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Abstract

With the envisioned growth in the residential electricity demand and increased share of intermittent renewables in the supply mix, consumers will need to be better informed about their electricity consumption and to play an active role in managing their electricity use. However, consumer inattention and lack of information are ubiquitous, especially in household energy-related settings. Thus, by using a novel survey and actual monthly electricity consumption data, this study set out to measure the level of awareness about electricity bills, prices, and costs among some Finnish households – as captured by the answers to six questions – and to investigate whether higher levels of 'electricity awareness' are associated with electricity savings. In addition, this study analyzes the willingness to receive extra information about energy consumption and savings and how it differs between 'electricity aware' and 'electricity unaware' respondents. The results indicate low levels of 'electricity awareness' among the respondents of the survey. Compared to the respondents with little knowledge about electricity bills, prices, and costs, the respondents with higher levels of 'electricity awareness' tend to consume less electricity. Higher levels of awareness about electricity use and consumption might "materialize" inconspicuous consumption patterns, as opposed to more general facts about the largely invisible environmental consequences of everyday practices. More than two-thirds of the total number of respondents would like to receive additional information about energy consumption and how to save energy. However, there exists a significant portion of 'electricity unaware' respondents who are not only unwilling to receive such information but are also unaware of their own knowledge deficits. To maximize the impact of any information strategy, decision-makers should attempt to engage with this type of consumer; by becoming more aware of their knowledge deficits, people might become more receptive to information that can benefit them.

Keywords: electricity awareness; electricity demand; information; self-assessment; residential buildings; Finnish households.

1. Introduction

The key economic assumption that all individuals are fully informed is often contradicted in the real world, especially in household energy-related settings. Since energy is intangible and composes only a modest share of household budgets, albeit constant and unavoidable, it is difficult for consumers to know how their daily habits translate into energy consumption, and it may be rational for them not to invest the time and effort to resolve this uncertainty (Jessoe and Rapson, 2014; Ramos et al., 2015). In addition, energy is not consumed for its own sake but is 'derived demand' that is bound up within the doings and sayings of everyday life (Grønhøj and Thøgersen, 2011; Shove et al., 2012). Thus, information provision about electricity use and cost is intended to make consumers more energy conscious, encourage them to make decisions to change their energy-use behaviors, and thereby reduce their consumption. Regardless of the form, timing, and context of the feedback, there is a clear consensus in the literature that information provision is not a sufficient but necessary condition for action to reduce electricity demand, as most consumers have little or no knowledge about their electricity use and consumption, which prevents them from making 'optimal' choices (Darby, 2006; Fischer, 2008; Delmas et al., 2013; Karlin et al., 2015; Hargreaves, 2018).

Recent technological advancements in the energy market offer the potential for closing the gap between the lack of awareness and action towards energy-saving behaviors by making energy more visible and removing the information acquisition costs. Therefore, the vast majority of research has recently focused on the impact on reducing electricity consumption of real-time information feedback to households via an in-home display (IHD); several studies report electricity savings ranging from 8% to 22% (Grønhøj and Thøgersen, 2011; Jessoe and Rapson, 2014; Lynham et al., 2016; Aydin et al., 2018), while others show that display feedback does not necessarily contribute to lower electricity use (Nilsson et al., 2014; Schultz et al., 2015; Matsukawa, 2018). Despite being very valuable, these studies represent only a niche subset of the population and are set up under 'ideal conditions', which may bias the results and lead to overestimates (Buchanan et al., 2015). First, they are targeted towards households already interested in reducing electricity consumption, who are willing to receive information about their electricity use and learn from the monitor (Wallenborn et al., 2011; Murtagh et al., 2014). Second, according to the 'Hawthorne effect', the participants in these types of experiments might save electricity not because of information provision but just because of the feeling of being observed (Schwartz et al., 2013). In addition, IHDs are far from widespread in the residential sector, and security concerns combined with privacy issues raise doubts about their future large-scale implementation (Wallenborn et al., 2011).

In this context, by using survey data collected in Finland between 2016 and 2017, this study provides the first assessment and investigation of the relationship between awareness about electricity bills, prices, and operating costs of appliances with domestic electricity consumption in a nonexperimental setting. Here, households do not actively participate in an experiment and can be expected to be more similar to a 'normal' population. In this study, awareness (or knowledge) of the electricity use and consumption refers to the consumers' attention and understanding of electricity bills, prices, and costs, and its role in influencing electricity-saving behaviors. A score obtained from the answers to six questions about electricity bills, prices, and costs is used to capture the level of 'electricity awareness' among the respondents of the survey. In addition, this study analyzes the willingness to receive extra information about energy consumption and savings and how it differs between less and more 'electricity aware' respondents.

Finland is a compelling case to analyze as the domestic electricity consumption has increased by 54.2% over the last 30 years (Eurostat, 2019a), and the electricity prices for consumers are among the cheapest in the EU (Eurostat, 2019b), thus undermining incentives to reduce (and to be informed about) electricity consumption (Trotta, 2020a). The national roll-out of smart meters completed in 2014 (Heiskanen and Matschoss, 2016), enabled the provision of more sophisticated pricing structures to households, including real-time pricing (Ruokamo et al., 2019). Nevertheless, there seems to exist a trade-off between the complexity of the tariff model and the engagement of households in demand-response programs (Grünewald et al., 2015; Trotta, 2020b); for instance, only 9% of households had a dynamic electricity price supply contract in Finland in 2017 (Energy Authority, 2018). In the context of the evolution of the electricity market and the strengthening of the role of consumers, higher levels of awareness about electricity use, consumption, and prices could, in principle, enhance the attractiveness of complex tariff structures and increase the potential for demand-side flexibility (Hall et al., 2016; Alberini et al., 2019; Prest, 2020).

The remainder of this paper is organized as follows: Section 2 introduces the theoretical framework and presents the research hypotheses. Section 3 describes the data and methodologies used for the Finnish case study. The results are presented and discussed in Section 4. Section 5 concludes by providing conservation implications and directions for future research.

