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# Abstract

This paper offers insights on the factors that determine household choices related to energy use, based on data from the third OECD Survey on Environmental Policies and Individual Behaviour Change (EPIC). The analysis profiles households according to patterns in reported energy use and investment in energy-related technologies, assesses the factors driving such decisions and estimates households' willingness to pay to reduce the emissions of the electricity they use. Results suggest that the feasibility of installing low-emissions energy technologies appears to remain a key obstacle to their uptake, and that households are willing to pay a small but positive premium for electricity produced with fewer emissions. The presence of cross-country differences in behaviours and preferences signals the importance of considering local factors in approaches to energy policies. Environmental concern and environmental motivation increase engagement in sustainable choices, pointing to the cross-cutting relevance of policy efforts to improve environmental knowledge and awareness.

**Keywords:** residential energy consumption, household behaviour, energy conservation, energy efficiency

**JEL Codes:** Q40, Q42, Q54, D12, D91, C25

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This paper is an output of the OECD Environmental Policy Committee and its Working Party on Integrating Environmental and Economic Policies (WPIEEP). The paper was carried out under the overall supervision of Shardul Agrawala, Head of the Environment and Economy Integration Division in the OECD Environment Directorate.

All sections of the paper contain contributions by Katherine Hassett, Rose Mba Mébiame and Ioannis Tikoudis (OECD Environment Directorate). Nicolina Lamhauge (OECD Environment Directorate) oversaw the paper and Ioannis Tikoudis reviewed the technical input. Nick Johnstone (International Energy Agency) provided support in guiding and contributing to the quantitative analyses and assembling collaborators. David Shipworth (University College London) and Samuel Thomas (UsersTCP) also provided valuable feedback and guidance in developing the report. The co-authors of each section of the paper are identified in the table below.[1] The Secretariat thanks the co-authors and those mentioned above for their useful feedback on all sections of the report. Helene Ahlborg, Olufolahan Osunmuyiwa, David Shipworth, and Samuel Thomas also contributed to the design of the EPIC survey questionnaire. Ijeoma Inyama-Dalles, Ivan Babiy, Vilma Gertrane, and Illias Mousse Iye (OECD Environment Directorate) provided administrative and editorial assistance.

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| 2. The role of households in the energy transition | Katherine Hassett, Helene Ahlborg, Kavya Michael, Olufolahan Osunmuyiwa, Rose Mba Mebiame, Ioannis Tikoudis |
| 3. Household profiles in energy use | Rose Mba Mebiame, Katherine Hassett, Helene Ahlborg, Kavya Michael, Olufolahan Osunmuyiwa, Ioannis Tikoudis |

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| 4. Determinants of sustainable energy behaviours | Aline Mortha, Rose Mba Mebiame, Katherine Hassett, Ioannis Tikoudis, Toshi Arimura and Nick Johnstone |
| 5. Preferences for lower-emissions intensive electricity | Miwa Nakai, Ugur Ozdemir, Ioannis Tikoudis, Katherine Hassett, Toshi Arimura, Nick Johnstone |
| 6. Demand-side policy considerations for an effective energy transition | Katherine Hassett, Rose Mba Mebiame, Nicolina Lamhauge, Ioannis Tikoudis, Helene Ahlborg, Nick Johnstone |

# Table of contents



## FIGURES

## TABLES

# Executive summary

Household choices with respect to energy use, choice of energy provider and investments in low-emissions energy technologies such as solar panels and heat pumps, have important implications for the climate and the environment. Energy policies that encourage households to make more sustainable energy choices therefore continue to be important for reducing the environmental impacts of residential energy use. This paper offers insights on the factors that determine household choices related to energy use based on data from the third OECD Survey on Environmental Policies and Individual Behaviour Change (EPIC), which was implemented to more than 17 000 households in nine OECD countries in 2022. The comprehensive scope and international perspective of the survey allows for identifying common drivers of household choices across countries, as well as identifying differences across countries.

The analysis offers new insights regarding the relative impact of a range of factors on behaviour and the importance of country-context in determining household decisions. Findings suggest that while the barriers to energy conservation tend to be attitudinal or behavioural in nature, the barriers to investing in energy equipment tend to be structural or financial. Financial barriers pertain to affordability-related constraints, whereas structural barriers pertain to obstacles to installation that may exist even in the absence of financial barriers (e.g. the infeasibility of installing solar PV in multi-unit buildings). While measures to improve affordability can remove some financial barriers, they do not address structural constraints. The analysis points to the importance of addressing structural barriers in order to more fully address the environmental impacts of the residential energy sector. The results also point to significant cross-country differences in households' environmentally relevant behaviours and preferences, signalling the importance of considering local factors in policy approaches to conservation and investment behaviour alike. The consistent impact of environmental concern and environmental motivation as determinants of sustainable choices point to the cross-cutting relevance of policy efforts to improve environmental knowledge and awareness.

A comparison between the 2022 and 2011 EPIC Surveys suggests that renewably generated electricity has become more widely available to households in several countries. Despite this, there appears to be continued unmet demand for renewably generated electricity: 64% of respondents report not having this option in 2022, and 39% indicate that they would be interested if it were available. Survey results also point to a lack of awareness among households regarding the availability of green electricity options. Additionally, results suggest that over the last decade, households have shifted from investments in energy efficiency technologies such as insulation, towards renewable energy and heat pumps. This shift in choices, together with evident financial barriers suggest that improving financial support available to install these technologies continues to be an important policy tool in increasing their uptake.

The paper also includes an estimation of households' willingness to pay for renewable electricity supply, showing that in most countries, households are willing to pay a premium of between 1% and 9% to reduce the greenhouse gas emissions from their electricity supply by 10%. These differences in willingness to pay for cleaner energy are evident among countries with similar sociodemographic, climatic and energy mix characteristics, suggesting that national policy contexts, environmental awareness, and other non-financial or cultural factors may play an important role in household attitudes towards renewable energy. Results from the discrete choice experiment also suggest that while a given carbon tax has differing impacts on household choices of household energy provider across countries, this is mainly due to cross-country differences in the emissions intensity of electricity generation rather than differences in households' price sensitivity.

The paper also identifies distinct groups of households with respect to energy conservation and investment in low-emissions energy technologies. With respect to energy conservation, households can be classified as either *conservers* (i.e. they engage in various energy conservation behaviours) or *non-*

*conservers*. The two groups comprise an average of 65% and 35% of the sample, respectively. *Conserver* households tend to be older, more environmentally concerned, and more likely to live in rural areas and in detached houses than *non-conserver* households. These findings point to specific groups for targeted interventions, e.g. those that are younger, live in urban areas, and live in multi-unit buildings. To the extent that the estimated proportion of *conserver* households differs across countries, these findings also provide an indication of where policy efforts may be more or less needed with respect to increasing household engagement in energy conservation.

For investments in low-emissions energy technologies (e.g. highly energy-efficient appliances, heat pumps, energy efficient windows), the analysis identifies six household profiles. *Super-investors* are characterised by the highest likelihood of investing in all types of technologies (14% of the sample); *Low-cost investors* (16%) exhibit a tendency to invest in technologies with lower installation costs (e.g. highly energy efficient appliances) rather than those with higher installation costs (e.g. heat pumps); *Invest when possible* households (26%) invest in both low-cost and high-cost technologies when it is possible to do so; finally, *Don't invest* households (23%) tend not to invest in any technologies, even when investment is possible. Two additional groups include the *Not possible* group (13%) that tend to report that installing most types of technologies is not possible, and the *Don't know* group (8%) that most often lack knowledge about the technologies or whether they have been installed. Household profiles are characterised by differences in income levels, home ownership rates and residence types, confirming evidence from other elements of the current analysis that financial and structural factors are important in determining to what extent households invest in low-emissions energy technologies.

Future work could further explore differences among countries, in particular regarding remaining barriers to sustainable energy choices. Beyond financial incentives, differences in attitudes and choices suggest that there may be significant opportunities for peer-to-peer learning that could be investigated in case studies and country comparisons. Future work could also include a comparison of the survey data on reported energy behaviours and expenditure with administrative data on actual energy use, as gaps between the two could provide insights on how engaged households are and how well they understand their energy consumption and expenditures. An exploration of household- or country-level determinants of energy-related knowledge formation could also be a fruitful area of research with potential policy implications. Further work could also assess the comparability of willingness to pay for carbon reductions as estimated by the discrete choice experiment in the EPIC Survey with other Social Cost of Greenhouse Gas emissions estimates. Scope also remains to further explore how household behaviours may be related to policy preferences, trust in institutions and trust in specific information sources, as well as the extent to which attitudes may have different impacts on behaviour among different socioeconomic groups. Finally, further analysis could also assess possible spillover effects between investing in low-emissions energy technologies and engagement in energy conservation, as well as the possibility that the choices that individuals make may influence the attitudes they hold.

# 1. Introduction and objectives

The climate crisis underscores the urgent need to change how energy is produced and used. Despite dramatic improvements in energy efficiency, greenhouse gas emissions from the energy sector have more than doubled worldwide between 1971 and 2021, reaching an all-time high of 36.8 Gt in 2022 (IEA, 2023[1]; IEA, 2023[2]). While growth in clean energy technologies has mitigated what could have been a higher increase in emissions, growth in renewables has not matched increases in energy demand. This highlights the importance of accelerating decarbonisation efforts and reduce energy use, including from households. The continued importance of this issue today signals that removing barriers to reducing energy use are more important than ever.

