with the understanding that the quotations will be anonymous. I have made this decision based on the information I have read in the Information Email that directed me to this survey. All the procedures, and any risks and benefits have been explained to me. I have had the opportunity to ask any questions and to receive any additional details I wanted about the study. If I have questions later about the study, I can contact one of the researchers or Waterloo North Hydro. This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee. However, the final decision about participation is yours. If you have any comments or concerns resulting from your participation in this study, please contact Dr. Maureen Nummelin, Chief Ethics Officer, Office of Research Ethics at 519-888-4567 Ext. 36005 or mnummelin@uwaterloo.ca.)

Please write your answer(s) here:

Your address (street name and number, city, postal code):

[] Please choose which store you would like your \$20.00 gift certificate to be associated with:

Only answer this question if the following conditions are met:

Answer was 'I agree' at question '1 [D1]' (Consent to Participate If you agree to the following statements, please select 'I agree,' below. By agreeing to the contents of this consent form, you are not waiving your legal rights or releasing the project team or involved institution(s) from their legal and professional responsibilities. I agree to take part in a research study being conducted by Dr. Ian Rowlands in the Department of Environment and Resource Studies at the University of Waterloo. This research project is being conducted in partnership with Waterloo North Hydro. I am aware that after agreeing to participate in this research project, my input from a survey I filled out as part of the Electricity Audit Impact Study in 2012 will be linked to results of the survey that I complete as a part of this project, as well as to my electricity consumption data between March 2010 and August 2015. I was informed that I may withdraw from the study at any time without penalty by telling one of the researchers or Waterloo North Hydro. I am aware that excerpts from the survey and/or interview may be included in publications, papers, or reports to come from this research, with the understanding that the quotations will be anonymous. I have made this decision based on the information I have read in the Information Email that directed me to this survey. All the procedures, and any risks and benefits have been explained to me. I have had the opportunity to ask any questions and to receive any additional details I wanted about the study. If I have questions later about the study, I can contact one of the researchers or Waterloo North Hydro. This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee. However, the final decision about participation is yours. If you have any comments or concerns resulting from your participation in this study, please contact Dr. Maureen Nummelin, Chief Ethics Officer, Office of Research Ethics at 519-888-4567 Ext. 36005 or mnummelin@uwaterloo.ca.)

Please choose only one of the following:

- ☐ Loblaw
- ☐ Sobeys
- ☐ Home Depot
- ☐ Rona

Appliance Questions

[] From the list below, please select which energy consuming devices you have in your home. In the textbox beside each device, please indicate the number of devices that are currently in use.

Comment only when you choose an answer.

Please choose all that apply and provide a comment:

☐ Furnace	
☐ Central air conditioner	
☐ Window or standalone air conditioner	
☐ Clothes washer	
☐ Clothes dryer	
☐ Fridge and/or Fridge/Freezer combo	
☐ Stove/oven	
☐ Dishwasher	
☐ Stand alone freezer	
☐ Hot tub	
☐ Pool	
☐ Hot water tank/Water Heater	

[]

From the list below, please select which energy consuming devices have been upgraded and/or replaced between March 2010 and August 2015. Please indicate the month and year during which the device was upgraded/replaced, and the number of units that were upgraded/replaced. If possible, please also include the specific date on which the device was installed or upgraded.

Please note: We will be asking the same question, except relating to energy consuming devices that were newly installed, rather than upgraded/replaced, in the next question.

Comment only when you choose an answer.

Please choose all that apply and provide a comment:

☐ Furnace

☐ Central air conditioner

☐ Window or standalone air conditioner

☐ Clothes washer

☐ Clothes dryer

☐ Fridge and/or Fridge/Freezer combo

☐ Stove/oven

☐ Dishwasher

☐ Stand alone freezer

☐ Hot tub

☐ Pool

☐ Hot water tank/Water Heater

[]

From the list below, please select which energy consuming devices have been newly installed between March 2010 and August 2015. Please indicate the month and year during which the device was installed. If possible, please also include the specific date on which the device was installed or upgraded.

For this question, please only consider energy consuming devices that had not previously been operating in your home. For example, if you replaced a central air conditioner unit, please do not include this here. However, please do consider multiples of devices that have been installed in your home. For example, if you installed a secondary refrigerator, please include this here. If more than one device was installed (e.g. three refrigerators), please include installation dates for each.

Comment only when you choose an answer.