2. Theoretical framework and hypotheses

Real decisions often deviate from what is strictly rational. The research in psychology, behavioral economics, and consumer behavior has shown that consumers usually display "bounded rationality" in decision-making, which means that they are constrained by limited knowledge, resources, and time, and are not always able to acquire and process all the necessary information to trade-off the various available alternatives (Simon, 1955; Kahneman, 2003; Reisch and Thøgersen, 2017). As a result, consumers may not act to the best of their interests (Reisch and Zhao, 2017). The literature in the field

of bounded rationality is extensive, and it covers a wide variety of domains and issues, including energy consumption and efficiency (DellaVigna, 2009; Palmer and Walls, 2015; Blasch et al., 2017). Research in energy consumption and efficiency suggests that energy conservation may not be high on the list of priorities of consumers and that the lack of salience leads to underestimating the energy costs, which, in turn, leads to higher electricity consumption (Allcott, 2011a; Costa and Kahn, 2013; Sexton, 2015). Further, the intangibility of energy makes it difficult for households to know how their behaviors and everyday practices translate into energy consumption and savings.

Many studies have documented lack of awareness and common misperceptions about electricity use and consumption among households of different countries (Attari et al., 2010; Dianshu et al., 2010; Brounen et al., 2013; Ameli and Brandt, 2015; Sexton, 2015; Kažukauskas and Broberg, 2016). However, the level of 'electricity awareness' of Finnish households has not been previously analyzed. Therefore, it is hypothesized that:

Hypothesis 1. The level of consumers' awareness about electricity bills, prices, and costs is low.

Experimental studies have determined that awareness about electricity usage is typically associated with electricity savings (Georgiou et al., 2013; Jessoe and Rapson, 2014; Lynham et al., 2016; Blasch et al., 2017; Aydin et al., 2018; Alberini et al., 2019; Frondel et al., 2019; Prest, 2020) and that nonprice and educational interventions targeting electricity-specific knowledge might facilitate consumers' behavioral changes towards electricity demand reductions (Lynham et al., 2016). In the U.S., Sexton (2015) shows that inattention to electricity bills induces additional electricity consumption; in particular, diminished price salience associated with enrollment in automatic bill payment programs caused a 4% to 6% increase in residential electricity consumption.

If the positive relationship between increasing levels of awareness about electricity use and savings in a 'real-word' (nonexperimental) setting holds true (Crawshaw and Williams, 1985; Salkind, 2010; Schwartz et al., 2013), the residential electricity demand and related emissions might be reduced in a significant and faster way. Thus, the second hypothesis is:

Hypothesis 2. Consumers with high levels of awareness about electricity bills, prices, and costs tend to consume less electricity.

Unlike previous research documenting a gap between general environmental knowledge and pro-environmental behaviors (e.g., Kollmuss and Agyeman, 2002; Frederiks et al., 2015; Steg et al., 2015; Grimmer and Miles, 2017; Paço and Lavrador, 2017; Torma et al., 2018; Eldesouky et al., 2020), the focus of this study is on the relationship between a narrow knowledge of electricity use and consumption, which is mainly driven by concrete financial motives (rather than altruistic values), and actual electricity savings (Brounen et al., 2013; Blasch et al., 2017; Trotta et al., 2017). Awareness of electricity use and consumption, being one component of 'energy literacy', was found to be correlated

with 'financial literacy', savvy financial choices, and lower electricity consumption (Blasch et al., 2017). In addition, findings from recent studies investigating the response to electricity price changes, provide evidence that persons who are more aware of their electricity consumption levels, bills, and tariffs have a more elastic demand for electricity, even though they do not differ from the rest of the sample in terms of sociodemographic and dwelling characteristics (Sexton, 2015; Alberini et al., 2019; Prest, 2020).

Lastly, this study contributes to the previous literature by investigating the willingness to receive extra information about energy consumption and how to save energy between two groups of respondents: 'electricity aware' and 'electricity unaware'. Although a growing body of literature explores the impact of different types of information on domestic electricity consumption (Delmas et al., 2013; Karlin et al., 2015), little is known about consumers who are more or less receptive to the same type of information and the reasons why some consumers might not be interested in receiving additional information to improve their energy-related knowledge, even when the information is free (Kažukauskas and Broberg, 2016; Allcott and Kessler, 2019). In addition to the theory of rational inattention (Jessoe and Rapson, 2014; Sallee, 2014), strategic ignorance (Poortinga, 2003; Thunström et al., 2014; Thunström et al., 2016), and lack of salience and attention (Brounen et al., 2013; Costa and Kahn, 2013; Kažukauskas and Broberg, 2016), this paper introduces the 'Dunning–Kruger effect' (Kruger and Dunning, 1999), also known as 'confidence-skill disconnect', as alternative/additional argument to explain the unwillingness of some consumers to receive information about energy-related matters and electricity bills. The 'Dunning–Kruger effect' has been studied in several domains (Gross and Latham, 2012; Pavel et al., 2012; Schlösser et al., 2013; Selm, 2016; Torcello, 2016; Motta et al., 2018), but it has received little attention in the energy conservation literature. Thus, the third hypothesis is:

Hypothesis 3. Consumers with low levels of awareness about electricity bills, prices, and costs are less willing to receive free information to improve their knowledge.

3. Materials and Methods

The survey was designed between 2016 and 2017, drawing upon previous work in survey design (Bowling, 2005; Dillman et al., 2009; 2014; De Leeuw et al., 2012; Stern et al., 2014; Sterrett et al., 2017), and questionnaires on households' energy use, awareness, and literacy (Dianshu et al., 2010; Martinsson et al., 2011; Brounen et al., 2013; Ameli and Brandt, 2015; Kažukauskas and Broberg 2016; Blasch et al., 2017).

