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Energy-related financial literacy and electricity consumption: Survey-based evidence from Finland

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Abstract

We provide new insights into (i) the level of energy-related financial literacy in Finnish households, (ii) the sociodemographic characteristics that affect energy-related financial literacy, and (iii) whether energy-related financial literacy influences household electricity consumption. We use a data set consisting of energy-related financial literacy questions combined with monthly electricity consumption data. We draw from the recent literature on energy-related financial literacy and suggest two new variables based on subjective perceptions on energy-related financial literacy. Gender has a strong association with energy-related financial literacy. Our results also indicate that households of respondents with higher levels of energy-related financial literacy tend to consume less electricity when we control for other factors such as dwelling and household characteristics. This implies that measures to promote energy-related financial literacy might guide consumers' decisions toward energy efficiency and conservation.

KEYWORDS

electricity use, energy-related financial literacy, households

1 | INTRODUCTION

The problems associated with global warming and the depletion of fossil fuels make the promotion of energy conservation a timely issue. The key role of the residential sector in reducing energy demand is not negligible: unlocking the potential of the residential sector to reduce energy consumption can lead to significant abatements in environmental pressures.

Energy efficiency investments such as geothermal heat pumps, wall insulation, double or triple glazed windows, and "A" class appliances offer considerable promise for reducing energy consumption; however, consumers have not made such investments to the degree that would be justified, thus creating the so-called "energy efficiency gap" between expected and actual investments (Gerarden et al., 2017; Gillingham & Palmer, 2014). Low levels of investments in energy efficiency have long been associated with market failures, such as credit constraints, imperfect information, and the landlord-tenant problem (Allcott & Greenstone, 2012). More recently, economists and psychologists have become interested in other potential reasons for the persistent energy efficiency gap, such as bounded rationality in the consumer decision-making process (Pollitt & Shaorshadze, 2013), systematic behavioral biases in consumer decision-making such as incorrect "perceptions" of fuel cost savings, and a lack of attention to and information about energy costs (Allcott et al., 2014; Tietenberg, 2009). According to Brounen et al. (2013), the main reason for these behavioral failures is the lack of knowledge about energy costs and consumption, although they represent a significant part of household expenses. Recently, Blasch et al. (2021) developed a new concept of energy-related financial literacy that is based on the abovementioned assumptions of bounded rationality and other behavioral biases to measure consumers' cognitive ability to calculate the lifetime costs of energy efficiency investments. This concept is useful for integrating two key components that can explain the lack of investment in energy efficiency measures, namely, computational *skills* related to the application of financial concepts and *awareness*, such as of energy prices and energy consumption.

In this article, we further develop the concept of energy-related financial literacy by introducing new indicators for it, and we present the first empirical study on the effects of energy-related financial literacy in Finland. We use the definition of Blasch et al. (2021) and its three dimensions (energy investment literacy, financial literacy, and cost awareness) as our starting point for the construction of our concept of energy-related financial literacy. We augment it by the considerations of Warmath and Zimmerman (2019) by including measures of self-efficacy. Consistent with the work of Allgood and Walstad (2016), we include a measure describing subjective perception of energy knowledge in our definition. Drawing from Brown and Graf (2013), we also include a measure of interest in energy-related financial literacy. The inclusion of these two new empirical measures of energy-related financial literacy is a key contribution we make to the literature.

While financial literacy has been previously studied in Finland and has been found to be relatively high (Kalmi & Ruuskanen, 2018; Klapper & Lusardi, 2020), the level of energy-related financial literacy has not been studied in Finland to date. There are several reasons why there is much to be learned from energy-related financial literacy in Finland. Mainly due to its cold climate, the final residential energy consumption per capita in Finland is among the highest in the EU, and residential electricity consumption increased by 54.2% over the period of 1990–2016 (Eurostat, 2018a). Moreover, domestic consumers in Finland face among the lowest electricity prices in the EU (Eurostat, 2018b), thus undermining incentives to save energy. In Finland, the retail side is a competitive market, whereas the distribution network is handled by

Distribution System Operators (DSOs) with their regulated local monopoly (Ruokamo et al., 2019). Many customers in Finland have separate contracts with a DSO and a supplier. Customers have combined billing (supply and distribution) only when the supplier and DSO are part of the same company group (NordReg, 2017). Additionally, the energy efficiency improvements in the residential space-heating subsector registered in recent years in Finland did not lead to actual reductions in energy consumption due to various issues, including an increase in the average size of the stock of dwellings, aging population, rebound effects, and improved thermal comfort expectations (Trotta, 2020a). Against this background, we collected survey data on energy-related financial literacy and its components in Finnish households to examine the level of energy-related financial literacy in Finnish households.

In the theoretical section of this article, we discuss the lessons from the literature of bounded rationality in energy consumption and financial literacy and how this informs our approach to energy-related financial literacy. We then review the existing literature on energy-related financial literacy. Based on our literature review, we propose two new subjective measures of energy-related financial literacy.

In the empirical part of the analysis, we first discuss the alternative that we investigate regarding the extent to which gender, age, education, and income are associated with different aspects of energy-related financial literacy and the degree to which earlier findings by Blasch et al. (2021), Filippini et al. (2020), and others can be observed in countries with very high electricity consumption levels, such as in Finland. We then follow the approach of Blasch et al. (2017) in order to study the relationship of energy-related financial literacy to household-level energy consumption.

The article proceeds as follows. Section 2 presents the relevant prior literature on bounded rationality in the energy consumption and efficiency domains, financial literacy, and energy-related financial literacy. Section 3 describes the data. Section 4 discusses the empirical strategy employed and the main results in comparison with previous research. Section 5 provides concluding remarks and policy implications.

2 | ENERGY-RELATED FINANCIAL LITERACY REDEFINED

2.1 | Behavioral issues influencing household energy consumption

Multiple barriers prevent households from investing in energy efficiency solutions and/or adopting conservation behaviors. Aside from market failures, there are behavioral failures associated with limited attention and bounded cognitive abilities that influence consumers' decision-making and energy use (Allcott & Mullainathan, 2010; Gillingham & Palmer, 2014).

Costa and Kahn (2013) trace several sources of difficulties in realizing energy-saving potential: first, consumers may lack the necessary information to act in their best interest; second, even if consumers know in principle what is in their best interest, energy conservation may not be high on their list of priorities; and third, consumers make suboptimal choices because of the lack of salience of the energy-saving issue. Other studies provided evidence on households' limited knowledge about energy bills and the impact of own behaviors on energy consumption. For example, Ameli and Brandt (2015), through an empirical analysis of the Organization for Economic Co-operation and Development (OECD) Survey on Household Environmental Behavior and Attitudes, found that although the respondents were asked to obtain their energy

bills before answering the survey, only approximately 55% were able to provide information about their energy spending. In the United States, the participants of a national survey considered energy curtailment behaviors, such as turning off lights, more effective for saving energy than energy efficiency investments, such as buying energy-efficient appliances (Attari et al., 2010). Although being only one component of a successful intervention strategy, the authors emphasize the role of accurate information in addressing misconceptions about energy consumption and savings to help people make better decisions for their pocketbooks and the planet.

The literature on the impact of information provision on energy consumption has reached somewhat mixed results. Using an experimental setting, Allcott and Knittel (2019) recently found no significant effect of providing tailored fuel cost information on purchased vehicles' average fuel economy. On the other hand, Cerruti et al. (2019) found that awareness regarding the existence of fiscal incentives to promote the purchase of energy-efficient vehicles affected consumers' decisions in Switzerland.