Please choose all that apply and provide a comment:

☐ Furnace☐ Central air conditioner☐ Window or standalone air conditioner☐ Clothes washer☐ Clothes dryer☐ Fridge and/or Fridge/Freezer combo☐ Stove/oven☐ Dishwasher☐ Stand alone freezer☐ Hot tub☐ Pool☐ Hot water tank/Water Heater

[]

Did you change from using a gas appliance to an electric appliance between March 2010 and August 2015?

Please choose only one of the following:

☐ Yes

☐ No

[]

**Please indicate which appliance has made this change and in what month and year the change was made.
Please separate multiple entries (e.g. more than one appliance switched over) with a semicolon.**

If possible, please enter the exact date on which the appliance was changed.

Only answer this question if the following conditions are met:

Answer was 'Yes' at question '7 [A4]' (Did you change from using a gas appliance to an electric appliance between March 2010 and August 2015?)

Please write your answer here:

[] Did you change from using an electric appliance to a gas appliance between March 2010 and August 2015?

*Please choose **only one** of the following:*

☐ Yes

☐ No

[]

Please indicate which appliance has made this change and in what month and year the change was made. Please separate multiple entries (e.g. more than one appliance switched over) with a semicolon.

If possible, please enter the exact date on which the appliance was changed.

Only answer this question if the following conditions are met:

Answer was 'Yes' at question '9 [A6]' (Did you change from using an electric appliance to a gas appliance between March 2010 and August 2015?)

Please write your answer here:

Household Characteristics

[]What is the size of your home (not including any unfinished basement) in square feet?

Please choose only one of the following:

- ☐ *Less than 1000*
- ☐ *1000-1499*
- ☐ *1500-1999*
- ☐ *2000-2499*
- ☐ *2500-2999*
- ☐ *3000-3499*
- ☐ *More than 3500*

[]Does your home have a finished basement?

Please choose only one of the following:

- ☐ *Yes*
- ☐ *No*

[]

Has the main source of energy used to heat your home changed between March 2010 and August 2015?

Main source means greater than 50% of your total energy use.

Please choose only one of the following:

☐ Yes

☐ No

[]If yes, please indicate the source that your home used to be heated with as well as the source that you switched to. Further, please include the month and year during which this change occurred. If possible, please indicate the exact date on which the change occurred.

For multiple changes, please separate responses using a semi-colon.

Only answer this question if the following conditions are met:

Answer was 'Yes' at question '13 [B4]' (Has the main source of energy used to heat your home changed between March 2010 and August 2015? Main source means greater than 50% of your total energy use.)

Please write your answer(s) here:

Heating energy source before change (Natural Gas, Electricity, Wood, Oil, etc):

Heating energy source after change (Natural Gas, Electricity, Wood, Oil, etc):

Date(s) of heating energy source change:

[]

During the week (Monday through Friday), at what time of the day is your house generally occupied by members of your household?

Please feel free to combine multiple time periods and include specific times and details in the accompanying text boxes.

Comment only when you choose an answer.

Please choose all that apply and provide a comment:

☐ Morning

☐ Afternoon

☐ Evening

[] Please select which of the following have occurred between March 2010 and August 2015 in your household (please check all that apply). In the boxes beside the activity, please provide details about the activity (e.g. the kind of major renovation, when and who moved in/out, the change in appliance inventory, the period the house was unoccupied):

Comment only when you choose an answer.

Please choose all that apply and provide a comment:

- ☐ *Major Home Renovations*
- ☐ *An additional person living regularly in your house (e.g. birth of a child, new boarder, child at post-secondary education returns home, parents move in, etc.)*
- ☐ *A reduction in the number of people regularly living in your house (e.g. child moves out, boarder moves on, etc.)*
- ☐ *Discarded major appliance(s) without purchasing a replacement (e.g. got rid of an old fridge)*
- ☐ *House unoccupied for one week or more (please indicate the start and end date of the week and the year)*

[]**How long do you plan to live in your current home?****Please provide your best estimate of the year. If you do not know, please write "I don't know."***Please write your answer here:***[]How many people live in your home?***Please write your answer here:***[]How many children under the age of 6 live in your home?***Please write your answer here:*

[]How many children between the ages of 6 and 18 years live in your home?

Please write your answer here:

[]

How many people over the age of 65 live in your home?

Please write your answer here:

[]In what year were you born?

Please write your answer here:

[]Please indicate your gender. If you would prefer not to say, please leave this question blank.

Please write your answer here:

[]Are you currently:

Please choose **all** that apply:

- ☐ In school?
- ☐ Working?
- ☐ Retired?
- ☐ Homemaker?
- ☐ Volunteering?
- ☐ Unemployed?
- ☐ Other:

[]What is the highest earned certificate, diploma, or degree of any individual in your household?