The survey data were collected through an online questionnaire, which was carried out between April and May 2017 using the online survey tool Webropol 2.0[1]. The survey collected data from a sample of Finnish customers of Vaasan Sähkö (Finnish electricity provider) and Vaasan Sähköverkko (Finnish electricity distribution company) using a multichannel recruitment strategy (customer magazine, local newspapers, e-mail, and shopping mall). The online questionnaire was initially pretested on a sample of academics in March 2017 and then sent to 244 people (invited sample), of whom 184 completed it (realized sample) – a response rate of 75%. Assuming maximum heterogeneity and no error from nonresponse, measurement, or coverage, 95 out of 100 times that a random sample of 184 people is selected from the total population of Finland (confidence interval), the sample estimate would be within ±10 and ±5 percentage points of the true population value (Dilman et al., 2014). Given the high penetration rate of the internet across segments of the population (approximately 88%)[2], the use of an internet survey likely had little coverage error. To further minimize the coverage error, the online questionnaire was optimized for mobile devices, and a €100 gift card incentive was provided to 20 randomly selected respondents to partially compensate for nonresponse bias. In addition, to avoid language and literacy issues, the questionnaire was provided in Finnish, Swedish, and English as most of the respondents live in Vaasa, which is a bilingual city on the west coast of Finland.

The survey consists of 57 energy-related (and financial-related) questions, including information regarding sociodemographic and dwelling characteristics, and takes approximately 20 minutes to complete. The questionnaire was kept reasonably short to reduce potential midquestionnaire cutoffs; in addition, the inclusion of financial questions likely ensured a broader interest in the survey. An English version of the survey is available in Appendix (A). The survey data were linked with the monthly electricity consumption data from April 2015 to March 2017 provided by Vaasan Sähkö (Finnish electricity provider) and Vaasan Sähköverkko (Finnish electricity distribution company)[3].

To test the ability of the sample survey to estimate the distribution of the main characteristics of the population, the gender, age, education, and income of the sample were compared to the Official Statistics of Finland[4]. While the bias for gender and age is relatively low, people with higher education and income are overrepresented, as is often the case for online surveys (Sterrett et al., 2017) – Table 1.

[1] http://w3.webropol.com/start/

[2] https://www.stat.fi/til/sutivi/2017/13/sutivi_2017_13_2017-11-22_tie_001_en.html

[3] The respondents of the survey have given permission to have access and use their monthly electricity consumption data for research purposes.

[4] http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/?rxid=fec9945e-16f1-4184-85bc-1b7c628b2822

Table 1. Comparison of sociodemographic characteristics of the sample with the Official Statistics of Finland in 2017 (%).

Six survey questions are used to identify the respondents' level of awareness about electricity bills, prices, and costs. Specifically, to measure the 'awareness about electricity bills', the respondents were asked to provide the average monthly amount of their summer and winter electricity bills (Table 2).

Table 2. Awareness about electricity bills.

To select the correct answers, the reported range of electricity spending (e.g., 60-89 euros) was compared with the actual electricity bills (summer and winter) provided by Vaasan Sähkö and Vaasan Sähköverkko.

With regard to the 'awareness about electricity prices', the respondents were asked to give an estimate of their electrical energy cost and electrical distribution charge (cents per kWh) – Table 3.

Table 3. Awareness about electricity prices.

As for the electricity bills, the reported estimates of electricity prices were compared with the actual electrical energy cost and electrical distribution charge. As it might be difficult for respondents to gauge their individual electricity prices, a reported estimate with a deviation of ±50% from the actual average electrical distribution charge and electrical energy cost was considered as the correct answer.

To test the level of 'awareness about electricity operating costs', the respondents were asked to provide a reasonable estimate of the running costs of a dishwasher and an oven for two hours (Table 4).

Table 4. Awareness about electricity operating costs.

Assuming an average electricity price (both energy and distribution costs) of 16 cents/kWh, running a conventional 1,300-watt dishwasher and a 2,300-watt oven for two hours[5] would cost 41 and 73 cents, respectively. With regard to the running costs of a dishwasher, answers between 20 and 60 cents are

[5] https://www.vattenfall.fi/energianeuvonta/sahkonkulutus/sahkolaitteiden-energiankulutus/

considered correct, whereas answers between 50 and 90 cents are considered a reasonable estimate of the running costs of an oven (a deviation of approximately ±50% from the actual operating costs).

Subsequently, an 'electricity awareness' score is constructed. The 'electricity awareness' score, which ranges from 0 to 6, is the sum of the individual scores obtained from the six questions about electricity bills, prices, and costs. The higher the score, the more the respondent is aware of the specific electricity-related matters. In addition, the 'electricity awareness' score gives an overall indication of the level of awareness among the respondents of the survey.

The 'electricity awareness' score, together with the sociodemographic, dwelling and household characteristics, electricity sale price, electricity plan, and reported attitudes and behaviors variables, is included in a regression model to identify the factors influencing electricity consumption. Although the electricity consumption data are collected for a period of twenty-four months, the survey data are time-invariant as they take a 'snapshot' of the proportion of households in the population at a specific point in time (April-May 2017). For this reason, a cross-sectional analysis using sample averages is preferred to a panel data analysis, and an ordinary least squares (OLS) regression is employed to interpret the results. Therefore, the electricity demand function is specified as follows:

$$lnE_{it} = \alpha_0 + lnp_{it}^{E} + a_{EA}EA_i + a_{EP}EP_i + a_{SD}SD_i + a_{AB}AB_i + a_{DH}DH_i + \varepsilon_{it} \quad (1)$$

where E_{it} is the actual average monthly electricity consumption (kWh) from April 2015 to March 2017, p_{it}^{E} is the actual average electricity sale price[6], EA_i is the 'electricity awareness' score, EP_i is the type of electricity plan ('fixed-term'), SD_i is a vector of respondent socio-demographic characteristics such as income, age, and education ('Bachelor's degree or more'), AB_i represents energy-saving/pro-environmental attitudes and behaviors, DH_i is a vector of dwelling and household characteristics such as floor area (m^2), heating system ('electric heating'), and household size, and ε_{it} is the error term. Consistently with a previous study targeted at British households (Trotta, 2018a), the energy-saving and pro-environmental attitude variables are captured by the answers "strongly disagree" or "tend to disagree" to the following statements: "I don't really give much thought to saving energy in my home", and "I buy environmentally-friendly products only if they cost the same or less than non-eco-friendly products". The energy-saving behaviors result from the answers "never" or "occasionally" to the question (how frequently you personally) "leave lights on when you are not in the room" and the answers "often" or "always" to the questions (how frequently you personally)

[6] The choice of the average rather than the marginal price is driven by the empirical findings of recent studies that show that consumers tend to react to average prices because of the difficulty or impossibility of understanding the nonlinear structure of their pricing (Borenstein, 2009; Ito, 2014; Frondel et al., 2019).