Newell and Siikamäki (2014) found that providing information on energy consumption of water heaters in monetary terms rather than physical units increased the willingness to pay for energy savings. Similarly, Blasch et al. (2019) found that displaying consumption information in monetary rather than physical units increased the likelihood that consumers identify the most energy-efficient household appliances and that more energy-literate consumers are more likely to benefit from this information.

While there is broad literature on the lack of awareness of energy in terms of both prices and quantities and on information provisions, few studies have investigated the impact of limited cognitive abilities on energy use. Such abilities are usefully investigated under the general rubric of "literacy." An important policy issue is how the provision of information about energy consumption behaviors can be influenced through two different channels: improving cognitive abilities and financial literacy skills and correcting price misperceptions (Allcott & Kessler, 2019; Brent & Ward, 2018). We first review the literature on financial literacy and show how this literature can be used to construct measures of energy-related financial literacy. We then review the existing literature on energy-related financial literacy and how our contributions are positioned. Finally, we discuss the implications for our empirical work.

2.2 | Relevance of financial literacy to the concept of energy literacy

Probably the most influential contributors to the literature, Lusardi and Mitchell (2014) defined financial literacy as people's ability to process economic information and to make informed decisions about various financial issues. In various contributions, Lusardi and Mitchell (2008, 2011) studied this issue by including the so-called big three of financial literacy questions (discussed in more detail below). This approach defines financial literacy by the knowledge of concepts and the ability to apply these concepts in solving financial problems occurring in everyday life. There have also been other conceptualizations that have used a much broader set of questions, for example, Huston (2010) and Houts and Knoll (2020). These articles still very much focus on the knowledge dimension of the concept. Recently, Warmath and Zimmerman (2019) used Bloom's domains of knowledge (Bloom et al., 1956) to broaden the concept of financial literacy to include skills and self-efficacy (Bandura, 1982). Notably, the mainstream approaches to financial literacy regard attitudinal factors such as cultural preferences, behavioral biases and time preferences as external to the definition of financial literacy. These factors are considered as external influences to financial behaviors (Huston, 2010).

In terms of measurement, most empirical approaches to financial literacy heavily stress the use of knowledge questions (Lusardi & Mitchell, 2014). However, there have been alternative measures that have been related to financial literacy, perhaps most notably subjective self-assessments of financial literacy. Allgood and Walstad (2016) provided evidence that subjective measures can be as strongly linked to behaviors as objective measures. There has been relatively little discussion on the role of attention in financial literacy. One notable exception here is Carpena and Zia (2020), who found that financial awareness can be more easily influenced by financial education than numeracy skills, but numeracy might have stronger influence on behaviors than awareness. Clearly, this is a topic, that would benefit from further studies.

Financial literacy studies have also uncovered evidence on the determinants of financial literacy. Not surprisingly, financial literacy has been found to correlate heavily with education (Lusardi & Mitchell, 2014). Perhaps a more interesting finding in this regard is that there are systematic differences in financial literacy between men and women. Women score much lower in objective measures of financial literacy than men, and they also give themselves lower subjective financial literacy scores than men (Bucher-Koenen et al., 2017); there is also evidence that women are less interested in financial issues than men (Brown & Graf, 2013).

2.3 | Energy-related financial literacy

The literature on energy-related financial literacy is still in its infancy compared with that of financial literacy. An early contribution was that of DeWaters and Powers (2011), who proposed a concept of energy literacy that emphasizes general knowledge of energy-related issues and attitudes toward energy conservation. While in many ways it is a broad and holistic concept, it is more related to engineering and natural sciences rather than to economics or personal finance.

More recently, related concepts that focus more narrowly on the economic aspects of energy consumption were proposed. For Brounen et al. (2013), energy literacy means consumers' ability to calculate the long-term impacts of energy efficiency investments. Therefore, their focus is on energy efficiency investment decisions. They also employ the concept of energy awareness, which they measure by the respondents' awareness of their energy consumption. Broberg & Kažukauskas (2021) also included awareness of the costs related to the energy consumption of various appliances in their measure of "attention." Trotta (2021) constructed an indicator of awareness of electricity use and consumption, which refers to consumers' attention and understanding of electricity bills, prices and costs and shows that consumers with higher levels of "electricity awareness" tend to consume less electricity.

Blasch et al. (2021) proposed a new idea of energy-related financial literacy by combining the three different concepts of (i) financial literacy, (ii) the ability to calculate the lifetime costs of energy efficiency investments (energy literacy), and (iii) cost awareness measures. Their measures thus encompass both cognitive and computational *skills* related to the application of financial concepts in the style of Lusardi and Mitchell (2014) but also broaden the domain by including issues of *awareness* in the sense of alertness to relevant parameters, such as energy prices and the energy consumption of, for example, household appliances. The inclusion of awareness is likely to reflect its central role in the literature of household energy consumption in general.

There is some prior empirical evidence on the determinants of energy-related financial literacy. Similar to the literature on financial literacy in general, the previous literature on energy-

related financial literacy has also highlighted the role of education and gender differences. Most of the studies have found that women possess lower energy literacy levels than men (e.g., Blasch et al., 2021; Brounen et al., 2013; Filippini et al., 2020; Martins et al., 2020a, 2020b).

Another interesting issue related to gender divisions in energy use is that in households with spouses, women spend more time on energy-intensive household labor such as cooking and laundry (IEA, 2018; Petrova & Simcock, 2021) and can often be more influential than men in the purchase of household appliances (Blasch et al., 2021). This is one reason why energy-related financial literacy, especially concerning energy efficiency investments, is crucial. It is worth mentioning, however, that energy efficiency is only one attribute in appliance replacement, building envelope insulation, or heating and water systems changes. Comfort, convenience for organizing daily life, safety, brand, aesthetics, and other nonenergy-related attributes play a significant role in purchasing and renovation decisions, and their relative importance differs also with respect to the type of energy efficiency investment (Aravena et al., 2016; de Ayala et al., 2021; Trotta, 2018; Wilson et al., 2015). Also, energy efficiency investments might be perceived differently by men and women as a consequence of different everyday practices that exist in a house, and these gender practices might reflect different purchasing and renovation preferences (Tjørring, 2016).

2.4 | Energy literacy and energy consumption

Ultimately, the interest in energy-related financial literature is not to build this knowledge base for its own sake but to promote the saving of energy. There are several channels through which higher energy-related financial literacy could be transformed into energy-saving behaviors. Among these are household investments in renewable energy sources, such as solar panels, geothermal energy, or heat pumps; investments in energy-saving home appliances; and changes in everyday behaviors, such as switching off the lights or using less hot water. Greater knowledge, skills to apply the knowledge and greater awareness of the costs and savings would be expected to correlate negatively with energy consumption, other things equal.

Another dimension in which we broaden the literature is that we consider how the direction in which the respondents err in their cost awareness influences their energy consumption. While improving the skills component will likely reduce consumption, the effect of changing cost awareness might go both ways: consumers who underestimate electricity prices are likely to reduce consumption, whereas consumers who overestimate prices may actually increase consumption once misperceptions are corrected.