The potential impact of decarbonising the residential sector is significant. Buildings are responsible for 31% of global $CO_2$ emissions, half of which are emitted by residential buildings (IPCC, 2022[3]). However, this global statistic masks diversity between and within countries in terms of the energy sources available to households and the levels of electricity use and fuel consumption (Han and Wei, 2021[4]; Wolske, Gillingham and Schultz, 2020[5]; Zhou and Yang, 2016[6]). The European building sector saw an overall lowering of emissions in 2022 due in part to mild winter temperatures but also high energy prices and inflation which reduced overall energy demand. Although this fall in demand illustrated the potential role of behavioural change, high energy prices also had significant consequences for household welfare, especially among low-income households (OECD, 2023[7]). More policy efforts are likely needed to ensure these short term changes become permanent, and that they do not come at the cost of lower household welfare. To the extent that reducing excess energy consumption does not reduce household comfort, the additional welfare benefits of lower energy demand come in the form of lower social costs associated with lower emissions of greenhouse gases and local air pollutants, as well as lower energy expenditures for households.

Decarbonising the residential energy sector requires simultaneous efforts to lower emissions and to extend affordable services to currently underserved households. Both energy suppliers and households have an important role to play. Households can contribute the decarbonisation of their dwellings in three ways. First, they can conserve energy by lowering their energy consumption (e.g. by minimising their use of heating or cooling). Second, they can use energy more efficiently (e.g. by investing in more efficient appliances or improving the thermal insulation of their home). Third, they can reduce the emissions intensity of their energy use by shifting to cleaner energy sources (e.g. renewably generated electricity). Further, households can significantly affect the pace and direction of the energy transition in their roles as producers of energy, innovators, activists and supporters, and by acting as early adopters or laggards (Schot, Kanger and Verbong, 2016[8]; Wilkinson et al., 2020[9]).

Household engagement is key to sustained reductions in emissions. Energy conservation is typically the lowest cost option for reducing energy use and an option that is available to most households provided that they can still meet their basic energy needs. Investments in technologies to improve energy efficiency or to reduce emissions intensity may not be possible for all households due to financial constraints, tenure status, building characteristics or the commercial availability of these technologies. Effectively supporting households in their efforts to decarbonise their homes will rely on a good understanding of the factors that influence household decisions in these areas (van Valkengoed, Abrahamse and Steg, 2022[10]).

This paper provides evidence regarding the role of a range of factors in determining household behaviours that can be used to inform policy approaches that seek to influence these behaviours. Using data from the third round of the EPIC Survey (Box 1.1), this paper aims to i) characterise households according to their reported energy use and investment in low-emissions energy technologies, ii) identify the determinants of energy use and investment decisions and iii) analyse households' willingness to pay to reduce the emissions intensity of their electricity consumption. The analysis makes use of the energy-related survey items, which were completed by a total of 8,486 respondents.

The strength of the analyses carried out in this paper stem from the topical and geographic scope of the EPIC Survey. First, in addition to self-reported household choices related to energy use, the survey gathers information on a broad range of socioeconomic, attitudinal, and household characteristics. Examining the role of these factors simultaneously enables the analysis to generate insights regarding the relative importance of various barriers at the individual and household level in making more sustainable choices related to energy use. A better understanding of this relative importance can contribute to identifying the policy objectives and measures that should be prioritised. Second, the cross-country nature of the data provides information on the extent to which household conditions and behaviours vary across countries, demonstrating the importance of contextual factors in determining household choices.

***Section 2*** uses latent class analysis to identify groups (or classes) of households with similar patterns in their reported energy use and investment behaviours. This analysis yields information about the types of households that tend to engage in sustainable energy-related choices and those that do not, providing an indication of the barriers that households generally face in making such choices. It also identifies household profiles that should be of particular interest to policymakers aiming to increase engagement in energy conservation and investment in low-emissions energy technologies.

***Section 3*** explores the role of various socioeconomic, attitudinal and residential factors in determining household choices through an econometric analysis of specific energy use behaviours and investments in low-emissions energy technologies. The analysis identifies the most important factors determining household choices in these areas, providing an indication of the barriers and incentives that policies could target to effectively improve the sustainability of household energy use. It also identifies household characteristics that should be taken into account when designing targeted interventions (e.g. eligibility criteria for energy equipment subsidies).

***Section 4*** examines the role of price and GHG emissions intensity on household choice of electricity provider. It also estimates households' willingness to pay for reductions in GHG emissions intensity of electricity consumption. The analysis in this section is based on a discrete choice experiment included in the EPIC Survey, which constitutes a novel methodology relative to previous rounds of the survey and yields more detailed insights regarding households' preferences for electricity consumption. The results obtained in this section contribute new evidence regarding variation in preferences for GHG emissions reductions and willingness to pay across countries.

**Section 5** concludes with a summary of insights obtained in the preceding chapters and implications for the design of demand-side policies seeking to leverage the mitigation potential of household decisions in the energy transition.

## Box 1.1. Aim and scope of the EPIC Survey

The third OECD Survey on Environmental Policies and Individual Behaviour Change (EPIC) explores households' environmental attitudes and actions in the areas of energy, transport, waste and food across nine OECD countries. The survey collects information on reported environmental behaviours. It also records the socioeconomic characteristics of respondents and households, as well as the characteristics of their residence and residential location. As such, the survey provides information on a wide range of factors that can influence environmentally relevant household decisions. Each round of the EPIC Survey is described in Table 1.1. The questionnaire and further information on the implementation of the survey are available in (OECD, 2023[11]).

### Table 1.1. OECD EPIC surveys: coverage, thematic areas and sample sizes

| | 2008 | 2011 | 2022 |
|---|---|---|---|
| Countries included | Australia | Australia | Belgium |
| | Canada | Canada | Canada |
| | Czech Republic | Chile | France |
| | France | France | Israel |
| | Italy | Israel | The Netherlands |
| | Korea | Japan | Sweden |
| | The Netherlands | Korea | Switzerland |
| | Norway | The Netherlands | United Kingdom[1] |
| | Mexico | Spain | United States |
| | Sweden | Sweden | |
| | | Switzerland | |
| Total sample size | 10 000 | 12 303 | 17 216 |
| Methodology for measuring preferences and behaviour | Self-reporting | Self-reporting | Self-reporting + choice experiments |
| Number of thematic areas | 5 | 5 | 4 |
| Possibility to test hypothetical policy interventions | No | No | Yes |
| Distributional issues addressed | No | No | Yes |

[1]The sample from the United Kingdom includes households in England, Northern Ireland, Scotland and Wales.

The third EPIC Survey was implemented in June-July 2022, more than a decade after the second round of the survey, in 2011. Changes since then pertain to the environmental, political, technological and economic context and have all contributed to a need to reassess environmental attitudes and behaviours, as well as the effectiveness of environmental policies. At the time of implementation, most significant COVID-19-related restrictions (lockdowns and international travel bans), had been lifted in all the countries sampled. However, the period continued to be characterised by historically high energy prices, inflation and geopolitical tensions. The particularities of this context could have several implications for survey responses. Self-reported levels of support for tax instruments, for example, may be lower, while support for policy measures involving financial support (e.g. grant and subsidies) may be higher. Increasing economic concerns may reduce the political acceptability of disincentives (e.g. taxes); however, the same concerns could make measures that align sustainable habits with monetary savings (e.g. energy conservation) more likely to be adopted. Further, the energy crisis may have also led to increased interest in energy efficiency technologies that reduce energy costs over the long term.

# 2. The role of households in the energy transition

## 2.1. Demand-side policies and household energy use

Encouraging changes in individual or household behaviour regarding residential energy use, be it energy conservation or investment in technologies such as energy efficient appliances or low-emissions heating and cooling systems, is sometimes referred to as demand-side management.[2] As a complement to supply-side technological improvements, demand-side policy measures are critical to addressing environmental issues (e.g. Mundaca et al. (2019[12]), IPCC (2022[13])). In the IEA Net Zero Emissions (NZE) pathway to 2050, 37% of emissions reductions from the energy sector come from supply-side technological changes, while the remaining 63% involve the demand side. Without demand-side policy measures, final energy consumption in 2050 would be almost 90% above the level projected in this scenario (IEA, 2021[14]). Additional evidence confirms that households' daily choices can be a significant determinant of energy use. In the Netherlands, for example, differences in the way that households use energy (rather than, for example, the size of the home or the number of people in it) account for 50% of the variation in energy use for water and space heating (Guerra Santin, Itard and Visscher, 2009[15]). Evidence from Denmark indicates that how households use equipment has a stronger impact on overall energy use than the energy efficiency of the equipment used (Gram-Hanssen, 2011[16]).

The role of behaviour change is also critical insofar as it can be implemented immediately by a large number of households, representing a potential 10% reduction in total final energy demand by 2050. Demand-side energy management can also contribute to energy security and reducing energy poverty (Warren, 2018[17]). Additionally, demand-side policy measures can lead to cost savings that are variable but positive (Arimura et al., 2012[18]; Gillingham, Newell and Palmer, 2009[19]; Gillingham, Newell and Palmer, 2006[20]).[3] IEA's NZE scenario, for example, projects that the savings enabled by behavioural changes could amount to USD 4 trillion by 2050 (IEA, 2021[14]).

Demand-side policy measures have been implemented in many country contexts (Box 2.1), and ex-post assessments have provided evidence of their effectiveness in reducing energy demand. Energy efficiency standards and labelling programmes, for example, have been estimated to deliver annual reductions of around 15% of total current electricity consumption (IEA/4E TCP, 2021[21]). Dynamic energy pricing, such as critical-peak pricing, peak-time rebate and real-time pricing have been effective in reducing peak loads

[2] While demand-side management (DSM) can include all aspects of electricity demand, including industrial and grid management of electric demand, it is used in this paper solely with respect to households' energy-related choices.