"lower the heating temperature when you go out for a few hours" and "air-dry your clothes rather than using clothes dryer".

Following Huebner et al. (2015; 2016), the potential presence of multicollinearity, which occurs when independent variables in a regression model are correlated, is tested and measured by the variance inflation factor (VIF). To confidently draw conclusions from the regression analysis, a conservative VIF value of 2 is used (O'brien, 2007; Huebner et al., 2015; 2016).

Lastly, the willingness to receive extra information about energy consumption and the relationship between self-perceived and actual abilities and how it may differ between 'electricity aware' and 'electricity unaware' respondents are analyzed. 'Electricity aware' respondents are those who provided correct answers to at least three out of the six questions about electricity awareness, whereas 'electricity unaware' respondents provided only two, one, or zero correct answers. The willingness to receive extra information about energy consumption is captured by the answers "strongly agree" and "tend to agree" to the following statements:

- "I would like to have more detailed and customized information on how to save energy at home".
- "I would like to have information about my energy consumption compared with the energy consumption of similar households".
- "I would like to have information about my current energy consumption compared with my past energy consumption".
- "I would like to have specific information about the operating cost of all the electric appliances".

On the other hand, a positive self-assessment about energy-related matters and capability of reading and understanding the electricity bills is captured by the answers '8', '9', or '10' (on a scale from '0' to '10', where '10' indicates very high interest and excellent capabilities) to the following questions:

- "How would you rate your own interest in energy-related matters?"
- "How would you evaluate your own capability to read and understand the electricity bills?"

Descriptive statistics are provided in Table 5.

Table 5. Descriptive statistics.

4. Results and Discussion

4.1 Levels of 'Electricity Awareness'

Table 6 provides the percentage (%) of correct answers to the questions about electricity bills, prices, and costs among the respondents of the survey.

Table 6. Percentage (%) and number (n) of correct answers to the questions about electricity bills, prices, and operating costs.

A total of 41.8% of the respondents correctly reported the average range of the summer electricity bill, whereas a lower proportion of respondents correctly reported the average range of the winter electricity bill (32.5%). As the winter electricity bill is typically higher and tends to vary more than the summer electricity bills due to heating and lighting costs, it might be more difficult for consumers to gauge the exact range of expenditures.

On average, the questions capturing the awareness about the electricity bills (winter and summer electricity bills) were correctly answered by 37.1% of the respondents. This result is lower than the results reported by the study of Ameli and Brandt (2015), in which, on average, 55% of the respondents were able to provide information about their electricity bill across eleven OECD countries. However, in contrast to the study of Ameli and Brandt (2015), the respondents in this survey were not asked to view their electricity bills before answering the questions.[7]

Although the electrical distribution charge (including taxes and levies) is the largest component of the price of electricity in Finnish households, only 24.5% of the respondents provided a reasonable estimate, as opposed to the 44.6% of the respondents who provided correct answers for the electrical energy cost; therefore, some consumers might not be aware of the fact that they pay two different bills, one for electricity sales and one for electricity distribution, as they confused the electrical distribution charge with the electrical energy cost. One possible explanation of this result is that consumers can only choose the electricity retailing company but not the electricity distributing company, as it has a monopoly over its territory.

Only 22.8% and 10.3% of the respondents were able to give a correct estimation of the operating costs of a dishwasher and an oven for two hours, respectively. A possible explanation of these results is that compared to questions about electricity bills and prices, respondents were required to have preexisting

[7] However, it is not possible to know whether some respondents of this study viewed the electricity bills before answering the questions.

knowledge about the electricity prices and power consumption of appliances combined with numerical skills. In contrast to Kažukauskas and Broberg (2016), among the respondents who provided an estimate but failed to answer correctly, the cost perceptions (especially of the oven) tended to be downward biased.

Figure 1 shows the distribution of the 'electricity awareness' score, which indicates the number of correct answers to the questions about electricity bills, prices, and costs provided by the respondents of the survey. The individual 'electricity awareness's score' ranges between 0 and 5 (the maximum potential score is 6), with an average value of 1.7.

Figure 1. 'Electricity awareness' score.

More than one-quarter of the respondents (28.3%) failed to correctly answer any of the questions; the respondents correctly answered as follows: one question (19%), two questions (25%), three questions (13.6%), four questions (10.9%). Only six respondents (3.3%) correctly answered five questions, and none of them correctly answered all six questions.

Figure 2 illustrates the proportion of the respondents who correctly answered three or more questions and are classified as 'electricity aware' (27.7% of the sample), and those who provided two, one, or zero correct answers to the six questions about electricity-specific matters, are classified as 'electricity unaware' and represent 72.3% of the sample.

Figure 2. '**Electricity aware**' **and** '**electricity unaware**' **respondents.**

4.2 Factors Influencing Electricity Consumption

Table 7 shows the results of the OLS regression with average electricity consumption data in the column next to the VIFs. All VIFs have a lower value than 2, and the average value is 1.28; thus, multicollinearity is not a threat to the validity of the results.

Table 7. Factors influencing electricity consumption (OLS).

The electricity sale price elasticity (β = -0.877, $p < 0.01$) is, understandably, negatively correlated with electricity consumption. This result needs to be interpreted with caution as it does not account for potential endogeneity issues, which may inflate the price elasticity coefficient (Frondel et al., 2019). However, this result is in line with OECD and U.S. studies investigating the price elasticity of residential electricity demand by using average price (Alberini et al., 2011; Krishnamurthy and Kriström, 2015). In addition, compared to many other countries, since the demand for space heating in

Finland is higher and the electricity is one of the primary sources for heating[8], there is more flexibility to modify behavior to reduce electricity consumption. It is worth mentioning that, in similar fashion, Huebner et al. (2015; 2016) analyzed the determinants of electricity consumption in English households, by omitting the average electricity sale price from the model the results do not change in any significant way (Appendix B, Table 10).