There are some prior works on this. Brounen et al. (2013) did not find any evidence on the effect of energy literacy and energy awareness on Dutch households' self-reported energy consumption. In contrast, Blasch et al. (2017), who used actual consumption data in lieu of self-reported data, found lower levels of electricity consumption in Swiss households exhibiting higher levels of energy and investment literacy. Brent and Ward (2018) found that respondents who had higher financial literacy made core consistent choices in terms of willingness to pay for energy efficiency investments.

One challenge in analyzing energy consumption at the household level is that in multiperson households, energy consumption depends on the behaviors and decisions of other household members rather than solely on the survey respondent. This is a general problem in studies making inferences from a single survey respondent to household behavior and is relevant to financial literacy research in general (Lusardi & Mitchell, 2014). We attempt to address this issue by using household-level data where possible.

2.5 | A visual model of comparing financial literacy and energy-related financial literacy

In Figure 1, we present a visual model contrasting energy-related financial literacy with the standard definition of financial literacy. At the intersection between financial literacy and energy-related financial literacy, the figure presents the standard definition of financial literacy drawing on figs. 1 and 2 of Huston (2010). Financial literacy according to that definition consists of financial knowledge and the ability to apply that knowledge to make effective decisions across a range of financial contexts. We augment Huston's (2010) definition by introducing the subjective energy literacy measures, addressing self-efficacy issues discussed in Warmath and Zimmerman (2019). These define financial literacy, which then in turn influences financial behavior, together with cultural and economic conditions, time preferences, and behavioral biases (including what is sometimes referred to as financial attitudes).

On the right-hand side, we then give a similar depiction of energy-related financial literacy, drawing on the description in Blasch et al. (2021). Here, we also include financial knowledge, where the key issues are very similar to standard financial literacy questions, thereby justifying the use of standard financial literacy questions in assessing energy-related financial literacy. These can be augmented by questions measuring the ability to apply financial literacy in energy-related contexts, thereby suggesting energy investment literacy questions first developed in Brounen et al. (2013). We also include herein cost awareness, consistent with the Blasch et al. (2021) definition and due to its central role of awareness in the energy consumption literature. We augment the Blasch et al. (2021) definition in the spirit of Warmath and Zimmerman (2019) and Brown and Graf (2013) by including the subjective energy literacy and interest in energy-related financial literacy, respectively. These considerations together form our measures of energy-related financial literacy. This in turn affects household energy consumption, together with other influences, such as cultural and climate issues, economic conditions, housing conditions, and environmental and energy-saving attitudes and behaviors, and energy efficient renovations.

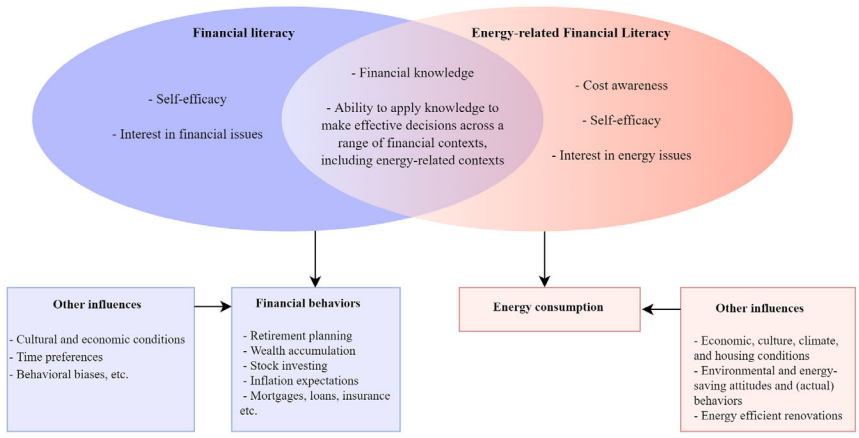

FIGURE 1 Visual model of financial literacy and energy-related financial literacy. Adapted from Huston (2010), Blasch et al. (2021), and Warmath and Zimmerman (2019)

3 | DATA

We study the connection between energy-related financial literacy and energy consumption by drawing on a novel survey conducted in collaboration with an electric utility in Finland. The survey questionnaire was designed in 2016–2017 and is based on an extensive literature review of survey methodology (e.g., Beck et al., 2009; Bowling, 2005; Chang & Krosnick, 2009; Dillman et al., 2009) and household surveys related to financial literacy and energy issues (Ameli & Brandt, 2015; Broberg & Kažukauskas, 2021; Brounen et al., 2013; Lusardi & Mitchell, 2014). It was reviewed by several national and international experts and pretested on a sample of colleagues in March 2017.[1] Between April and May 2017, we collected data by using the online survey tool Webropol 2.0.[2]

Household customers of Vaasan Sähkö (a Finnish electricity provider) and Vaasan Sähköverkko (a Finnish electricity distribution company) were asked to participate in a survey consisting of 57 energy- and finance-related questions, including information regarding socio-economic and demographic characteristics. In addition, the survey includes questions about environmental attitudes, dwelling characteristics, and respondents' willingness to obtain more information about energy consumption, how to save energy, and the operating costs of electric appliances. An English version of the survey is available in the online Appendix.

Different methods and channels were used to recruit the survey respondents, such as Vaasan Sähkö's customer magazine, local newspapers, e-mail, and a shopping mall.[3] We first collected the contact information of the individuals who were interested in responding to the survey. Of the 244 adults who initially expressed interest in participating in the survey, 184 completed the questionnaire (75%). The questionnaire was provided in Finnish, Swedish, and English, as most of the respondents lived in Vaasa, which is a bilingual city on the west coast of Finland. The high penetration of the Internet across the Finnish population likely reduced the coverage error; in 2017, 94% of people aged between 16 and 74 used the Internet[4] (88% including people aged between 75 and 89[5]), which was significantly above the EU average (82%).

Approximately 75% of the respondents were Finnish speakers, while 25% were Swedish speakers. Only one person completed the questionnaire in English. Of those who submitted a complete questionnaire, 20 respondents were randomly selected to be awarded a €100 gift card.

The survey data were then linked with the monthly electricity consumption data from April 2015 to March 2017 provided by Vaasan Sähkö (the Finnish electricity provider) and Vaasan Sähköverkko (the Finnish electricity distribution company).[6] However, these data were not available for all respondents. Ultimately, we had both complete survey data and data on electricity consumption for 156 respondents. Because the survey data were collected at one point only (April–May 2017) but electricity consumption data covered a two-year period, we made all data cross-sectional by taking the averages of electricity consumption for these 2 years.