[3] The avoided costs from demand-side policy measures include the costs of energy generation, generation capacity, ancillary services, transmission and distribution capacity and greenhouse gas emissions that would otherwise have been incurred in the absence of such measures (California Public Utilities Commission, 2022[163]). In the United States, for example, utility-run demand response programmes led to energy savings of approximately 30 million mWh in 2017 and reduced peak demand by up to 3.7% in the same year (US EIA, 2019[162]).

in energy demand. In comparison, time-of-use and inclining block rate pricing more effectively lead to sustained reductions in energy demand (Bergaentzlé, Clastres and Khalfallah, 2014[22]). Evidence that household energy use can be driven by heuristic decision-making and cognitive biases (Frederiks, Stenner and Hobman, 2015[23]) also points to the relevance of interventions informed by behavioural insights (OECD, 2017[24]). In Switzerland, for example, the provision of renewable electricity as a default option increased subscription rates for renewable electricity from 5% to 80%, an effect that persisted over multiple years despite higher prices and the option to opt out (Liebe, Gewinner and Diekmann, 2021[25]).

Although the potential for households to reduce energy use is clear, the barriers that households face to making these changes are numerous.[4] Designing policies that are effective at inducing desired behavioural change requires a well-developed understanding of the most important factors that influence individual and household behaviours regarding energy use.

[4] Energy conservation behaviours may, moreover, be subject to rebound effects (Sorrell, Gatersleben and Druckman, 2020[150]).

### Box 2.1. Examples of demand-side policy measures to reduce household energy use

**Clean Energy Tax Credits in the United States (2022)**

The Inflation Reduction Act (IRA) builds on a long history of supporting energy efficiency and emission reductions from households. As part of the IRA, households can receive a clean energy tax credit equal to 30% of the expense of installations for solar electric panels, solar water heaters, wind turbines, heat pumps, fuel cells and battery storage technology. Under this system, taxable income is reduced by the amount of money spent on such investments. Other tax credits are available for conducting home energy audits and installing thermal insulation and highly efficient heating and cooling systems (IRS, 2023[26]).

**Greener Homes Grant in Canada (2022)**

The Greener Homes Grant offers households between CAD 125 and 5,000 for eligible retrofitting costs, and up to CAD 600 toward the cost of pre- and post-retrofit energy audits. The programme also makes retrofit recommendations for improving energy efficiency (Natural Resources Canada, 2023[27]).

**Property tax exemption in France (2021)**

Households in participating cities are eligible for a 50% to 100% property tax exemption for investing in low-emissions energy technologies. Eligible investments include thermal insulation, renewable energy equipment, heat pumps, and heat regulation equipment (IEA, 2022[28]). Costs associated with connecting to district heating fuelled by renewables or combined heat and power generation are also considered eligible investments.

**Social Housing Decarbonisation Fund and Home Upgrade Grant allocations in the United Kingdom (2023)**

The UK Government has allocated funding to upgrade homes and off-grid households with energy efficiency measures, such as thermal insulation and energy-efficient windows with estimated savings of GPB 220-400 in households' annual energy costs. Additional funding is provided for publicly and privately provided social housing and charities (Department for Energy Security and Net Zero, 2023[29]).

**Zero interest green loans in Belgium (2017)**

Residential owners as well as renters are eligible for loans at preferential rates for the purchase of solar PV panels, heat pumps (hot water and space heating) and solar water heaters. Households with an income of less than EUR 30,000 for one person and EUR 60,000 for two people are eligible for a 0% loan, while households with higher incomes are eligible for a 1% loan (IEA, 2022[30]).

## 2.2. Factors that affect energy-related household decisions

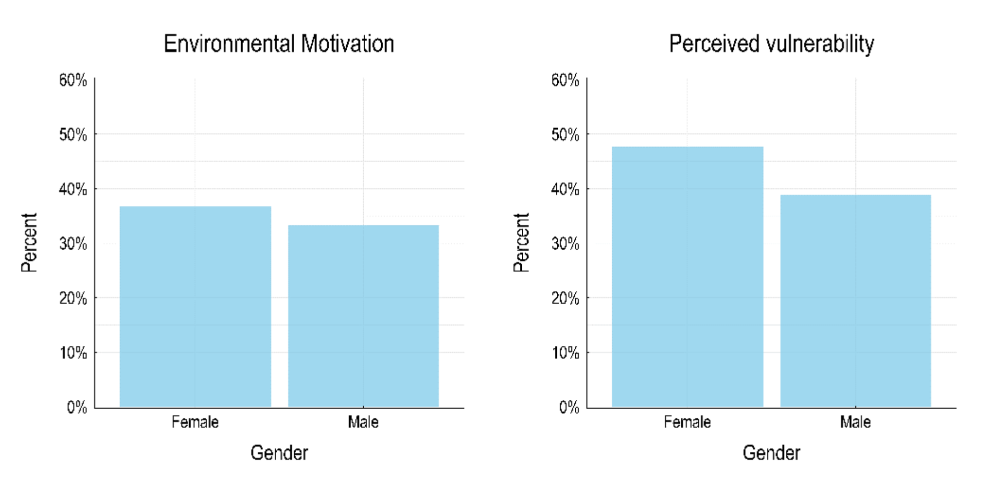
Both socioeconomic characteristics and broader contextual factors influence households' energy use. *Socioeconomic characteristics* such as income, sex and education have all been shown to be influential in determining energy-related behaviours (Ding et al., 2017[31]; Frederiks, Stenner and Hobman, 2015[32]; Guo et al., 2018[33]; Yang, Zhang and Zhao, 2016[34]). Their exact effects, however, depends on the behaviour considered. Higher levels of education have been associated with a preference for renewable energy (Kim, Park and Lee, 2018[35]; Bertsch et al., 2016[36]) and energy conservation (Lynn and Longhi, 2011[37]).

Although women generally exhibit a higher sensitivity to environmental issues (Van Rijnsoever, Van Mossel and Broecks, 2015[38]), the impact of sex on energy-related behaviours differs. For example, some research shows that women are more likely to buy energy-efficient devices (Newell and Siikamäki, 2013[39]), but less likely to prefer renewable energy (Kim, Park and Lee, 2018[35]). Differences between men and women have also been observed in terms of environmental attitudes, adoption of new technologies and willingness to engage in savings behaviour (MacGregor, 2016[40]). Box 2.2 provides information on systematic differences observed across genders with respect to energy-related behaviours in the EPIC Survey.

## Box 2.2. Gender and energy-related behaviours

Gender differences have been observed across a number of energy-related behaviours.[5] One avenue through which these differences may arise could be underlying differences in attitudes across genders. For example, the EPIC Survey data suggest that female respondents are more likely to report that they feel personally responsible for addressing climate change and other environmental issues, and to feel vulnerable to the impacts of climate change (loss of employment, personal health, quality of life).[6] 37% of female respondents report being environmentally motivated compared to 33% of male respondents. The extent to which female respondents feel vulnerable to environmental hazards relative to male respondents is more striking. 48% of female respondents report feeling vulnerable, while 39% of male respondents report feeling vulnerable.

### Figure 2.1. Environmental motivation and perceived vulnerability by gender




Note: See Table 4.1 for the construction of the environmental motivation and perceived vulnerability variables.
Source: OECD Survey on Environmental Policies and Individual Behaviour Change (EPIC)

[5] Reasons for gender-differentiated behaviour with respect to energy use include differences in physiologies and the division of labour, as well as cultural socialisation (Shrestha et al., 2021[176]).

[6] Details regarding the measurement of perceived vulnerability and environmental motivation can be found in Table 4.1. In the environmental psychology literature, the environmental motivation construct is referred to as ascription of responsibility and reflects "the extent to which people personally feel responsible for the (negative) environmental consequences of their actions" (van Valkengoed, Abrahamse and Steg, 2022[10]). Perceived vulnerability, referred to as risk perception in the literature, is considered to reflect "an individuals evaluation of the likelihood and severity of a particular environmental hazard" (van Valkengoed, Abrahamse and Steg, 2022[10]).

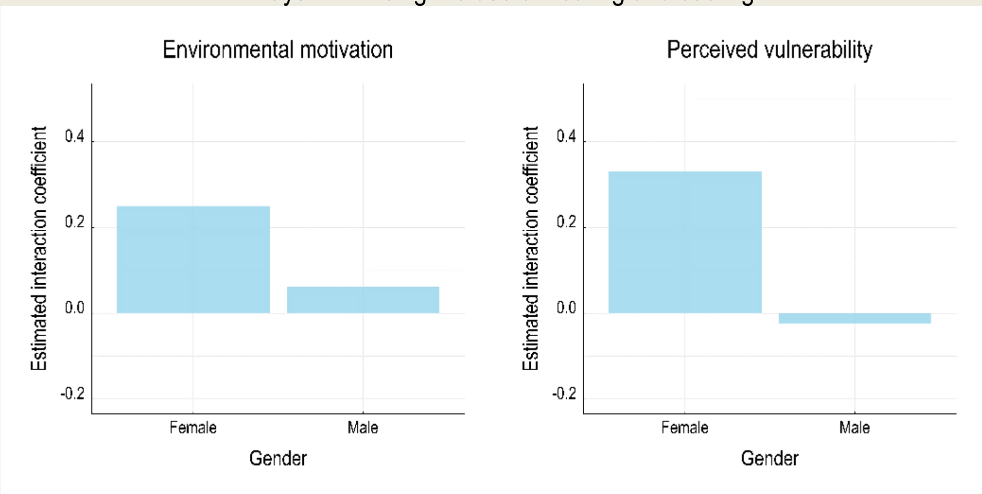
As is demonstrated in this report, attitudes have an impact on concrete actions. The results suggest that environmental motivation and perceived vulnerability impact behaviour among female respondents but not among male respondents, a finding that persists when taking into account baseline differences in behaviours that may exist across female and male respondents.

Figure 2.2 suggests that the impact of attitudes differs by gender with respect to engagement in minimising heating and cooling,[7] turning of the lights when leaving a room and investing in highly energy-efficient appliances. For example, the effect of environmental motivation increases the likelihood of engaging in minimising heating and cooling among female respondents, but has no such effect among male respondents. This is also true for the effect of perceived vulnerability, and extends to behaviours such as turning off the lights when leaving a room and investing in energy efficient appliances ( The results suggest that environmental motivation and perceived vulnerability impact behaviour among female respondents but not among male respondents, a finding that persists when taking into account baseline differences in behaviours that may exist across female and male respondents.