The main variable of interest, 'electricity awareness', is significant and negatively correlated with electricity consumption ($\beta = -0.076$, $p < 0.05$). This means that compared to the respondents with little or no knowledge about electricity bills, prices, and costs, the respondents with higher levels of 'electricity awareness' tend to consume less electricity. In contrast to reported pro-environmental and energy-saving behaviors, which, in line with other studies, are not significant and might be highly affected by social desirability concerns (Frederiks et al., 2015; Huebner et al., 2016; Trotta, 2018a), tangible energy-saving behaviors are driven by actual attention to and knowledge of electricity use and consumption – as captured by the 'electricity awareness' variable. A speculative extrapolation of this result suggests that, in contrast to the 'environmental knowledge–behavior gap', in which people often fail to align environmental knowledge with pro-environmental and energy-saving behaviors (Kollmuss and Agyeman, 2002), a narrow knowledge of electricity use and consumption might be better interwoven with actual energy-saving behaviors as it relates to more concrete and daily issues than the (often perceived) distant environmental problems and is driven by financial motives rather than altruistic values. Higher levels of awareness about electricity use and consumption might then "materialize" inconspicuous consumption patterns, as opposed to more general facts about the largely invisible environmental consequences of everyday practices.

Another interesting result emerges from the type of electricity plan; specifically, respondents who reported having a fixed-term electricity contract are associated with higher electricity consumption ($\beta = 0.606$, $p < 0.05$). As a fixed-term plan ties the customer to the same supplier for a fixed period and price, preventing them from switching supplier (if not through early termination fees), it may be considered a proxy for consumer inattention to price variation, which leads to lower price perceptions and, subsequently, to higher electricity use. In addition, there is a strong link between the type of electricity plan and the length of the plan to stay in the current home; 91.7% of the respondents who plan to move in the near future (or are uncertain about their staying) have a fixed-term electricity plan[9]. This household group, which encompasses tenants but also owners who want to move into a new house, might be less likely to invest in energy efficiency measures and thus have higher energy

[8] Approximately 40% of the respondents stated that they use electricity as the main heating source (question n. 19).

[9] 91.7% of the respondents answered "no" or "cannot say" to question number 18: "Do you plan to stay in your current home for at least five years from now?"

consumption. By expanding the 'energy efficiency disconnect between landlord and tenant'[10], the focus is not only on tenants but also on owners who plan to move in the near future and might be less likely to adopt energy-efficient technologies because the cost of the investments is not easily recoverable (Trotta, 2018b).

Consistent with French (Risch and Salmon, 2017), Danish (Gram-Hanssen, 2013), and especially UK studies (Huebner et al., 2015), when controlling for dwelling and household characteristics (floor area, heating system, and household size), the sociodemographic characteristics (respondent age, income, education) have little or no impact on electricity consumption (including space heating). In particular, as the floor area ($\beta = 0.007$, $p < 0.01$) and the number of occupants ($\beta = 0.152$, $p < 0.05$) increase, more electricity is used because the space heating needs and the number and use of appliances typically increase (Gram-Hanssen, 2013; Kavousian et al., 2013; Jones et al., 2015). Lastly, compared to the other types of fuels used for the space heating system, there is a significant and positive relationship between a heating system fueled by electricity and electricity consumption ($\beta = 0.647$, $p < 0.01$) - Ndiaye and Gabriel, 2011; Huebner et al., 2015; Jones et al., 2015.

4.3 Willingness to Receive Extra Information About Energy Consumption and How to Save Energy

Although the level of awareness about electricity bills, prices, and costs among Finnish households, as captured by the 'electricity awareness score', is low, on average, over 70% of the respondents would like to receive more information to help them improve their knowledge on (1) how to save energy at home; (2) their energy consumption compared with the energy consumption of similar households; (3) their current energy consumption compared with past energy consumption; and (4) the operating cost of all the electric appliances. Nevertheless, this aggregated result can lead to misleading conclusions and mask the actual potential of information provision in raising awareness. One would expect that the demand for more information about energy consumption would come from 'electricity unaware' respondents. However, when disaggregating data further, the respondents with higher levels of 'electricity awareness' are, in relative terms, the respondents who ask for more information about energy consumption and are more willing to improve their knowledge (Table 8). The results based on each 'electricity awareness' score (0, 1, 2, 3, 4, and 5) are shown in Appendix B, Table 11.

Table 8. Willingness to receive extra information about energy consumption and how to save energy (%;n).

[10] The landlord-tenant dilemma occurs when a landlord has few or no incentives to invest in the energy efficiency of the property because it is the tenant who benefits from lower energy bills (Ástmarsson et al., 2013). Therefore, rented dwellings tend to be less energy efficient (Davis, 2011; Souza, 2018).

On average, 74.5% of the respondents with a high 'electricity awareness' score "strongly agree" or "tend to agree" about receiving additional information on energy consumption and how to save energy, whereas a slightly lower percentage of respondents with a low 'electricity awareness' score (71.2%) provided the same answers[11]. This means that there exists a significant portion of the total respondents (20.8%), who not only have a poor understanding of electricity consumption and use but that are also not willing to receive additional information to improve their knowledge. Recent studies within the context of energy consumption and energy efficiency in households support this finding. For example, Kažukauskas and Broberg (2016) find that Swedish households with poor knowledge about electricity consumption and the costs of appliances are less willing to receive customized information about their own and other's energy use, whereas Palmer and Walls (2015) find that the marginal effects of going from 'fully attentive' to 'fully inattentive' lowers the probability of receiving an energy audit by approximately 11%. According to Allcott and Kessler (2019), 'nudge-style interventions'–such as information provision, reminders, social comparisons, default options–that are often deemed successful in causing large behavior change, can have very different effects on consumer welfare, and thus very different social welfare effects; they argue that the nudge's welfare effects are driven down by the fact that almost 60% of nudge recipients are not willing to pay the marginal social cost of the nudge, including many who prefer not to be nudged even if the nudge is free.