Table 1 provides a summary of the primary data for these 156 observations used in the empirical analysis, including all dependent and independent variables. To assess the representativeness of the data, we compared the data to the official survey data of Statistics Finland of 2016 (see Appendix 1). The main discrepancies appear in the education and income variables: our survey respondents were more educated than the average Finnish adult and less likely to have a low income (defined as a personal income below €20,000). Moreover, of our survey respondents, 49.4% lived in single-family or detached housing, whereas the national average is 39.3% of households, and in the Vaasa region, the average is 44.4%. The overrepresentation of single-family housing is likely an outcome of having wealthier respondents. These kinds of

TABLE 1 Summary statistics (n = 156)

Variable	Mean	Standard deviation	N
Female	0.47	0.50	73
Male	0.53	0.50	83
Age 18–28 years	0.15	0.36	23
Age 29–39 years	0.20	0.40	31
Age 40–50 years	0.19	0.40	30
Age 51–61 years	0.20	0.40	31
Old age (62+ years)	0.26	0.44	41
Education: BA or more	0.49	0.50	76
Low personal income (−€20,000 p.a.)	0.23	0.42	36
Middle personal income (€20,001–40,000 p.a.)	0.46	0.50	72
High personal income (€40,001 p.a.)	0.31	0.46	48
Low household income (−€40,000 p.a.)	0.38	0.49	59
Middle household income (€40,001–80,000 p.a.)	0.51	0.50	79
Household high income (€80,001 p.a.)	0.12	0.32	18
Rental	0.19	0.40	30
Single/detached housing	0.49	0.50	77
Electric heating	0.35	0.48	55
Floor size (m^2)	110.12	51.28	
Number of household members	2.28	1.10	
Year of construction −1939	0.08	0.28	13
Year of construction 1940–1969	0.16	0.37	25
Year of construction 1960–1999	0.42	0.49	65
Year of construction 2000–present	0.33	0.47	51
Energy investment literacy	1.28	0.66	
Financial literacy	2.38	0.83	
Number of correct responses	1.40	1.44	
No answer dominant	0.53	0.51	83
Overestimate dominant	0.08	0.27	12
Underestimate dominant	0.05	0.22	8
Energy interest	7.61	1.82	
Subjective energy literacy	7.18	2.31	
Energy consumption	582.60	510.07	
Log of energy consumption	5.95	0.98	

Note: Mean, standard deviation, and number of observations belonging to binary categories (N).

biases are common in online surveys (Hoogendoorn & Daalmans, 2009). Although the data seems to be reasonably representative, the relatively small sample size may limit the possibilities of data analysis, as there is a danger that models become overspecified (Table 1).

4 | EMPIRICAL STRATEGY AND RESULTS

4.1 | Measuring energy-related financial literacy

4.1.1 | Dimensions of energy-related financial literacy

We use the definition of Blasch et al. (2021) and its three dimensions (energy investment literacy, financial literacy, and cost awareness) as our starting point for the construction of our concept of energy-related financial literacy. We augment it by the considerations of Warmath and Zimmerman (2019) by including measures of self-efficacy (subjective energy literacy, interest in energy issues). Consistent with the work of Allgood and Walstad (2016), we include a measure describing subjective perception of energy knowledge in our definition. Drawing from Brown and Graf (2013), we also include a measure of interest in energy-related financial literacy. Consistent with mainstream definitions of financial literacy (Huston, 2010; Lusardi & Mitchell, 2014; Warmath & Zimmerman, 2019) and the Blasch et al. (2021) definition of energy-related financial literacy, we exclude attitudes toward energy consumption from our definition of energy-related financial literacy.

4.1.2 | Energy investment literacy

Energy investment literacy is focused on making energy-efficient choices. We asked the respondents two questions (presented in Table 2) that assess their ability to choose between two different heating systems with the same lifespan but different retail prices and monthly heating bills. The first question was adapted from Brounen et al. (2013). We also added another question to reduce the impact of potential superficial and cognitive processing and therefore encourage the respondents to perform an investment analysis. In the first question (economic lifespan of 15 years), the heating system A would cost €21.750 and model B would cost €19.400, while in the second question (economic lifespan of 5 years), the heating system A would cost €9.750 and model B would cost €9.800.

As shown in Table 2, regarding the first question, approximately 69% had a preference for model B, 14% preferred A, 11% stated that the plans are equally good, and 6% could not say. The percentage of respondents choosing the option that has the lowest cost over the lifespan (B) was slightly higher than that found by Brounen et al. (2013). However, the preference for A might also be due to time preferences.

The second question addresses this issue by shortening the relevant time span from 15 to 5 years. This made model A slightly more attractive than B; in fact, unless we assume (perhaps unrealistically) time preferences where individuals actually place greater weight on future than current consumption, no-one would choose model B in the second scenario. However, as the setup suggests that model B is associated with lower energy use than model A, environmentally conscious consumers may prefer model B over model A even in a situation where B is more expensive than A.

We capture these considerations in our variable *Energy investment literacy*, taking values 0–2, which builds on the idea that a respondent rationally chooses B in the first scenario and A in the second scenario.[7] If the respondent makes both of these choices, we assign the respondent a value of 2 on this variable. If the respondent makes one of the choices but not the other, we assign a value of 1. If he/she makes neither of these choices, we assign a value of 0. The mean of this variable is 1.28 (see Table 1).

TABLE 2 Energy investment literacy (correct responses in bold)

	Energy investment literacy	
Response	**Trade-off between two models of heating systems—lifespan of 15 years**	**Trade-off between two models of heating systems—lifespan of 5 years**
	Q1. Think about a hypothetical situation where you own your home, and your heating system breaks down and is beyond repair. As a replacement, you can choose between two heating systems. Model A sells for €3750, and the heating is expected to cost €100 per month. Model B is more expensive, with a retail price of €5000, but the heating will cost €80 per month. You can assume that both models have an economic lifespan of 15 years. Which heating system would you choose? • Heating system A • **Heating system B** • Both models are equally adequate • Cannot say	Q2. What would happen if both models had an economic lifespan of 5 years (instead of 15 years as assumed before)? Which heating system would you prefer? • **Heating system A** • Heating system B • Both models are equally adequate • Cannot say
Heating system A	14.1	59.6
Heating system B	68.6	10.3
No preference	10.9	22.4
Cannot say	6.4	7.7

4.1.3 | Financial literacy

We next discuss the standard financial literacy questions popularized by Lusardi and Mitchell (2011). These include questions related to understanding and applying the concepts of the inflation rate, interest rate, and risk diversification. These questions are shown in Table 3.

The responses to the financial literacy questions, presented in Table 3, indicate a surprisingly high level of financial literacy in this sample: for each question, more than three-quarters of the respondents replied correctly. Previous research by Kalmi and Ruuskanen (2018) indicated somewhat lower levels of financial literacy in Finland. The high level of financial literacy in this sample might be a result of the above-average education level in the sample—financial literacy correlates positively with the education level (Lusardi & Mitchell, 2014).

In the regression analysis, we will use the number of correct responses, taking values 0–3, as the dependent variable. This variable, called *Financial Literacy*, takes the mean value of 2.38 (Table 1).

4.1.4 | Cost awareness

The third component of energy-related financial literacy in our study is *cost awareness*. Here, we have five different components: the respondent's perception of electricity sales price per

TABLE 3 Financial literacy (correct responses in bold)

	Financial literacy		
Response	**Inflation**	**Compound interest rate**	**Risk and diversification**
	Q1. Suppose you put €1000 into a savings account with a guaranteed interest rate of 1% per year. The inflation rate is 2% annually. You do not make any further deposits into this account, and you do not withdraw any money. In 1 year's time, will you be able to buy: • The same amount as today • **Less than you could buy today** • More than you could buy today • Cannot say	Q2. Suppose you put €100 into a savings account with a guaranteed interest rate of 2% per year. You do not make any further deposits into this account, and you do not withdraw any money. Assume that there is no tax on interest paid. How much would be in the account at the end of 5 years? • **More than €102** • Exactly €102 • Less than €102 • Cannot say	Q3. When you buy a wide range of stocks, it usually means a higher risk of decrease in value than in investing in one stock only. • True • **False** • Cannot say
Correct	85.2	75	77.6
Incorrect	7.7	18.6	13.6
Do not know	7.1	6.4	9

kWh, the perception of electricity distribution price per kWh, the estimated cost of using an ordinary dishwasher for 2 h, the cost of using an ordinary oven for 2 h, and the percentage increase in the heating cost of increasing the desired temperature by two degrees. Table 4 presents these questions. The respondents either chose to provide an estimate or chose the option "do not know." When they provide an estimate, it may be roughly correct, an underestimate, or an overestimate. In Appendix 2, we explain how we chose the critical values for these prices.