Figure 2.2). The results suggest that environmental motivation and perceived vulnerability impact behaviour among female respondents but not among male respondents, a finding that persists when taking into account baseline differences in behaviours that may exist across female and male respondents.

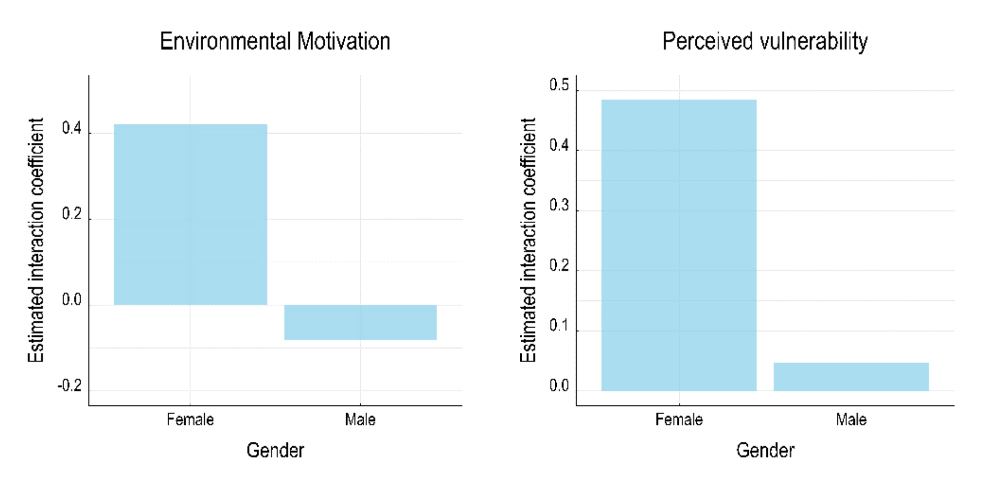
### Figure 2.2. Effect of attitudes on selected energy-related behaviours and investments, by gender

Always minimising the use of heating and cooling




Investing in highly energy-efficient appliances

7 This results could also depend on the energy source the household uses for heating and cooling.




Note: Columns indicate the size of the effect of environmental motivation or perceived vulnerability on behaviour. For investment in highly energy-efficient appliances, the sample is restricted to households in which there is only a single “head of household” since decisions related to costly investment in appliances are often taken collectively.
Source: OECD Survey on Environmental Policies and Individual Behaviour Change (EPIC)

Evidence suggests that energy use patterns are also influenced by broader contextual factors. Attitudes towards the environment, social norms and trust in government, for example, have been shown to play a role in determining energy-related behaviours (Boomsma et al., 2019[41]; Yang, Zhang and Zhao, 2016[34]; Arimura, Katayama and Sakudo, 2016[42]; Ding et al., 2017[31]; Frederiks, Stenner and Hobman, 2015[32]; Wang, Lin and Li, 2018[43]). Energy use patterns can also arise from differences in households’ interests, needs and capacities for changing energy-related behaviours. Such differences can pertain to convenience, personal comfort, awareness, access to alternatives, as well as individual preferences regarding the way in which energy use is embedded in daily routines (OECD, 2023[11]). Some evidence suggests that energy consumption can vary up to five-fold even among households with similar residential characteristics (Gram-Hanssen, 2011[44]). Household knowledge about their energy use and the perceived ability to engage in energy conservation practices have also been shown to play a role in domestic energy use (Steg, 2008[45]; Madden, Ellen and Ajzen, 1992[46]; MacGregor, 2016[40]). Finally, situational and contextual factors can influence energy-related decision-making (Osunmuyiwa et al., 2020[47]; Kuhe and Bisu, 2019[48])).

The literature has also identified a number of *psychological barriers* that prevent households from making sustainable choices related to energy use (Gifford, 2011[49]). These include limited capacity to calculate future financial benefits, considerations related to social norms and expectations and an aversion to the perceived risks of change (Gifford, 2011[49]; Allcott and Greenstone, 2012[50]; Allcott and Wozny, 2014[51]; Swim et al., 2009[52]). Environmentally-relevant behaviours are often characterised by a value-action gap in which households’ decisions do not always align with their sustainable intentions (Lacroix, Gifford and Chen, 2019[53]; Lorenzoni, Nicholson-Cole and Whitmarsh, 2007[54]; Kollmuss and Agyeman, 2002[55]).

More concrete *structural barriers* to action exist to the extent that some household choices are possible only in the presence of supporting infrastructure (e.g. the option to use renewable electricity), the availability of end-user technologies (e.g. heat pumps) and the feasibility of installing such technologies at the residence. Barriers to action vary across geographies, with institutional and policy-related factors (e.g. infrastructure provision) important in some regions, and societal factors (e.g. social norms, awareness) in others.

As this review shows, household decisions regarding energy use are complex and ultimately depends on sufficient incentives and capacity to act. Effective policy approaches should therefore seek to improve the benefits of sustainable choices related to energy use, while at the same time removing the barriers to household action. While some factors that influence household decisions can be targeted via policy interventions (e.g. financial support to reduce the cost of low-emissions technologies), others such as socioeconomic characteristics, are fixed. Understanding these characteristics, as well as the attitudes and behaviours across different user groups, can inform better targeted interventions that align with the needs and motivations of different household groups (Whitmarsh, Poortinga and Capstick, 2021[56]; Lu et al., 2020[57]).

## 2.3. Data considerations

The EPIC Survey relies on a stated preference empirical approach to data collection. As opposed to revealed preference approaches, which make use of data on observed behaviours, stated preference approaches use data gathered by asking individuals to either report their actual behaviour, or report how they would behave in a given hypothetical situation. Although revealed preference approaches have high reliability and validity because they reflect the real-world constraints faced by individuals, this also constitutes a limitation insofar as analyses are limited to addressing only those choices and conditions that are available in real-world contexts. The main challenges of stated preference approaches, on the other hand, include response bias and sample representativeness. Cross-country variation exists in a number of factors that might affect the results. These include differences in the proportions of households living in urban and rural areas, as well as differences in the proportion of households that own or rent their homes. Summary statistics for these variables, as well as several socioeconomic characteristics other than those used to generate representative quotas (i.e. gender, age, income and region), can be found in Table A.1. in the Annex.

Generally speaking, limitations of analyses based on survey data arise from the extent to which reported responses may differ from actual behaviours (i.e. hypothetical bias), as well as the extent to which the characteristics of survey respondents may diverge from those of the actual population. Care should therefore be taken to evaluate the representativeness of survey samples when extrapolating findings to the general population.[8] Despite these challenges, stated preference approaches offer a number of advantages over revealed preference approaches when it comes to ex-ante policy evaluation (OECD, 2018[58]). Discrete choice experiments, for example, are well-suited to analysing choices in the context of relatively complex, multi-dimensional issues (Bateman et al., 2002[59]; OECD, 2018[58]).

The household choices addressed in this report encompass both decisions that are made at an individual level (e.g. turning off the lights when leaving a room), as well as decisions that are made at the household level (e.g. installing a heat pump). In order to obtain a sample appropriate for this analysis, survey respondents were screened to ensure that they had at least partial responsibility for purchase decisions made at the household level. In what follows, analyses of the determinants of behaviour therefore control for both individual as well as household characteristics, as relevant to the behaviour in question. It should be noted that the potential degree of response bias varies across survey items, as some items (e.g. reported engagement in energy conservation behaviours) may be subject to greater response bias than others (e.g. whether a household has installed a given technology).

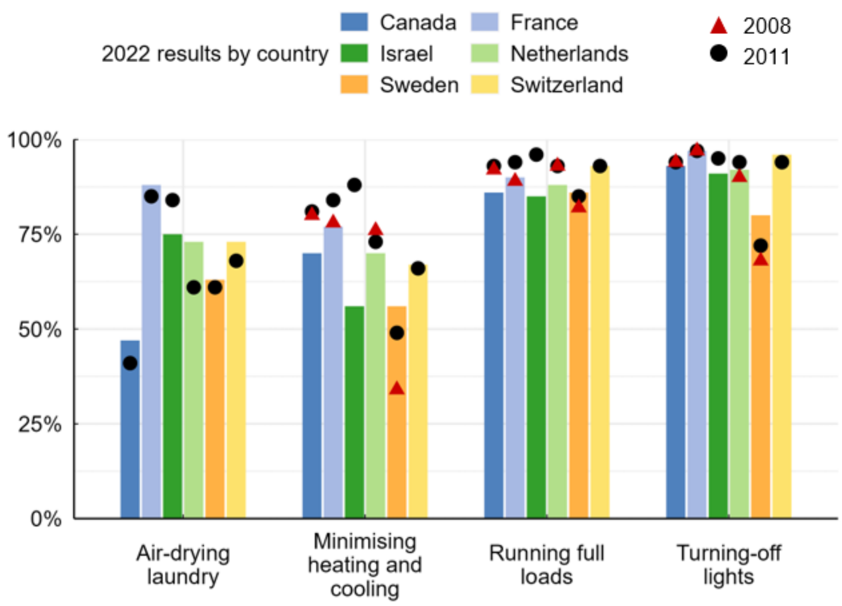
[8] To ensure a representative survey and avoid sample bias, the target sample for the EPIC Survey was stratified by income, age, gender and region in each country. Following implementation, to correct for divergences between the sample and the population with respect to age, gender, region and income, weighting factors were calculated to ensure representativeness at the population level. Post-stratification weights were calculated on a country-by-country basis based on age, gender, region and income variables. Additional details about the implementation of the EPIC Survey are provided in (OECD, 2023[11]).