People may avoid free information and use their ignorance strategically as an excuse to overindulge in activities that provide immediate pleasure and potential future harm (Thunström et al., 2016). 'Strategic ignorance' allows people to avoid the intrapersonal conflict between what one feels one 'should do' and what one 'wants to do' (Thunström et al., 2014). In fact, engaging in energy-saving activities is often associated with additional effort or decreased comfort (Poortinga et al., 2003).

To further understand the reasons why 28.8% of the 'electricity unaware' respondents are not willing to receive free information to improve their knowledge, whether it is because of 'strategic ignorance' or due to a blissful unawareness of their own 'real ignorance', they have been asked to self-assess their interest in energy-related matters and capability of reading and understanding the electricity bill (Table 9). The results based on each 'electricity awareness' score (0, 1, 2, 3, 4, and 5) are shown in Appendix B, Table 12.

Table 9. Self-assessment about energy-related matters and the capability of reading and understanding the electricity bills (%;n).

[11] In particular, with the exception of the demand for more information about current energy consumption compared to past energy consumption, 'electricity aware' respondents ask for more information than 'electricity unaware' respondents.

On average, more than one out of every two respondents stated that they have a high ('8' or more) interest in energy-related matters and a high capability of reading and understanding the electricity bill; not surprisingly, for most of the respondents with a high 'electricity awareness' score (84.3%), there is no discrepancy between self-perceived and actual abilities. On the other hand, more than half of the respondents with a low 'electricity awareness' score (57.1%) stated to have a high ('8' or more) interest in energy-related matters, and a slightly lower proportion (45.9%) reported to have a high capability of reading and understanding the electricity bill. This confidence-skill disconnect, in which some respondents do not recognize their incompetence and mistakenly assess their knowledge as greater than it is, is known as the 'Dunning–Kruger effect' (Kruger and Dunning, 1999). A crucial implication of this effect is that a high level of confidence in their own knowledge, although not supported by actual abilities, may prevent people from searching for and obtaining further information (Dunning, 2011; Gross and Latham, 2012). While several studies have proven that providing feedback and additional information have caused households to reduce energy consumption (e.g., Fischer, 2008; Allcott, 2011b; Ayres et al., 2012; Jessoe and Rapson, 2014; Karlin et al., 2015; Lynham et al., 2016; Mogles et al., 2017), this result raises the question of whether and how customized information can lead to energy savings in households that are not only unwilling to receive that information but are also unaware of their knowledge deficits. Psychological research suggests that pointing out people's deficits does not necessarily lead them to strive to overcome their limitations and misbeliefs. Due to preexisting knowledge and motivational defenses aimed at keeping self-esteem high, poor performers may rebel against the advice, even in the face of direct feedback (Dunning, 2011).

5. Conclusions

This paper set out to measure, using a novel survey, the level of awareness about electricity bills, prices, and costs among some Finnish households, and to investigate whether higher levels of 'electricity awareness' are associated with reductions in electricity consumption. In addition, this study analyzes the willingness to receive extra information about energy consumption and the relationship between self-perceived and actual abilities about energy-related matters among 'electricity aware' and 'electricity unaware' respondents.

There are three main takeaways. First, the levels of awareness about electricity bills, prices, and costs among the respondents of the survey are low. On average, only 27.7% of the respondents correctly answered more than two questions out of the six questions designed to assess their knowledge on electricity use and consumption. Based on the predetermined measure of 'electricity awareness', analysis results support the first hypothesis – *"the level of consumers' awareness about electricity bills, prices, and costs is low".*

Second, and most importantly, higher levels of 'electricity awareness' are associated with lower electricity consumption and influence the formation of actual energy-saving behaviors. It can then be concluded that the results confirm the second hypothesis – *"consumers with higher levels of awareness about electricity bills, prices, and costs tend to consume less electricity"*. A crucial implication of this finding is that making consumers more aware about their electricity bills, prices and costs could have large effects on the reduction of total electricity demand. In addition to overall demand reduction, strategies raising knowledge of electricity use and consumption might facilitate customer's engagement in demand response programs designed to time-shift peak loads (Hall et al., 2016). While sociodemographic characteristics (age, income, education) and reported pro-environmental attitudes and energy-saving behaviors have no influence on electricity consumption, living in larger household-dwelling units (both in terms of floor area and number of occupants), having an electric heating system and a fixed-term electricity plan are all characteristics associated with higher electricity consumption.

Third, more than 70% of the 'electricity unaware' respondents are willing to receive additional information to improve their knowledge about energy consumption and how to save energy. Engaging this type of consumer would be essential to maximize the impact of any information campaign or policy, while creating long-lasting behavioral changes. Alongside targeted information, nudging has proven to be an effective strategy in changing energy behavior, although it is still unclear whether it can have a positive effect on households not willing to receive information or to be nudged, which in this study represents 20.8% of the total sample. This finding partially supports the third hypothesis – "*consumers with low levels of awareness about electricity bills, prices, and costs are less willing to receive free information to improve their knowledge"*. 'Electricity unaware' respondents tend to be slightly less willing than 'electricity aware' respondents to receive additional information on energy consumption and how to save energy. A possible explanation of this result is that one out of every two respondents with a poor understanding of electricity use and consumption is unaware of his or her own knowledge deficits. This may prevent consumers from searching for and obtaining information to improve their knowledge. Before attempting to provide information strategies, future studies should investigate how to involve this type of consumer; by becoming more aware of their knowledge deficits, people might become more receptive to information that can actually benefit them.

The results of this study are associated with some limitations, which must be acknowledged and possibly overcome in future research. The main limitation is the sample size that does not fully represent the Finnish population and the lack of time-series observations of the variable measuring levels of 'electricity awareness'. In addition, due to both the specificities and limitations of the data set used in this study, which does not include regional-level price information and is composed of relatively small periods and number of individuals, the potential endogeneity of electricity prices in the electricity demand model was not tested. This is because the use of a simple instrumental variable approach or a more sophisticated dynamic panel data approach was either not possible or would make

the results biased and inconsistent (Blundell and Bond, 1998; Paul et al., 2009; Roodman, 2009; Krishnamurthy and Kriström, 2015; Frondel et al., 2019). Thus, additional data encompassing a larger sample size and longer periods of investigation are needed to replicate the study and provide more robust results.