Table 4 also presents the distribution of the responses to each question. Note first that the modal answer to each question is "do not know." In 3 out of 5 questions, the majority of respondents chose not to answer the question. Among those who responded, the modal response was the correct one. This is, of course, dependent on the range of responses we accept as correct. Our findings indicate that in most cases, the estimates were not too far off. Under- or overestimates of costs were less common, but for the cost of using appliances and heating costs, there was a larger proportion of overestimates than underestimates.

The upper part of Table 5 presents the distribution of the dominant mode of response, that is, whether the respondent provided quantitatively more correct responses than over- or underestimates or no responses, and so on. Approximately one-third of the respondents tended to be well informed about the costs and gave more correct responses than any other kind of response. More than one-half of the sample had very little idea of the costs, and the dominant response was "do not know." Few respondents tended to systematically over- or underestimate the costs.

TABLE 4 Energy cost awareness

	Energy cost awareness	
Response	Awareness of electricity prices	
	Electrical energy cost	Electrical distribution charge
	How many cents per kilowatt hour do you pay for *electrical energy costs*, on average? *Please provide the exact amount or an estimate.* • Cents per kilowatt hour [.....] • Cannot say	How many cents per kilowatt hour 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 kilowatt hour [.....] • Cannot say
Correct	43	28.9
Underestimate	4.5	7.7
Overestimate	4.5	6.4
Do not know	48.1	57.1
	Awareness of different operating costs	
	Oven	*Heating bill*
	How much does it cost (in cents) to use an ordinary oven for 2 h (at 200°C)? *Please provide an estimate.* • Cents [.....] • Cannot say	What is the percentage (%) by which your heating bill goes up, on average, if you increase the temperature of your house by two degrees in a month? *Please provide an estimate.* • My heating bill goes up by (percent) [.....] • Cannot say
Correct	18.6	32.7
Underestimate	5.8	6.4
Overestimate	19.2	14.7
Do not know	56.4	46.2
	Dishwasher	
	Q1. How much does it cost (in cents) to run an ordinary dishwasher for 2 h? *Please provide an estimate.* • Cents [.....] • Cannot say	
Correct	17.3	
Underestimate	5.1	
Overestimate	20.5	
Do not know	57.1	

The lower part of Table 5 presents the distribution of correct responses. This is used as a variable ranging from 0 to 5 to measure cost awareness. Here, the modal response is zero—typically, the respondents failed to give any answer to the question. Even those respondents who had at least one correct response seldom had more than a few—only 12% had 4 or 5 correct

TABLE 5 Distribution of dominant responses and the number of correct answers to different questions (%)

Dominant responses	
Correct responses dominant	34.0
Underestimates dominant	5.1
Overestimates dominant	7.7
No answer dominant	53.2
Number of correct answers	
0 correct	38.5
1 correct	19.2
2 correct	19.9
3 correct	10.9
4 correct	9.0
5 correct	2.6

TABLE 6 Correlations between energy-related financial literacy variables

	Energy investment literacy	**Financial literacy**	**Number of correct answers**	**No answer dominant**	**Energy interest**
Financial literacy	0.20**				
Number correct responses	0.17**	0.32***			
No answer dominant	−0.26***	−0.24***	−0.68***		
Energy interest	0.16*	0.21**	0.35***	−0.32***	
Subjective energy literacy	0.23***	0.35***	0.40***	−0.41***	0.50***

***p <0.01.
**p <0.05.
*p <0.1.

responses. In this sense, the respondents display quite limited awareness of energy costs and consumption.

4.1.5 | Interest in energy issues and subjective energy literacy

We broaden the concept of energy-related financial literacy to include more subjective assessments. The first of these questions (*Energy interest*) was formulated: "How would you rate your own interest in energy-related matters?" The second question (*Subjective energy literacy*) was: "How would you evaluate your own capability to read and understand the electricity bills?" Both of these questions take values from 1 to 10. The mean of *Energy interest* is 7.61, and the mean of *Subjective energy literacy* is 7.18 (Table 1).

In Table 6, we present the pairwise correlations of our measures of energy-related financial literacy. All of them appear statistically significant and of expected sign. Generally, the lowest correlations occurred with the *Energy investment literacy*—variable. The highest pairwise correlations were between the awareness variables, but this largely occurred because they are codependent by construction. The correlation between the two subjective variables was also high, 0.50.

4.2 | Determinants of energy-related financial literacy

We next proceed to analyze the determinants of the five different components of energy-related financial literacy. In this analysis, we control for gender by including the *Female* dummy, four age dummies for various categories, one dummy variable for education (BA or higher), two dummies for personal income, and a dummy for tenant housing. The summary statistics for these variables can be found in Table 1.

In doing so, we report the average marginal effects from probit models for one binary dependent variable (*No answer dominant*); for variables taking more than two values, we present the ordered probit (OP) coefficients. These results are presented in Table 7.[8]

From specification 1, it is apparent that the variation in *Energy investment literacy* is difficult to explain using any of the standard variables. The only explanatory variable that is (marginally) significant is the age bracket 18–28 years. This is also the only specification in Table 7 where the likelihood ratio (LR) test indicates that the overall model is not statistically significant.

The results concerning *Financial literacy* are more aligned with standard results. We find that financial literacy is lower among women than men and is higher among more educated respondents. Moreover, *Financial literacy* is lower among age category of 29–39 years.

Next, we examine the determinants of cost awareness. Specification 3 presents the results for the variable *Number correct responses*, which takes values 0–5. There is a significant relationship with gender (men being more cost-aware than women), age (younger persons being less cost-aware), and education (the more educated being more cost-aware). In specification 4, we use the binary variable *No answer dominant*. Here, only the relationship with gender is significant; females are more likely to answer "do not know."[9]

Above, we mentioned that the variation in *Energy investment literacy* is difficult to explain. It is possible that the questions concerning *Energy investment literacy* are cognitively more taxing. As noted, the results of Allgood and Walstad (2016) concerning the subjective measures of financial literacy suggest that such measures can perform as well as objective measures. Therefore, we report the results concerning these subjective measures concerning *Energy interest* and *Subjective energy literacy*.

From these results, it is apparent that the main variable driving these subjective variables is gender. Both *Energy interest* and *Subjective energy literacy* are much lower for women than men. There are also some other significant results, notably the variable *Tenant* is negative and significant in *Subjective energy literacy* (for the only time in these specifications). Education is marginally significant and positive for *Subjective energy literacy*.