It should also be noted that, as the analyses carried out in this paper simultaneously control for a variety of factors on reported behaviour, they provide evidence of association, but do not provide evidence of causation strictly speaking. The stated preference and observational nature of the EPIC data mean that some uncertainty remains regarding the effects of policies on behaviour. An assessment of the consequences of policy settings on different outcomes requires an ex-post policy evaluation framework. As such, a cross-sectional survey of self-reported preferences, behaviours and investments is not the appropriate tool for robust policy evaluation, and this study does not call into question the results of evaluations that have sought to identify the causal impact of a specific policy interventions. Following the convention in the environmental economics literature, however, the independent variables used in the analysis are referred to as determinants.

Four countries (Canada, France, Netherlands and Sweden) have participated in all three rounds of the EPIC Survey, and an additional two (Israel and Switzerland) participated in two rounds (2011 and 2022). While results from the three rounds are not strictly comparable due to differences in sample sizes, representativeness, and in how survey questions are worded, qualitative comparisons over time can be indicative of overall trends but also shed light on potential data constraints.[9]

In varying forms, respondents across survey rounds were asked about the provision of green electricity options, the extent to which they engage in energy conservation behaviours, as well as invest in low-emissions energy technologies. Figure 2.3 indicates no significant changes to reported engagement in energy conservation between 2008 and 2022. Reported engagement in 2022 is either at the same or slightly below the levels reported in 2011 for most behaviours. An exception is engagement in minimising heating and cooling in Israel and Sweden, which appear to be considerably lower and higher, respectively, in 2022 than in earlier years.

## Figure 2.3. Reported engagement in energy conservation behaviour across EPIC Surveys



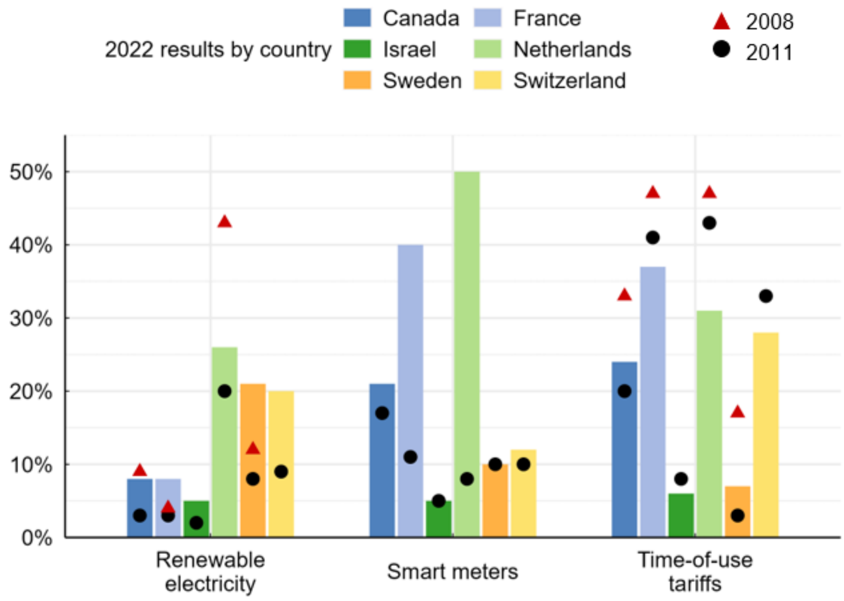

Note: This figure displays the proportion of households reporting that they always or often engage in energy conservation behaviours. Countries with no indicators for 2008 did not participate in this survey round; survey weights were not used in 2008.

[9] Weighting methodologies used in 2008, 2011 and 2022 differ.

Source: OECD EPIC Survey 2008, 2011, 2022.

Figure 2.4 suggests an increased uptake of some green electricity options over time. A comparison between the 2022 and 2011 survey, for example suggests that renewably generated electricity has become more widely used by households in Canada, France, Sweden and Switzerland (OECD, 2013[60]; OECD, 2011[61]).[10] Despite this, there appears to be continued unmet demand for renewably generated electricity: 64% of respondents report not having this option in 2022, and 39% indicate that they would be interested in it if it were available. Increases in the use of smart meters of 30-40% are also observed in France and the Netherlands over this period. Lower reported use of time of use tariffs over time in most countries could reflect differences in the sampling or changes implied by the numerous price interventions implemented in 2022 in response to the energy crisis, particularly in European countries.

## Figure 2.4. Reported uptake of green electricity options across EPIC Surveys




Note: This figure displays the proportion of households reporting that they have selected these options. Countries with no indicators for 2008 data points did not participate in this survey round; survey weights were not used in 2008. A lack of consumer awareness can result in disparities between reported availability and actual availability.
Source: OECD EPIC Survey 2008, 2011, 2022.

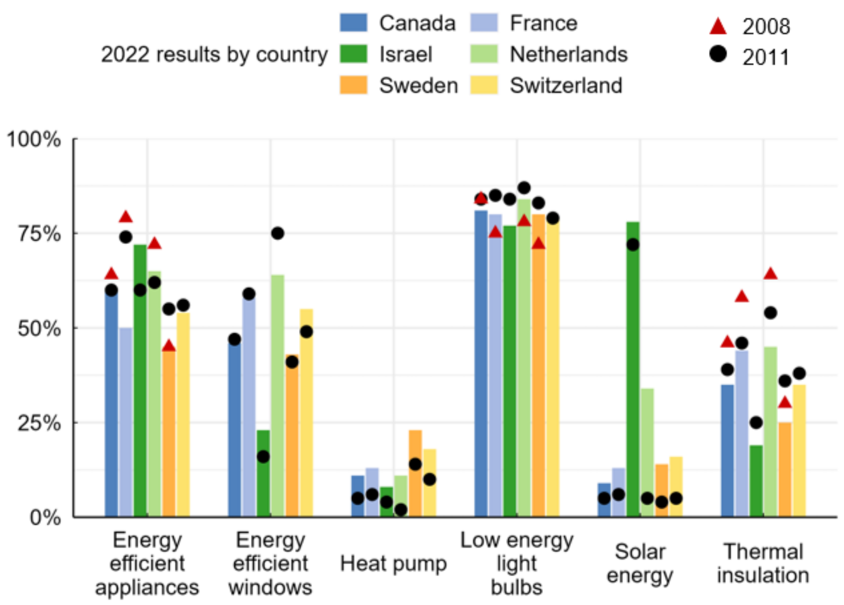
Discrepancies between actual and reported availabilities of these options could be due in part to a lack of consumer awareness. In France, for example, 25% reported to have been proposed electricity generated by renewable energy sources, 65% reported to have been proposed smart meters, and 48% of respondents report to have been proposed differentiated tariffs in 2022. In contrast, almost all electricity providers in France offer some form of green or carbon neutral options , i.e. offers that guarantee that the electricity is either directly from carbon free sources or offset by investments in renewable energy (Le

[10] It should be noted that country-level results mask regional differences in the development of renewable energy within countries that arise from differences in subnational energy policies (e.g. in Ontario, Canada (CER, 2022[164])).

Médiateur National de l'Energie, 2023[62])[11], while the actual prevalence of smart meters has been documented 92% in France, 89% in the Netherlands, 56% in the United Kingdom, and 22% in Belgium in 2022. In France, all electricity providers are required to offer time-of-use tariffs since 2013 (Ministre de l'économie et des finances and Ministre de l'écologie, 2013[63]), and time-of-use tariffs have also been documented as available in all of the countries sampled (ACER - CEER, 2023[64]).

Figure 2.5 shows that households report installing less energy efficiency appliances and thermal insulation over time. Newer technologies with clear definitions, such as heat pumps, energy efficient (double-glazed) windows, and solar energy, display either static or increasing levels of reported installation rates over time. In contrast, energy efficiency appliances and thermal insulation represent older technologies whose definitions may have evolved between 2011 and 2022. The apparent decrease in reported installation rates may in part also be explained by differences in the wording of the relevant survey item in the 2011 and 2022. In 2011, the survey asked respondents about their installation of "energy-efficient appliances." In 2022, the wording was changed to "highly energy-efficient appliances" in order to reflect a general increase in the stringency of efficiency standards over time. Increases in the actual stringency of energy efficiency standards during this period can also contribute to explaining the apparent trend. Improvements in thermal insulation technologies as well as in household knowledge and awareness about these technologies may have led to similar changes in household judgements regarding what constitutes thermal insulation. In particular, a more restricted definition of what constitutes thermal insulation could explain the observed decrease in reported rates of having invested in these improvements over time.

**Figure 2.5. Reported investment in low-emissions energy technologies across EPIC Surveys**




[11] This implies that almost everyone in France has access to green offers. In fact, while market shares of the 40 electricity providers vary, the market shares of the two historic electricity providers – EDF and Engie, which propose green offers – amount to 75% of French households (French Ministry of Environment, 2023[177]). The remaining 25% of households are scattered across the other 38 electricity providers, most of which also offer green electricity options (Hello Watt, 2024[178]).

Note: This figure displays the proportion of households reporting that either they installed these technologies within the past ten years, or that their residence was already equipped. Countries with no indicators for 2008 data points did not participate in this survey round; survey weights were not used in 2008.
Source: OECD EPIC Survey 2008, 2011, 2022.

# 3. Household profiles in energy use

## 3.1. Overview

This section explores whether households fall into distinct groups with respect to patterns in energy conservation and investment behaviours. This analysis provides a better understanding of variation in energy vulnerability across households and suggests the importance of considering how households may differ in their capacity to conserve energy and invest in low-emissions energy equipment. The analysis distinguishes different groups with respect to both investment in low-emissions technologies and in conservation. In particular, the analysis sheds new light on the characteristics of households that tend to invest heavily in low-emissions energy technologies, suggesting that income and environmental concern may not be the main drivers of their decisions. Household ownership status and residence type appear to play a role in decisions to invest in such technologies.