Please choose **only one** of the following:

- ☐ No certificate, diploma, or degree
- ☐ High school certificate or equivalent
- ☐ Apprenticeship or trades certificate or diploma
- ☐ College, CEGEP or other non-university certificate or diploma
- ☐ University certificate or diploma below bachelor level
- ☐ Bachelor's degree
- ☐ Degree in medicine, dentistry, veterinary medicine, or optometry
- ☐ Master's degree
- ☐ Earned doctorate
- ☐ Other

[]What was your total household income (before taxes) last year?

Please choose **only one** of the following:

- ☐ Under \$30,000
- ☐ \$30,000 - \$39,999
- ☐ \$40,000 - \$49,999
- ☐ \$50,000 - \$59,999
- ☐ \$60,000 - \$69,999
- ☐ \$70,000 - \$79,999
- ☐ \$80,000 - \$89,999
- ☐ \$90,000 - \$99,999
- ☐ \$100,000 - \$109,999
- ☐ \$110,000 - \$119,999
- ☐ \$120,000 - \$129,999
- ☐ \$130,000 - \$139,999
- ☐ \$140,000 - \$149,999
- ☐ \$150,000 and over
- ☐ I don't know

Telephone Interview

[]

Thank you for your participation in our research project. In the next few months we will also be conducting follow up telephone interviews with representatives from the 17 households that participated in this online survey. Interviews will take approximately 30 minutes and will help us develop a more in depth understanding of the audit's impact on your household's electricity consumption over time.

Would you, or a different adult household member in your home, be willing to participate in a follow up telephone interview? If you select yes, you will be added to a pool of potential interview participants. In September 2015 the project team will review the results of the survey and select a representative sample from the pool of potential interview participants. At this time, we will contact you to let you know if you have been chosen for an interview or not.

Please choose only one of the following:

- ☐ yes
- ☐ no

[]

Thank you for agreeing to participate in follow up interviews. Please provide us with your name, preferred contact information, and the best times at which you could be reached for an interview (e.g. weekday evenings between 7 and 8, etc).

Only answer this question if the following conditions are met:

Answer was 'yes' at question '27 [E1]' (Thank you for your participation in our research project. In the next few months we will also be conducting follow up telephone interviews with representatives from the 17 households that participated in this online survey. Interviews will take approximately 30 minutes and will help us develop a more in depth understanding of the audit's impact on your household's electricity consumption over time. Would you, or a different adult household member in your home, be willing to participate in a follow up telephone interview? If you select yes, you will be added to a pool of potential interview participants. In September 2015 the project team will review the results of the survey and select a representative sample from the pool of potential interview participants. At this time, we will contact you to let you know if you have been chosen for an interview or not.)

Please write your answer(s) here:

Name:

Preferred Contact Information (e.g. email address, telephone number, etc):

Best time for an interview:

End

[]

We would like to thank you for your participation in this survey.

If you are interested in viewing the results of this research project, they can be made available to participants in August 2016.

Please remember that the information provided here is confidential, and that the results will be anonymized and will not contain any direct or indirect identifiers of you or any household members.

This study has been reviewed and received ethics clearance through the Office of Research Ethics at the University of Waterloo. If you have any comments or concerns resulting from your participation in this study, please contact Dr. Maureen Nummelin, Chief Ethics Officer, Office of Research Ethics at 519-888-4567 Ext. 36005 or mnummelin@uwaterloo.ca

Sincerely Yours,

Ian Rowlands (Principal Investigator)

Professor, Environment and Resource Studies, University of Waterloo

Tel: 519-888-4567 ext. 32574

irowlands@uwaterloo.ca

*Submit your survey.
Thank you for completing this survey.*

Researcher: My name is Andrea Bale and I am a Master's student from the University of Waterloo, working with Prof. Ian Rowlands. I'm calling about the Electricity Audit Impact Study that we emailed about last week.

As a reminder, we're interested in how the electricity audit has impacted your household's electricity-related practices since you received the audit 4 years ago. We are greatly appreciative of your time. The interview should take approximately 10-15 minutes of your time.

Before we begin, I would like to ask you a few questions about recording and using the data collected during this interview. [Record answers for each participant]

1. Do you agree to participate in this interview?
2. Do you agree to have the interview recorded for transcription purposes?
3. Do you agree to the use of anonymized quotations in any publication that may come out of this research?

With your permission, I'll turn the tape recorder on now. [Turn on tape recorder] ... I'm going to put you on speakerphone, but I want to assure that you no one else is in the room. I'm also going to be taking some notes by hand, so you may hear that in the background.