Assessing the entire set of results, we find many similarities when comparing our results with those found in the literature. The fact that cost awareness measures are related mostly to education and gender is consistent with prior results, for example, in Blasch et al. (2021) and Filippini et al. (2020). The results that gender and education strongly affect financial literacy

TABLE 7 Determinants of energy-related financial literacy (n = 156)

Variable	Energy investment literacy	Financial literacy	Number of correct answers	No answer dominant	Energy interest	Subjective energy literacy
Female	0.014 (0.198)	−0.346* (0.204)	−0.872*** (0.198)	0.259*** (0.074)	−0.358** (0.151)	−0.760*** (0.184)
Age (Ref = ≥62)						
18–28	0.604* (0.345)	−0.248 (0.337)	−0.408 (0.330)	0.108 (0.141)	0.108 (0.308)	0.123 (0.308)
29–39	0.212 (0.284)	−0.592** (0.289)	−1.119*** (0.291)	0.179 (0.115)	−0.517** (0.259)	−0.261 (0.259)
40–50	0.089 (0.280)	0.053 (0.300)	−0.666** (0.275)	0.034 (0.115)	0.276 (0.256)	0.034 (0.255)
51–61	0.155 (0.274)	0.134 (0.290)	0.044 (0.258)	−0.029 (0.113)	0.122 (0.252)	−0.115 (0.251)
Education: BA or more	0.023 (0.201)	0.365* (0.208)	0.687*** (0.202)	−0.089 (0.121)	0.208 (0.182)	0.317* (0.182)
Personal income (Ref = High personal income)						
Low personal income	−0.143 (0.298)	−0.428 (0.305)	0.127 (0.290)	−0.088 (0.121)	0.173 (0.268)	−0.211 (0.268)
Middle personal income	−0.069 (0.237)	0.143 (0.247)	−0.226 (0.224)	0.043 (0.095)	−0.036 (0.212)	−0.353* (0.214)
Tenant	−0.281 (0.277)	0.262 (0.284)	−0.185 (0.272)	−0.024 (0.114)	−0.298 (0.251)	−0.655*** (0.254)
Observations	156	156	156	156	156	156
Pseudo R^2	0.013	0.061	0.107	0.085	0.030	0.059
Likelihood ratio	3.76	20.01***	52.10***	18.44**	17.60***	37.93***
Method	Ordered probit	Ordered probit	Ordered probit	Probit	Ordered probit	Ordered probit

Note: In the case of binary probit (*No answer dominant*), the coefficients are marginal effects. In other columns (ordered probit), they are coefficients from the probit model. Cutoff values and constant have been omitted. Standard errors in parentheses.
***p <0.01.
**p <0.05.
*p <0.1.

are also consistent with the literature reviewed by Lusardi and Mitchell (2014). However, the inability to explain the variation concerning energy investment literacy differs from both Brounen et al. (2013) and Blasch et al. (2021). The results indicate that, similar to earlier results concerning financial literacy (Brown & Graf, 2013; Bucher-Koenen et al., 2017), women are less interested in energy-related issues than men and give themselves lower subjective perceptions of energy knowledge scores. Overall, the difference between men and women seems to be the strongest result arising from this analysis.

4.3 | Energy-related financial literacy and energy consumption

Ultimately, interest in energy-related financial literacy is motivated by the concern regarding whether it is associated with lower electricity consumption. In the final empirical analysis of this article, we examine the associations between electricity use and the components of energy-related financial literacy. In this analysis, we control for various household and building-related characteristics. The dependent variable in this model is the natural logarithm of the electricity consumption in kilowatt hour per month.

We start Table 8 by providing a benchmark energy literacy regression model without including any energy-related financial literacy variables (specification 1). We include largely the same demographic variables as in the previous regressions (Table 7) with two exceptions: we use household income instead of personal income. This seems more appropriate, as the behavior of the entire household influences consumption. Similar to Blasch et al. (2017), we do not include gender in the specifications. One reason for this is that because 75% of households in the survey have more than one member (the energy consumption of the household is also determined by more persons than just the respondent alone). Second, we have no theoretical reasons to expect gender to influence energy consumption, and it is empirically not a significant determinant. Third, gender exerts such a heavy influence on financial literacy, including the *Female* dummy risks confounding the effects of both gender and financial literacy.

We also include household size and a host of building-related variables: whether it is a single/detached house, the square meters of the apartment/house, whether electricity is used as the main source of heating, and dummies for construction year. We do not include the electricity price, however, because most households in the sample have the same provider and thus face the same set of prices, leading to limited variation in price.[10]

In the first specification in Table 8, we see that few demographic variables are significant, whereas most of the building-specific variables and household size are significant. Electricity consumption is higher in single and detached houses than in other types of homes and in buildings with electric heating. Electricity consumption increases with both floor area and household size. It is lower in buildings constructed between 1940 and 1969 than in buildings built in the 2000s. Regarding the demographic variables, younger respondents consume less electricity than older respondents. The education of the respondent and household income are not significant determinants of energy consumption.

We next add energy-related financial literacy variables one by one. In specification 2, we add the *Energy investment literacy* variable. It is insignificant, with a very imprecise coefficient. In specification 3, we include the variable *Financial literacy*. Higher levels of financial literacy are associated with lower energy consumption. The coefficient is significant at the border of the 10% level. A one-point increase in financial literacy (on a scale of 0–3) leads to a reduction in consumption of an estimated 10%.

In specifications 4–6, we investigate the different cost awareness variables. In specification 4, we insert the variable *Number of correct answers*, which is associated with significantly low electricity consumption. The coefficient is significant at the 5% level and indicates that a one-point increase in the number of correct answers reduces energy consumption by an estimated 10%.

In specification 5, we insert the binary variable *No answer dominant*. This variable is significant at the 1% level. When the respondent does not have an idea about energy costs, consumption is over 31% higher than that of respondents who provide estimates of energy costs. In specification 6, we also insert binary variables *Underestimate dominant* and *Overestimate*

TABLE 8 Determinants of energy consumption

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Energy investment literacy		−0.00185 (0.0784)							0.0890 (0.0829)
Financial literacy			−0.103* (0.0625)						−0.0670 (0.0661)
Number of correct answers				−0.0954** (0.0377)					−0.0772* (0.0435)
No answer dominant					0.314*** (0.101)	0.265** (0.113)			
Overestimate dominant						−0.153 (0.213)			
Underestimate dominant						−0.202 (0.239)			
Energy interest							−0.0440* (0.0239)		−0.0162 (0.0295)
Subjective energy literacy								−0.0492* 0.0286)	−0.0207 (0.0331)
Age (Ref = ≥62)									
18–28	−0.391** (0.186)	−0.391** (0.189)	−0.414** (0.186)	−0.447** (0.184)	−0.451** (0.182)	−0.467** (0.184)	−0.407** (0.185)	−0.397** (0.185)	−0.492** (0.189)
29–39	−0.298* (0.175)	−0.298* (0.176)	−0.335* (0.175)	−0.413** (0.177)	−0.379** (0.172)	−0.354** (0.175)	−0.336* (0.175)	−0.360** (0.177)	−0.472** (0.183)
40–50	−0.0645 (0.171)	−0.0643 (0.171)	−0.0527 (0.170)	−0.141 (0.170)	−0.106 (0.166)	−0.0652 (0.174)	−0.0477 (0.169)	−0.0507 (0.170)	−0.114 (0.173)
51–61	0.0576 (0.148)	0.0577 (0.149)	0.0631 (0.148)	0.0623 (0.146)	0.0637 (0.144)	0.0701 (0.146)	0.0370 (0.148)	0.0707 (0.148)	0.0535 (0.148)
Education: BA or more	−0.0211 (0.104)	−0.0211 (0.104)	0.000836 (0.104)	0.0384 (0.105)	−0.00912 (0.101)	−0.0257 (0.103)	−0.00341 (0.104)	−0.00681 (0.104)	0.0539 (0.106)

(Continues)