Household classes are identified using LCA, a data-driven statistical method that classifies households based on patterns in their self-reported behaviours. An overview of this method is provided in Box 3.1 and additional details are provided in the Annex.

### Box 3.1. An overview of latent class analysis

Latent class analysis (hereafter, LCA) is a statistical procedure used to identify different subgroups (or latent classes) of households based on patterns in their behaviour (Lazarsfeld, 1950[65]; Goodman, 1974[66]; Eliason and Hagenaars, 1990[67]).[12] LCA assumes that observed behaviours, in this case self-reported energy conservation and investment in energy efficiency equipment, are driven by membership in unobserved household profiles. The latent variable is considered to be an unordered categorical variable.

Once the number of latent classes is specified, LCA uses maximum likelihood estimation to determine the proportion of observations that fall into each latent class. For each latent class, it also estimates the likelihood of observing each response option. Specifically, it maximises the statistical independence of the observed variables of a household conditional on its latent class. This process assigns households with similar behaviours to the same latent class. In a well-performing LCA model, each observation is estimated to have a high likelihood of belonging to one class and a low likelihood of belonging to the other classes. Common indicators of the statistical fit of latent class models include the Bayesian Information Criterion (BIC), the Akaike information criterion (AIC) and likelihood-ratio tests (LRT). In addition to statistical criteria, an important theoretical criterion for selecting the number of latent classes is the identification of distinct and interpretable classes.

LCA has a number of advantages over simpler algorithm-based approaches. It can account for class size during the allocation process and accommodate different types of data (e.g. categorical and numerical). LCA is model based insofar as it derives clusters using a probabilistic model that describes the distribution of the data. Because LCA models the latent structure of data rather than simply identifying similarities, it also allows for tests of goodness-of-fit and significance and thus can measure the degree of uncertainty in the resulting classifications.

Formally, the probability of obtaining response pattern $\boldsymbol{y}$, $P(\boldsymbol{Y} = \boldsymbol{y})$, is a weighted average of the $C$ class-specific probabilities $P(\boldsymbol{Y} = \boldsymbol{y} | X = x)$:

$$P(\boldsymbol{Y} = \boldsymbol{y}) = \sum_{x=1}^{C} P(X = x)\, P(\boldsymbol{Y} = \boldsymbol{y} | X = x)$$

Note: Additional details are provided in the Annex.

Section 3.2 examines household profiles with respect to five self-reported energy conservation behaviours and Section 3.3 with respect to investments in seven types of low-emissions energy technologies.[13] A comparison of the characteristics of the households that fall into different classes are suggestive of barriers that households face with respect to their engagement in conservation and investment behaviours.[14] The analysis also identifies household profiles that may be of interest to policymakers, such as households that tend not to make sustainable choices regarding their energy use. Additional econometric analyses

[12] See also, for example, Linzer and Lewis, 2011[2] and Weller, Bowen and Faubert, 2020[3].

[13] Further information on latent class analysis is provided in the Annex.

[14] These household characteristics can be a function of household preferences, skills, and other factors that may be simultaneously determined with their choices surrounding conservation and investment (on the basis of which household classes are identified). As a result, robust identification of barriers to engagement in conservation and investment would require empirical tests of the hypothesised mechanisms.

assessing the role that socioeconomic, attitudinal and energy-related characteristics play in driving household membership is provided in the Annex.

## 3.2. Engagement in energy conservation

In the analysis presented in this section, five energy conservation measures are considered for which respondents were asked to indicate the frequency with which they engaged (never, sometimes, often, always):

- turning off the lights when leaving a room;
- running only full loads of laundry and dish washing,
- air-drying laundry;
- minimising the use of heating and cooling;
- minimising hot water use.

Response options were grouped into never/sometimes and often/always. This approach facilitates interpretability of the resulting model and reflects the general nature of this exploratory analysis that aims to distinguish between households that tend to engage in conservation and those that do not. An examination of the determinants of engagement in specific conservation behaviours is presented in Section 4.

Following model testing, a two-class model was chosen based on a combination of statistical criteria and theoretical interpretability. Classes were labelled as energy "*conservers*" and energy "*non-conservers.*" Households in the *conserver* class generally report either often or always engaging in energy conservation across behaviours, while *non-conservers* tend to report never or rarely engaging in these behaviours, particularly air-drying laundry, minimising heating and cooling and minimising hot water use.

Overall, 65% of households in the sample are classified as *conservers* and 35% as *non-conservers*. The results indicate that the *conserver* class is to a greater extent composed of older respondents, those living in a house in rural areas and women compared to the *non-conserver* class. Conservers also appear to be more likely to be environmentally concerned than non-conservers. The distribution of education and income levels are similar across classes.[15] An overview of the characteristics of each class is provided in Table 3.1. [16]

[15] Results from a series of probit regressions to assess the determinants of class membership are also provided in the Annex. When controlling for household characteristics simultaneously, findings indicate that the highest-income households are less likely to be conservers, indicating scope for policies to target increased energy conservation among these households.

[16] Additional descriptive statistics across classes are provided in Table A.5 in the Annex.

## Table 3.1. Select characteristics of energy conservation classes

Percent of energy conservation classes with specific household characteristics

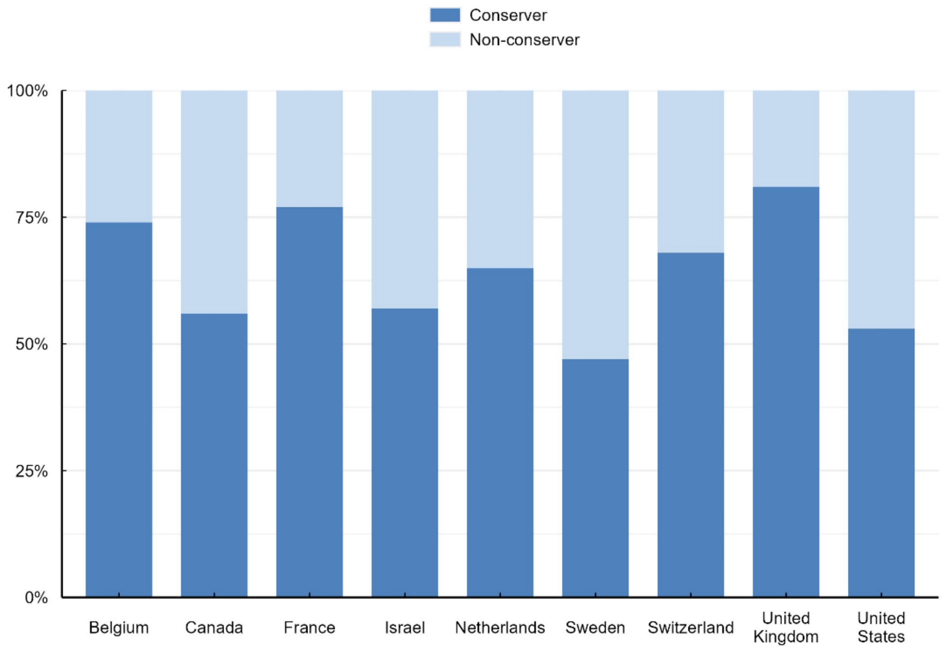
| Variable | Outcome | Conservers | Non-conservers |
|---|---|---|---|
| **Income quintile** | 1 | 11.4 | 12.6 |
| | 2 | 18.8 | 19.6 |
| | 3 | 21.3 | 21.2 |
| | 4 | 24.1 | 22.4 |
| | 5 | 24.4 | 24.2 |
| **Age** | 18-24 | 11.7 | 16.8 |
| | 25-34 | 12.6 | 16.8 |
| | 35-44 | 16 | 15.2 |
| | 45-54 | 15.7 | 16 |
| | 55+ | 44 | 35.2 |
| **Sex** | Female | 54.6 | 49.7 |
| | Male | 45.4 | 50.3 |
| **Education** | High school diploma or less | 40.7 | 40.7 |
| | Higher education | 59.3 | 59.3 |
| **Household has children** | No | 72.5 | 70 |
| | Yes | 27.5 | 30 |
| **Environmental concern** | Low | 29.6 | 44.8 |
| | High | 70.4 | 55.2 |
| **Home type** | Apartment | 38.7 | 45.1 |
| | House | 58.3 | 51.4 |
| **Location** | Rural | 42 | 35.4 |
| | Urban | 58 | 64.6 |

Note: This table displays the composition *within class*. The sum of outcome probabilities per variable *within class* equals 1. For example, results can be read as such: "In the *conserver* class, 42.5% of respondents live in rural area, while 57.5% of respondents live in urban area." Classes and descriptive statistics are based on the survey sample only and do not take into account survey weights. Additional descriptive statistics are provided in Table A.5 in the Annex.

Figure 3.1 presents the share of respondents falling into each class across the nine countries.[17] In all countries but Sweden, most respondents are classified as *conservers*. A cold climate and lower electricity prices could explain a relatively lower proportion of *conserver* households in Sweden. The proportion of *conserver* households is above the cross-country average of 65% in the United Kingdom, France, Belgium, Switzerland and the Netherlands.

[17] The LCA was conducted using pooled data from the sample of nine countries.