Before we get started, do you have any questions? ... Great, then let's get started!

I'm going to start off with some general questions about the electricity audit in March 2012 and how it has impacted your household's electricity-related practices.

1. To what extent do you remember your electricity audit?

2. Do you still have your audit report?

- a. Do you ever look back at your audit report?
 - i. *If yes: How often/how frequently do you look back at your audit report?*
- b. When was the last time you looked at your report?
- c. Was the audit report shared with all members of the household?

3. With regard to your electricity use in the home, are you doing anything differently because of the audit?

- a. Have any of your daily practices changed because of the audit?
 - i. *Can you give me a specific example or two of daily practices that you have changed?*
- b. What was it about the audit that impacted these practices?
 - i. *Prompts: providing ideas of how to change, providing you with information you didn't know before, increased your level of awareness*

c. Has the audit impacted the electricity practices of other members of your household?

i. If so, how do you think the audit has had an impact?

ii. If not, why do you think that is?

1. Is there anything about the audit that could have been done differently that might have been more impactful to the other members of your household?

4. Did you perform any one-off changes because of the electricity audit? (For example, installing a timer)

We're also interested in how electricity audits may impact household purchasing decisions of electrical appliances and accessories. Based on this theme, I'd like to ask you some questions based on some information from the survey you completed last [October].

5. On this survey, you noted some changes to appliances in your household.

a. Specifically, you indicated that you upgraded your [appliance].

i. Do you know, approximately, when you upgraded/replaced your [appliance]?

ii. Did the audit impact this decision at all?

iii. Did you consider more energy efficient options?

6. Thinking about any future appliance purchases your household may make, do you think the audit will have any impact on your decision-making?

a. If so, in what way?

7. Do you feel as though the audit has had a lasting impact on small appliances or electrical accessories you have purchased over the past 3 years?

a. If so, in what way?

8. Do you feel as though the audit has had a lasting impact on the types of lightbulbs you have purchased over the past 3 years?

b. If so, in what way?

Another theme we are interested in exploring is how electricity audits may impact household awareness and understanding of electricity consumption.

9. How would you characterize your level of awareness of your electricity consumption?

- a. Do you look at your utility bills? Do you look at your consumption data online?
- b. Has the audit impacted your awareness of your household's electricity consumption? How?

10. How would you characterize your level of understanding of your electricity consumption?

- a. Do you have a sense of what the major contributors are when you look at your month-to-month consumption?
- b. Has the audit impacted your understanding of your household's electricity consumption? How?

11. How do you think your electricity consumption has changed – if at all – since the audit?

Part of our analysis involves looking at trends in your electricity consumption patterns over the last 3 years and exploring the factors that may have influenced your electricity usage. The next few questions are related to specific periods over the last 3 years where your consumption has shown notable changes from the previous year.

12. In [month/year], your electricity consumption showed [change] compared to the previous year.

Were there any particular events occurring during [month/year] that may have resulted in shifts in consumption?

13. We're also interested in talking about time-of-use consumption. Does your household intentionally engage in any strategies to shift consumption to off-peak periods?

- a. Do you have any specific examples?

14. Do you think your household faces any particular challenges in moving to off versus on-peak electricity consumption?

15. From [month/year], your on-peak consumption decreased compared to the previous year. Were you doing anything specific to move consumption away from on-peak periods?

- 16. In spite of having the electricity audit, what – if anything – continues to be a challenge to electricity conservation in your home?**
- 17. With regard to your electricity use outside of the home, are you doing anything differently because of the audit? (eg. at work, when visiting friends or family, etc.)**
- a. What was it about the audit that impacted these practices?
 - i. Prompts: providing ideas of how to change, providing you with information you didn't know before, increased your level of awareness*
- 18. Have you encouraged anyone to complete an electricity audit since completing your own?**
- a. Have you encouraged anyone re: electricity consumption/conservation in other ways since the audit?
- 19. Based on your overall experience with the electricity audit, are there any changes that you would suggest to the audit process? More specifically, would you suggest any changes to the:**
- a. Walk-through inspection?
 - b. Audit report?
 - c. Follow-up from the auditor?
- 20. Are there any other comments you would like to add about how the audit has impacted your household over the last 3 years?**

That's all the questions that I have for you today. Do you have any questions for me? ... We'd like to thank you so much for your time during this interview. If you would like a summary when the final report becomes available, please email Prof. Ian Rowlands. If you have any questions, please feel free to call or email Prof. Rowlands or myself. I hope you have a wonderful day!