TABLE 8 (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Household income (Ref = High household income)									
Low household income	0.166	0.166	0.125	0.142	0.126	0.117	0.121	0.181	0.141
	(0.199)	(0.201)	(0.199)	(0.195)	(0.193)	(0.194)	(0.199)	(0.198)	(0.200)
Middle household income	0.0866	0.0861	0.0754	0.0769	0.0684	0.0719	0.108	0.105	0.111
	(0.174)	(0.176)	(0.173)	(0.171)	(0.169)	(0.169)	(0.173)	(0.173)	(0.174)
Detached home	0.524***	0.524***	0.531***	0.577***	0.595***	0.582***	0.546***	0.518***	0.584***
	(0.172)	(0.172)	(0.171)	(0.170)	(0.168)	(0.169)	(0.171)	(0.170)	(0.171)
Electric heating	0.608***	0.608***	0.613***	0.597***	0.606***	0.591***	0.587***	0.607***	0.591***
	(0.112)	(0.112)	(0.111)	(0.110)	(0.108)	(0.110)	(0.111)	(0.111)	(0.111)
Floor area	0.00476***	0.00476***	0.00469***	0.00461***	0.0042**	0.00425**	0.00468***	0.0049***	0.00454**
	(0.00179)	(0.00179)	(0.00178)	(0.00175)	(0.0017)	(0.0018)	(0.00177)	(0.00178)	(0.00177)
Nr household members	0.200***	0.200***	0.189***	0.194***	0.212***	0.213***	0.199***	0.211***	0.201***
	(0.0604)	(0.0610)	(0.0604)	(0.0593)	(0.0587)	(0.0594)	(0.0599)	(0.0603)	(0.0607)
Construction year (Ref = After 1999)									
Before 1940	−0.0847	−0.0851	−0.0898	−0.0977	−0.0669	−0.0340	−0.0848	−0.118	−0.0948
	(0.199)	(0.200)	(0.198)	(0.195)	(0.193)	(0.198)	(0.197)	(0.198)	(0.198)
1940–1969	−0.448***	−0.448***	−0.447***	−0.492***	−0.495***	−0.488***	−0.430***	−0.453***	−0.456***
	(0.154)	(0.156)	(0.154)	(0.153)	(0.151)	(0.153)	(0.153)	(0.153)	(0.155)
1970–1999	−0.204*	−0.205*	−0.190	−0.168	−0.156	−0.144	−0.164	−0.207*	−0.123
	(0.118)	(0.121)	(0.117)	(0.116)	(0.115)	(0.116)	(0.119)	(0.117)	(0.124)
Tenant	−0.0303	−0.0306	−0.0138	−0.0133	0.0264	0.0419	−0.0570	−0.0388	−0.00311
	(0.159)	(0.161)	(0.159)	(0.156)	(0.156)	(0.157)	(0.159)	(0.158)	(0.159)
Constant	4.687***	4.691***	4.970***	4.848***	4.541***	4.583***	5.005***	5.021***	5.098***
	(0.298)	(0.331)	(0.342)	(0.299)	(0.293)	(0.297)	(0.342)	(0.354)	(0.393)
Observations	156	156	156	156	156	156	156	156	156

TABLE 8 (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
R-squared	0.647	0.647	0.654	0.663	0.670	0.673	0.656	0.655	0.670
F-test (overall)	17.13***	15.94***	16.43***	17.07***	17.66***	15.65***	16.54***	16.47***	13.73***
F-test (demographic variables)	1.23								
F-test (energy-related financial variables		0.00	2.74*	6.39**	9.69***	3.56**	2.96*	3.38*	1.89*

Note: Dependent variable: Log of energy consumption in KwH/month). Standard errors in parentheses.
***p <0.01.
**p <0.05.
*p <0.1.

dominant to determine whether the direction in which the respondents err in their estimates is related to consumption. We do not find a statistically significant relationship with these issues.

In specifications 7 and 8, we evaluate the relationships between our subjective measures of energy literacy and energy consumption. Both of these variables are negatively correlated with consumption. A one-point increase in *Interest in energy issues* is associated with a 4% reduction in energy consumption, whereas a one-point increase in *Subjective energy literacy* is associated with an estimated 5% reduction in energy consumption.

In the final specification, specification 9, we insert all different aspects of energy-related financial literacy into the same specification.[11] Likely because of the multicollinearity of these variables, only our measure of cost awareness, *Number of correct answers*, is significant and only at the 10% level.

We include different *F*-tests in Table 8. The overall F-test indicates that the model is highly statistically significant. However, for specification 1, we test the significance of respondent characteristics and household income and find that these are not significant. The overall model is thus driven by house characteristics and household size. For the remaining specifications, we perform and report the F-test for the energy-related financial literacy variables. In most specifications with just one variable relating to energy-related financial literacy, this is equivalent to the t-test, and the test produces no additional information. However, for the final specification 9, the *F*-test of joint significance of energy-related financial literacy variables is significant, but only at the 10% level.

5 | CONCLUSIONS AND DISCUSSION

This study contributes to a small but growing literature on energy-related financial literacy as a subset of financial literacy. Households' energy behaviors present significant externalities, especially in the form of CO_2 emissions. An important question is whether households might voluntarily curb their electricity consumption if they were more aware of (at least) the private energy costs and able to calculate the financial costs of different alternative actions.

In our conceptual section, we review the literature on household energy consumption and especially its relation to skills and awareness. We suggest that the nascent literature on energy-related financial literacy might be useful in addressing these issues. We first discuss the general literature on financial literacy and then review the literature on energy-related financial literacy. By contrasting these two strands of literature, we suggest that the previous literature on energy-related financial literacy could be usefully complemented by considering subjective components of energy-related financial literacy.

When we look at the determinants of various components of energy-related financial literacy, we find that there are significant differences between males and females in most dimensions of energy-related financial literacy. These results are closely aligned with what we know about the determinants of financial literacy (Lusardi & Mitchell, 2014). The crucial role of women in influencing energy consumption and decisions on purchases of household appliances suggests that addressing the gender gap in energy-related financial literacy is an important policy issue. There are other results that are consistent with prior literature (especially the role of education), but these do not appear to be as important as the role of gender.

We then proceed to investigate the role of energy-related financial literacy in energy-related household consumption. We find that our energy-related financial literacy measures have a negative and statistically significant (at least at 10%) relationship with energy consumption

(with the exception of energy investment literacy). This relationship is especially strong concerning cost awareness measures. The finding that energy-related financial literacy is associated with lower household energy consumption is consistent with the results of Blasch et al. (2017), though they are in stark contrast to the findings of Brounen et al. (2013), who used self-reported data.

The results thus suggest that energy-related financial literacy may be useful in reducing energy consumption. From a policy perspective, the important question is whether energy-related financial literacy can be cultivated by educational or informational interventions. There has been a substantial debate in the financial education literature on the possibility of influencing financial literacy through educational interventions (Fernandes et al., 2014). The more recent literature takes the view that financial education can indeed be effective (Kaiser et al., 2020; Kaiser & Menkhoff, 2017). The effects of education on energy-related financial literacy remain largely untested.

Informational interventions can also improve energy savings at the household level. The results are somewhat mixed, but most studies have found that information sharing is effective in promoting energy-saving behaviors. Particularly important in this respect may be the findings of Blasch et al. (2017), who reported that consumers who have higher levels of energy-related financial literacy are more likely to identify energy savings, thus pointing out complementarity between information provision and energy-related financial literacy.