## Figure 3.1. Distribution of conservation classes across countries



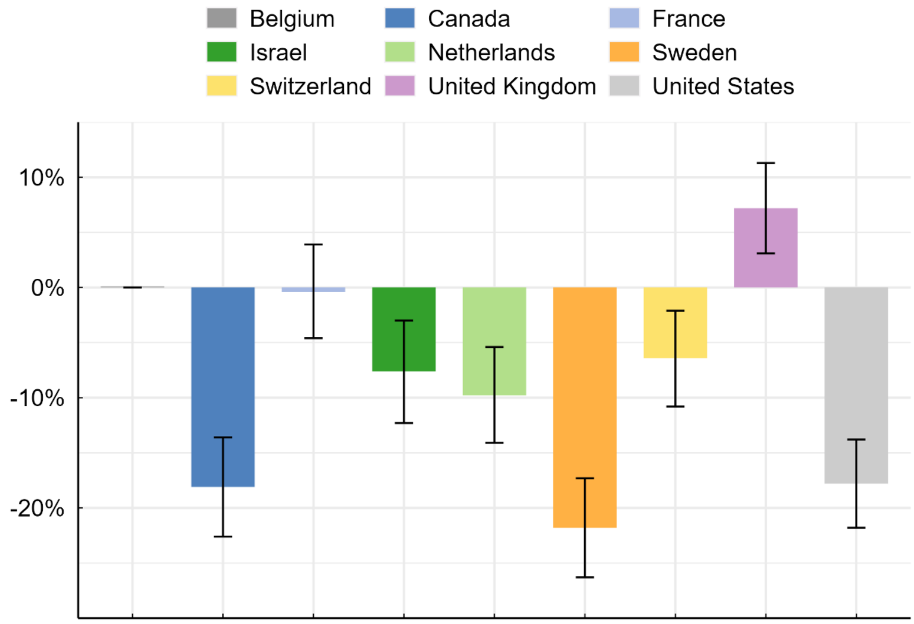

Note: This figure displays the proportion of households in each class per country. For example, in Belgium, 73.6% of respondents are classified as conservers, while 26.4% of respondents are classified as non-conservers.

Country fixed effects are included in the econometric analysis to capture baseline differences in households' propensity to be in the *conserver* class across countries (Figure 3.2).[18] The results indicate significant variation across countries, and it appears that the sample is comprised of roughly four groups of countries. The first group consists of the United Kingdom and is characterised by the highest likelihood that a given household falls into the *conserver* class. The second group, consisting of Belgium and France, exhibits a slightly lower propensity in this regard. The third group consists of Israel, the Netherlands and Switzerland, which are characterised by a lower propensity than Belgium and France, but a higher propensity than the fourth group, consisting of Canada, Sweden and the United States in which households have the lowest likelihood of being considered *conservers*.

Because country fixed effects capture numerous possible factors that pertain to national contexts, it is difficult to draw conclusions about the specific factors that contribute to the differences evidenced by the variation in these estimates. Potential factors could include climatic conditions, national level policies such as financial support for energy costs, the quality of the housing stock and norms surrounding energy-related practices. Relatively lower engagement in energy conservation in Canada and the US could be explained by social norms, and in Sweden could be due to the fact that electricity is already highly decarbonised, reducing the marginal environmental benefits of additional reductions in energy use.

[18] Details on the full econometric model are provided in  in the Annex.

### Figure 3.2. Country fixed effects for household propensity of falling into the *conserver* class




Note: This figure displays country fixed effects coefficients. The base country is Belgium (1st column), which has a coefficient set to 0. Black lines represent the 95% confidence interval of the parameter estimates.

Greater scope exists to increase engagement in energy-saving behaviours in countries with lower shares of *conservers*. A lower share of conservers represents larger potential gains to be had if these households were to increase their conservation efforts. However, households exhibiting low engagement may also be less responsive to policy efforts to encourage behaviour change, which could imply lower policy cost-effectiveness among this group.[19] As environmental policymaking should not restrict its focus to marginal abatement costs in the short term only, but should also consider total abatement costs in the longer term, policy objectives should not be limited to targeting improvements in the best-performing (i.e. potentially most receptive) households only, but should also seek to shift the behaviour of those that are least engaged. Policy packages to effectively reduce the environmental impact of residential energy use will include a combination of measures that target behaviour change among both responsive as well as less responsive households. Varying levels of responsiveness to any given policy imply a need for different interventions in order to effectively induce behaviour change among different groups of households.

Countries with a higher share of conservers may, for example, require interventions that target specific behaviours or groups of households that remain characterised by high energy use. A low share of conservers could indicate prevailing habits and norms that pose a challenge to achieving shifts in household behaviours, and could therefore indicate where added efforts may be required, e.g. in the form of greater financial incentives or interventions to influence public perceptions and norms. As households living in poorly insulated homes and lacking the ability to invest in better technologies are more vulnerable

[19] While most non-conserver households agree with the statement “I am willing to make compromises in my current lifestyle for the benefit of the environment” (56%), agreement is nevertheless lower than among conserving households (71%). Agreement with the statements “Environmental policies introduced by the government should not cost me extra money” and “Environmental issues will be resolved mainly through individuals voluntarily changing their behaviour” between non-conservers and conservers are more similar (63% vs. 64% and 50% vs. 58%, respectively).

to energy price increases, policy approaches to reduce energy use and increase energy efficiency should seek to do so while also seeking to lower energy cost burdens and improve well-being.

### 3.3. Investment in low-emissions energy technologies

The second LCA model classifies households based on their reported investment in low-emissions technologies. As with energy conservation, classes are identified and qualitatively described in a first step, and cross-country differences are examined after controlling for socioeconomic, attitudinal and residential characteristics in a second step. The LCA focuses on seven behaviours, notably whether the household has:

- purchased energy-efficient appliances;
- insulated the walls/roof of the residence;
- installed energy-efficient windows;
- installed a heat pump;
- installed solar panels;
- installed solar water heating;
- installed battery storage.[20]

Survey respondents could indicate if they had installed these items and if not and the reasons why not. Answers were grouped into the following categories: "Yes, I have installed", "No, I have not installed because it was not possible (e.g. not feasible in my house/apartment area and/or my landlord would need to install this)", "No, I have not installed for other reasons", and "I don't know if this equipment has been installed."[21]

Households that tend to report having invested in all seven types of low-emissions energy technologies, i.e. "*Super investors,*" account for 14% of the sample.[22] 16% of households report that they "*invest when possible.*" When technologies have not been adopted, respondents say that it is because it was not possible to install. A quarter (26%) of households are "*low-cost investors.*" They tend to have adopted technologies whose upfront cost is relatively low (e.g. energy-efficient appliances and windows), but not technologies with higher installation costs (e.g. heat pumps and battery storage). A slightly smaller share (23%), "*don't invest*" in any technology, even when investment is possible. 13% of the sample reports that

[20] While typically combined with renewable energy systems, battery storage can also be combined with automated price or conservation signals from the electricity provider to help consumers automate cost savings based on pre-defined settings such as electricity prices or a grid alert.

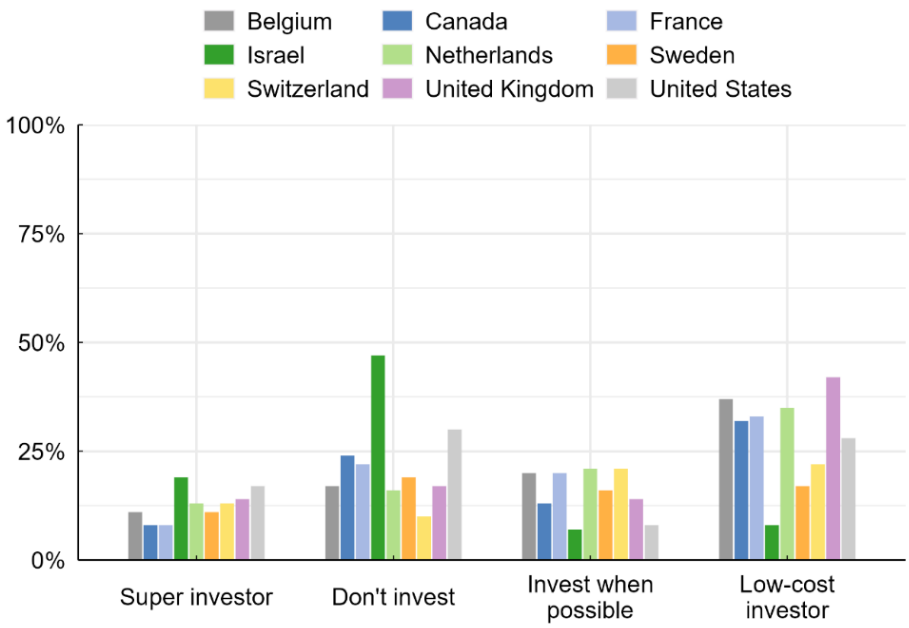
[21] The original responses included: "Yes", "No, already equipped/installed more than 10 years ago," "I am planning to install this in the next two/three years," "I am interested but cannot afford it," "Not possible (not feasible in my house/apartment and/or my landlord would need to install this)," "I am not interested," and "I am not aware of this or don't know if it is possible to install in my area/home." For the purposes of the LCA, the original responses "Yes" and "No, already equipped/installed more than 10 years ago" are considered as "Yes." The original responses "I am planning to install this in the next two/three years," "I am interested but cannot afford it" and "I am not interested" are considered as "No." The remaining two original responses ("Not possible (not feasible in my house/apartment and/or my landlord would need to install this)" and "I am not aware of this or don't know if it is possible to install in my area/home") are considered in the LCA as "No, not possible," and "I don't know," respectively. These categories are referred to in Table A.4 in the Annex.

[22] Estimated probabilities of investment in specific low-emissions technologies reported in Table A.4 in the Annex do not reflect actual survey responses. Instead, they reflect predicted outcomes based on patterns observed in actual responses. Households in the super investor class are characterised by the highest estimated probabilities of having installed each type of low-emissions energy technology compared to those in other classes. Estimated probabilities of investment for each type of technology by investor class are provided in Table A.4 in the Annex.

it is "*not possible*" to invest in any of the technologies examined. Finally, 8% of households report that they either "*do not know*" if the technology is already installed at their home or do not know if installation is feasible.