Although the constructed 'electricity awareness' index provides a useful baseline for future studies, further empirical research is needed to identify the broad spectrum of factors explaining common traits of knowledge and attention with respect to the electricity use and consumption issues and their relationship with energy-saving/pro-environmental attitudes and behaviors. In addition to 'strategic ignorance' (Thunström et al., 2014) or blissful unawareness of own 'real ignorance' (Dunning, 2011), future studies could explore in more detail the reasons why some consumers are not willing to receive (free) information about their electricity use and negatively perceive such information.

In the context of the future electricity market and distributional impacts of demand response strategies, increasing the levels of awareness about electricity use and consumption could be particularly relevant for households at risk of vulnerability that struggle with electricity bills and are less likely to benefit from energy-efficient appliances and IHDs. A better understanding and attention of this particular household group on electricity bills, prices, costs, and time-varying rates offered by the utility could reduce the risk of financial losses resulting from a change in the tariff and, in turn, minimize welfare losses.

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Tables

Table 1. Comparison of sociodemographic characteristics of the sample with the Official Statistics of Finland in 2017 (%).

	Sample	Official statistics
Gender		
Male	53,2	48,9
Female	46,8	51,1
Respondent age		
18-28	14,1	16,5
29-39	20,1	17,4
40-50	19,6	16,5
51-61	19	18
≥ 62	27,2	31,5
Education		
No Bachelor's degree	52,2	67,8
Bachelor's degree or more	47,8	32,2
Respondent gross annual income		
≤ €9.999	5,6	19
€10.000 - €29.999	41,6	42,8
€30.000 - €49.999	38,2	25,5
≥ €50.000	14,6	12,7

Table 2. Awareness about electricity bills.

Awareness about electricity bills	
Winter electricity bill	Summer electricity bill

Q1. How much did you pay for your monthly electricity bill (basic charge, energy charge, distribution charge and taxes) during the last winter (December 2016-February 2017)? *Please give the monthly average amount.*	Q2. How much did you pay for your monthly electricity bill (basic charge, energy charge, distribution charge and taxes) during the last summer (June 2016-August 2016)? *Please give the monthly average amount.*
➢ Under 30 euros ➢ 30-59 euros ➢ 60-89 euros ➢ 90-119 euros ➢ 120-149 euros ➢ … ➢ 480-499 euros ➢ 500 euros or more ➢ Cannot say	➢ Under 30 euros ➢ 30-59 euros ➢ 60-89 euros ➢ 90-119 euros ➢ 120-149 euros ➢ … ➢ 480-499 euros ➢ 500 euros or more ➢ Cannot say

Table 3. Awareness about electricity prices.

Awareness about electricity prices	
Electrical energy cost	Electrical distribution charge
Q1. How many Cents per Kilowatthour do you pay for the electrical energy cost on average? *Please provide the exact amount or an estimate.*	Q2. How many Cents per Kilowatthour do you pay for the electrical distribution charge on average including all taxes and levies? *Please provide the exact amount or an estimate.*
➢ Cents per Kilowatthour [……..] ➢ Cannot say	➢ Cents per Kilowatthour [……..] ➢ Cannot say

Table 4. Awareness about electricity operating costs.

Awareness about electricity operating costs	
Dishwasher	Oven
Q1. How much does it cost (Cents) to run an ordinary dishwasher for two hours? *Please provide an estimate.*	Q2. How much does it cost (Cents) to use an ordinary oven for two hours (at 200°C)? *Please provide an estimate.*
➢ Cents [……..] ➢ Cannot say	➢ Cents [……..] ➢ Cannot say

Table 5. Descriptive statistics.

Variables	Mean	Std Dev	Min	Max	N
Average monthly electricity consumption and sale price					
Average monthly electricity consumption (kWh) (April 2015-March 2017)	565.9	500.9	37	2.258	166
Average Ln_monthly electricity consumption (April 2015-March 2017)	5.925	0.962	3.611	7.722	166
Average electricity sale price (EUR per kWh) (April 2015-March 2017)	0.0617	0.0395	0.0236	0.505	147
Average Ln_electricity sale price (April 2015-March 2017)	-2.849	0.295	-3.746	-0.684	147
Electricity plan					
Fixed term	0.067	0.251	0	1	12
Open-ended (unspecified term)	0.933	0.251	0	1	167
Respondent characteristics					
Respondent age					
18-28	0.141	0.349	0	1	26
29-39	0.201	0.402	0	1	37
40-50	0.196	0.398	0	1	36
51-61	0.190	0.394	0	1	35
≥ 62	0.272	0.446	0	1	50
Respondent annual gross income					
≤ €9.999	0.0562	0.231	0	1	10
€10.000 - €29.999	0.416	0.494	0	1	74
€30.000 - €49.999	0.382	0.487	0	1	68
≥ €50.000	0.146	0.354	0	1	26
Education					
Bachelor's degree or more	0.478	0.501	0	1	88
No Bachelor's degree	0.522	0.501	0	1	96
Energy-saving attitudes and behaviors					
Attitude: Energy-savings	4.185	1.076	1	5	184