There are certain advantages in that awareness is a central variable in affecting consumption. It is likely easier to influence awareness than cognitive skills. In supporting cognitive skills, the use of various digital calculation tools might be useful.

In any case, even if both energy-related financial literacy skills and awareness could be raised to a very high level, there might still be possible limitations. The consumption of energy is constrained by the parameters imposed by technology; for instance, most dishwashers offer a limited menu of various programs. Even with technically savvy consumers with the latest technology and high energy-related financial literacy, hard-wired habits developed by routines may guide their decisions. Informed by theories of practice, a number of studies have highlighted the crucial role of everyday practices, rhythms, sequences, material arrangements, and embodied experience in practices in shaping domestic energy consumption (e.g., Shove & Walker, 2014). A recent Danish study (Trotta et al., 2020) showed substantial heterogeneity of electricity consumption patterns in households with very similar sociodemographic and dwelling characteristics, which are mainly determined by different everyday practices and their order in time.

Despite the well-documented role of consumer behavior in influencing energy consumption, technology may also offer solutions, for instance in terms of home automation systems that may lead to savings without continuous attention by household members. While home automation systems are often relatively expensive, there might also be low-hanging fruit, such as inexpensive devices that gather information about the electricity consumption of household appliances. If the main objective of policymakers is to reduce the residential energy use even for people with upward biased electricity cost perceptions or for people who are not responsive to informational/educational measures, policymakers should continue with the policies that affect the purchase decisions and the energy performance of new appliances.

Energy-related financial literacy might also become more important in the future due to issues such as dynamic pricing (which makes the timing of electricity consumption substantially important) or prosuming (where households can sell the surplus energy they produce back to the distribution network). These enable households that are skillful in terms of energy-

related financial literacy to benefit financially from their skills. Additionally, higher levels of energy-related financial literacy could especially benefit vulnerable household members who struggle with energy bills, are less likely to replace inefficient appliances with new ones or invest in energy-efficient retrofits, and that, in the absence of any change in behavior, might be proportionally more disadvantaged by dynamic pricing schemes.

Our approach, informed mostly by economics, particularly emphasizes the financial incentives of energy savings: that consumers are aware of how they can save energy and that they have skills to implement energy-saving actions. However, consumers may be motivated by broader considerations than just their own purse. Many consumers are concerned about climate change and may be interested in pursuing energy-saving actions even without financial incentives to do so. The link between energy-saving attitudes and concern for the environment may be usefully addressed in future studies.

Although there have been some recent contributions to energy-related financial literacy, such studies remain limited in number. The methodology and measurement of the topic, as well as investigations on the impact of education, will develop when more studies and knowledge accumulate. This study helps to assess and consolidate the findings in the literature. One clear shortcoming of our study is that it contains a relatively small sample. Future studies on energy-related financial literacy should also address the small sample issue that limits our and earlier works.

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ENDNOTES

[1] For the entire questionnaire text, see the online Appendix.

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

[3] Of the 244 respondents who initially signed up for the survey, 182 registered electronically and 62 did so in the shopping mall. There was a stand in the shopping mall, and student assistants asked people to register. The respondents who registered electronically had a higher response rate than those who did so in the mall.

[4] https://ec.europa.eu/eurostat/databrowser/view/tin00028/default/table?lang=en.

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

[6] The survey respondents granted permission to access and use their monthly electricity consumption data.

[7] This way of defining *Energy investment literacy*, while consistent with prior literature, can be criticized on the grounds that in the first scenario, time preferences may lead a person to rationally choose A over B, whereas in the second scenario, preferences toward environmental protection may lead a person to rationally choose B

over A. We experimented with an alternative definition of *Energy investment literacy* that was based on the idea that a person makes a time-consistent choice. However, this alternative variable did not produce additional insights in the regression analysis, so we omit the analysis from herein (the results are available from the authors).

[8] The results are virtually identical if we use ordinary least squares estimations instead of ordered probit. We report here the OP results as they are technically more appropriate. The marginal effects interpretation is messy in the case of OP, and therefore we report only the probit coefficients for the OP results.

[9] The tendency of women being more likely to answer "do not know" is familiar also in the context of financial literacy; see Bucher-Koenen et al. (2017).

[10] Even within the same provider, there is some variation in average prices depending on the contract the respondents have chosen and the relation between fixed and variable costs in consumption.

[11] We use here *Number of correct answers* as the proxy for energy awareness; the results are similar (though stronger for awareness) if we use the variable *No answer dominant*.

[12] https://energiavirasto.fi/en/statistics-and-publications.

[13] These are from https://www.vattenfall.fi/energianeuvonta/sahkonkulutus/.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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APPENDIX 1

Table A1

TABLE A1 Comparison of the sociodemographic and dwelling characteristics of the survey data with the Official Statistics of Finland (%)

	Survey data	Official statistics
Gender		
Male	53.2	48.8
Female	46.8	51.2
Respondent age		
18–39	34.6	34.0
40–61	39.1	35.1
>62	26.2	31.0
Education		
No BA	51.3	68.4
BA or higher	48.7	31.6
Respondent gross annual income		
−€20,000	23.1	39.5
€20,001–€40,000	46.2	36.3
>€50,000	30.1	24.2
Housing		
Single/detached housing	49.4	39.4
Rental housing	19.2	32.7

Note: Source: Survey data and Statistics Finland www.tilastokeskus.fi.

APPENDIX 2: THE DETERMINANTS OF COST AWARENESS 2

The cost awareness variable has five components: awareness of the electricity sales price, awareness of the electricity distribution price, the use of ovens and dishwashers for a prespecified period, and the relative increase in heating costs relative to a change in temperature. Each of these variables is such that it is difficult to have one precise answer to these questions for reasons that we discuss below.

Concerning the electricity sales price and the electricity distribution price, one of the challenges is that although most respondents had both sales contracts and electricity distribution contracts with Vaasan Sähkö and Vaasan Sähköverkko, our sample contained few observations that had one of these contracts with another electricity provider. Furthermore, Vaasan Sähkö offers different contracts with different combinations of fixed and variable pricing, and the price may also depend on the type of housing. Finally, it is not entirely clear whether the respondents interpreted the question to mean the average or the marginal price.

Data from the Finnish Energy Authority[12] indicate that the lowest sales price offered in Finland in March 2017 was 3.98 eurocents per kWh, and the average price was between 6 and

7 eurocents per kWh. Here, we have interpreted responses of between 4 and 10 cents per kWh as being correct. Concerning electricity distribution prices, the average price in March 2017 varied between 3.6 cents per kWh for single houses with electrical heating and 8.3 cents per kWh for multifamily properties. Here, we accept the range of correct responses to be between 3 and 10 cents.

The use of an oven for 2 h is estimated to consume 1.5–2 kWh of electricity, so with the specified electricity prices, the correct cost can be estimated to be approximately 10–40 cents. For dishwashers, the estimated consumption varies between 0.5 and 1.5 kWh, so we accepted estimated costs in a range of 4–30 cents.[13] Finally, for the heating cost, we used the rule of thumb that an increase in the desired temperature by one degree raises heating costs by approximately 3–5%. We accepted responses in the range of 5–10% because we asked about a two-degree temperature increase; some variation in this estimate is expected related to the insulation levels and heating systems of a home. However, any responses below the critical values were regarded as underestimates, and any responses above them were regarded as overestimates.