("I don't really give much thought to saving energy in my home". 1 – "Strongly agree". 2 – "Tend to agree". 3 – "Neither agree or disagree". 4 – "Tend to disagree". 5 – "Strongly disagree")					
Attitude: Eco-friendly products ("I buy environmentally-friendly products only if they cost the same or less than non-eco-friendly products". 1 – "Strongly agree". 2 – "Tend to agree". 3 – "Neither agree or disagree". 4 – "Tend to disagree". 5 – "Strongly disagree")	3.11	1.265	1	5	182
Energy-saving behavior: Turning off lights ("Leave lights on when you are not in the room". 1 – "Never". 2 – "Occasionally". 3 – "Often". 4 – "Always")	1.842	0.74	1	4	184
Energy-saving behavior: Lowering heating ("Lower the heating temperature when you go out for a few hours". 1 – "Never". 2 – "Occasionally". 3 – "Often". 4 – "Always")	1.297	0.648	1	4	182
Energy-saving behavior: Air-drying clothes ("Air-drying your clothes rather than using clothes dryer". 1 – "Never". 2 – "Occasionally". 3 – "Often". 4 – "Always")	3.552	0.862	1	4	183
Dwelling and household characteristics					
Floor area (m^2)	112	52.4	25	300	182
Heating system					
Electric heating	0.359	0.481	0	1	65
District heating	0.398	0.491	0	1	72
Wood or pellet	0.0442	0.206	0	1	8
Oil heating	0.0663	0.249	0	1	12
Ground source heat pump/Geothermal	0.105	0.307	0	1	19
Other	0.0276	0.164	0	1	5
Household size	2.31	1.105	1	5	184
Willingness to receive extra-information					
I would like to have more detailed and customized information on how to save energy at home (1 – "Strongly agree". 2 – "Tend to agree". 3 – "Neither agree or disagree". 4	2.201	1.236	1	6	184

– "Tend to disagree". 5 – "Strongly disagree". 6 – "Cannot say")					
I would like to have information about my energy consumption compared with the energy consumption of similar households (1 – "Strongly agree". 2 – "Tend to agree". 3 – "Neither agree or disagree". 4 – "Tend to disagree". 5 – "Strongly disagree". 6 – "Cannot say")	2.07	1.28	1	6	184
I would like to have information about my current energy consumption compared with my past energy consumption (1 – "Strongly agree". 2 – "Tend to agree". 3 – "Neither agree or disagree". 4 – "Tend to disagree". 5 – "Strongly disagree". 6 – "Cannot say")	2.168	1.318	1	6	184
I would like to have specific information about the operating cost of all the electric appliances (1 – "Strongly agree". 2 – "Tend to agree". 3 – "Neither agree or disagree". 4 – "Tend to disagree". 5 – "Strongly disagree". 6 – "Cannot say")	1.989	1.25	1	6	184
Self-assessment					
How would you rate your own interest in energy-related matters? (From 0 to 10. 0 – Very low. 10 – Very high)	7.636	1.824	2	10	184
How would you evaluate your own capability to read and understand the electricity bills? (From 0 to 10. 0 – Very bad. 10 – Excellent)	7.185	2.23	1	10	184

Table 6. Percentage (%) and number (n) of correct answers to the questions about electricity bills, prices, and operating costs.

Electricity awareness	Correct answers (%;n)
Awareness about electricity bills	
Winter bill	32.5%; n=53
Summer bill	41.8%; n=71

Awareness about electricity prices	
Electrical energy	44.6%; n=82
Electrical distribution	24.5%; n=45
Awareness about electricity operating costs	
Dishwasher	22.8%; n=42
Oven	10.3%; n=19

Table 7. Factors influencing electricity consumption (OLS).

Variables	**Electricity consumption Ln_kWh (mean)**	**VIF**
Ln_electricity_sale price (mean)	-0.877***	1.35
	(0.196)	
Electricity awareness	-0.076**	1.11
	(0.037)	
Electricity plan: Fixed-term	0.606**	1.14
	(0.289)	
Respondent age	0.001	1.46
	(0.004)	
Respondent gross annual income	0.048	1.31
	(0.076)	
Education: Bachelor's degree or more	-0.086	1.23
	(0.115)	
Attitude: Energy-savings	-0.078	1.22
	(0.163)	
Attitude: Eco-friendly products	-0.052	1.19
	(0.114)	
Energy-saving behavior: Turning off lights	-0.096	1.22
	(0.185)	
Energy-saving behavior: Lowering heating	-0.151	1.21

	(0.225)	
Energy-saving behavior: Air-drying clothes	0.150	1.11
	(0.155)	
Household size	0.152**	1.52
	(0.059)	
Floor area	0.007***	1.65
	(0.001)	
Electric heating	0.647***	1.18
	(0.118)	
Constant	2.148***	
	(0.568)	
Number of observations	131	
R^2	0.662	

*** indicates significance at the 1% level, ** significance at the 5% level,
* significance at the 10% level.
Standard errors in parentheses.

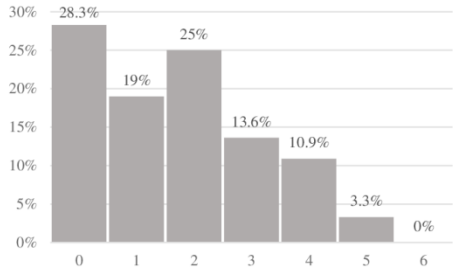
Table 8. Willingness to receive extra information about energy consumption and how to save energy (%;n).

	All respondents (%;n)	**Electricity aware (%;n)**	**Electricity unaware (%;n)**
Information			
I would like to have more detailed and customized information on how to save energy at home ("Strongly agree" or "tend to agree")	70.1%; n=129	76.5%; n=39	67.7%; n=90

I would like to have information about my energy consumption compared with the energy consumption of similar households ("Strongly agree" or "tend to agree")	75%; n=138	78.4%; n=40	73.7%; n=98
I would like to have information about my current energy consumption compared with my past energy consumption ("Strongly agree" or "tend to agree")	67.9%; n=125	64.7%; n=33	69.2%; n=92
I would like to have specific information about the operating cost of all the electric appliances ("Strongly agree" or "tend to agree")	75.5%; n=139	78.4%; n=40	74.4%; n=99

Table 9. Self-assessment about energy-related matters and the capability of reading and understanding the electricity bills (%;n).

	All respondents (%;n)	**Electricity aware (%;n)**	**Electricity unaware (%;n)**
Self-assessment			
High interest in energy-related matters ('8', '9', or '10', on a scale from '0' to '10')	64.7%; n=119	84.3%; n=43	57.1%; n=76
High capability to read and understand the electricity bills ('8', '9', or '10', on a scale from '0' to '10')	56.5%; n=104	84.3%; n=43	45.9%; n=61



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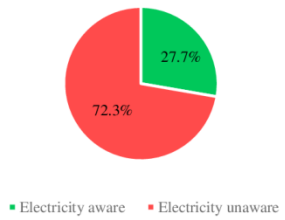

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