Some heterogeneity in investment classes across countries is observed. Israel is characterised by an above average proportion of households falling into the *Super investor* and *Don't invest* classes. Belgium, Canada, France, the Netherlands and the United Kingdom have a higher share of *Low-cost investors* than other countries. They also have a lower share of households in the *Don't invest* class. France and Canada are characterised by a significantly lower proportion of *Super investors* than other countries, but a larger share of households that *Invest when possible*. Switzerland is characterised by the lowest proportion of households that *Don't invest*. As with conservation behaviour, relatively low levels of reported investment may suggest the presence of barriers to uptake and the need for specific policy attention devoted to overcoming these barriers, such as information provision campaigns. Figure 3.3 reports the composition of households according to investment class across countries.

## Figure 3.3. Distribution of investment classes across countries




Note: This figure displays the proportion of households in each class per country and should be read as follows, e.g.: In Belgium, 11.1% of households are classified as *Super investors*, 19.5% are classified in the *Invest when possible* class, 36.9% are classified as *Low-cost investors*, and 17% are classified in the *Don't invest* class. For brevity, proportions for the *Cannot invest* and *Don't know* classes are not shown.

A qualitative comparison of household characteristics across classes provides an indication of the profiles of households in each group, which can be considered to be suggestive of the barriers that different groups may face to investing in low-emissions energy technologies. Households in the *don't invest* class are less likely to report being environmentally concerned than households in other classes, i.e. households that invest to some extent. Among this latter group, the likelihood of being environmentally concerned does not appear to vary substantially across differing levels of investment.

Interestingly, the group of *super investors* is not composed of a greater share of households that are environmentally concerned or environmentally motivated than those in the *low-cost investor* group.

Instead, this group of households may be more driven by an interest in technology rather than sustainability. Whereas 41% of households in the low-cost investor group agree with the statement that technology will resolve environmental problems, 64% in the super investor group report agreeing with this statement. Those in the *super investor* group are more likely to report that environmental issues should be dealt with primarily through voluntary individual behaviour change (67% vs 55%), but are also more likely to agree with the statement that environmental issues are overstated (52% vs. 27%). When it comes to household energy sources, a greater proportion of *super investors* also report using electricity for heating and cooling as well as for cooking compared to *low-cost investors* (70% vs. 58% and 58% vs. 43%, respectively). They are also more likely to be male, to own rather than rent their primary residence, to live in an apartment, to live in an urban area, and to have children in the house compared to those in the *low-cost investor* class. Table 3.2 reports selected characteristics of each class.

### Table 3.2. Select characteristics of household classes by investment in low-emissions energy technologies

Percent of investment classes with specific household characteristics

| Variable | Outcome | Super investor (14%) | Invest when possible (16%) | Low-cost investor (27%) | Don't invest (23%) |
|---|---|---|---|---|---|
| Age | 18-24 | 22.5 | 6.7 | 7.8 | 15.4 |
| | 25-34 | 22.3 | 11.4 | 7.6 | 15.9 |
| | 35-44 | 21.9 | 11.4 | 12.6 | 18.2 |
| | 45-54 | 9.9 | 17.9 | 16 | 17.6 |
| | 55+ | 23.4 | 52.8 | 56.1 | 32.8 |
| Household has children | No | 47.3 | 81.4 | 76.2 | 67.8 |
| | Yes | 52.7 | 18.6 | 23.8 | 32.2 |
| Environmental concern | Low | 31.1 | 28.4 | 34 | 43.6 |
| | High | 68.9 | 71.6 | 66 | 56.4 |
| Education | High school diploma at most | 30.7 | 42.3 | 38.3 | 42.9 |
| | Higher education | 69.3 | 57.7 | 61.7 | 57.1 |
| Employment | Employed | 74.3 | 52.5 | 50.8 | 60.4 |
| | Retired | 12.3 | 31.7 | 33.8 | 18.3 |
| | Unemployed | 13.4 | 15.8 | 15.5 | 21.3 |
| Household size | 1 | 16.4 | 37 | 20.3 | 26.1 |
| | 2 | 24.4 | 38.3 | 43.8 | 30 |
| | 3 | 19 | 11.8 | 15.7 | 16.8 |
| | 4 | 22.5 | 8.3 | 12.7 | 15.2 |
| | 5+ | 17.8 | 4.6 | 7.5 | 12 |
| Home type | Apartment | 39.1 | 61.6 | 13.4 | 36 |
| | House | 59.1 | 34.3 | 84.2 | 60.5 |
| Income quintile | 1 | 6.6 | 11 | 7.4 | 14 |
| | 2 | 15.7 | 18.5 | 14.8 | 22.8 |
| | 3 | 22.5 | 20.8 | 19.3 | 22.4 |
| | 4 | 29 | 23.4 | 24.9 | 22.3 |
| | 5 | 26.1 | 26.3 | 33.7 | 18.5 |
| Location | Rural | 32 | 38.4 | 49.7 | 35.7 |
| | Urban | 68 | 61.6 | 50.3 | 64.3 |
| Ownership status | Owner | 76.6 | 48.8 | 89.4 | 70.2 |
| | Renter | 23.4 | 51.2 | 10.6 | 29.8 |
| Sex | Female | 37.7 | 50.2 | 53.9 | 54 |
| | Male | 62.3 | 49.8 | 46.1 | 46 |

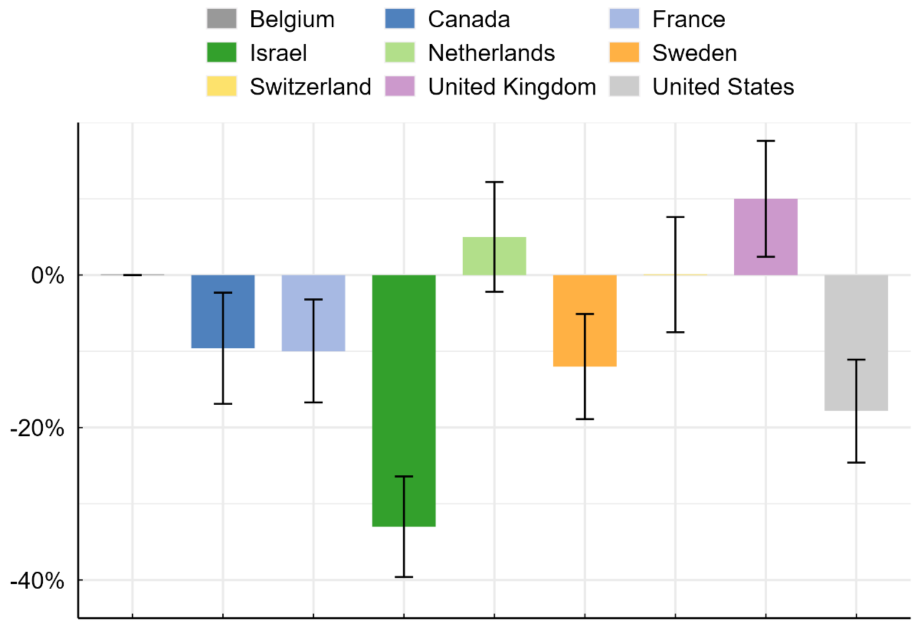
| | | | | | |
|---|---|---|---|---|---|
| Environmental motivation | No | 65.8 | 57.4 | 62.5 | 70.7 |
| | Yes | 34.2 | 42.6 | 37.5 | 29.3 |
| Perceived vulnerability | No | 68.6 | 51 | 54.8 | 61.1 |
| | Yes | 31.4 | 49 | 45.2 | 38.9 |
| Electricity for heating and cooling | No | 30.3 | 46.6 | 42.1 | 30.9 |
| | Yes | 69.7 | 53.4 | 57.9 | 69.1 |
| Electricity for hot water heating | No | 42.1 | 55.3 | 57 | 45.8 |
| | Yes | 57.9 | 44.7 | 43 | 54.2 |
| Electricity for cooking | No | 26.2 | 22.9 | 27 | 33.8 |
| | Yes | 73.8 | 77.1 | 73 | 66.2 |

Note: This table displays the composition within class. The sum of outcome probabilities per variable within class equals 1. For example, results can be read as such: "In the "Super investor" class, 68.4% of respondents live in rural area, while 31.6% of respondents live in urban area". For brevity, the classes "not possible" and "don't know" are not shown. Classes and descriptive statistics are based on the survey sample only and do not take into account survey weights.

An econometric analysis controlling for socioeconomic, attitudinal and building characteristics was carried out in order to provide a more robust estimate of the likelihood that a given household in each country falls into the *invest when possible* class compared to the *do not invest* category. A focus on these two classes provides a better understanding of household investment decisions at the extensive margin, i.e. household decisions to invest or not invest among those that may face fewer structural barriers to doing so. Figure 3.4 shows the fixed effects for each country.

Countries could be considered to fall into four groups based on the household propensities to *invest when possible*. The country with the highest propensity to *invest when possible* is the United Kingdom. The group of countries comprised of Belgium, the Netherlands and Switzerland, are characterised by a lower propensity to *invest when possible* than the United Kingdom. The group of countries comprised of Canada, France, Sweden and the United States exhibit a lower likelihood of falling into the *Invest when possible* class. The outlier in this regard is Israel, which is characterised by a significantly lower propensity than other countries for a given household to report that it invests in energy equipment when possible. A comparison of socioeconomic characteristics across groups indicates that *Super investors* tend to be younger and more highly educated than those in other groups, *Don't invest* households exhibit less environmental concern, *Low-cost investors* tend to be in the higher income quintiles, and *Invest when possible* households are comprised to a greater extent of apartment dwellers than other groups.

## Figure 3.4. Country fixed effects for household propensity of falling into the *Invest when possible* vs. the *Do not invest* class




Note: This figure displays country fixed effects coefficients. The base country is Belgium (1st column), which has a coefficient set to 0. Black lines represent the 95% confidence interval of the parameter estimates.

# 4. Determinants of sustainable energy behaviours

## 4.1. Overview

This section examines the determinants of household decisions regarding specific energy conservation measures and investment in specific types of low-emissions energy technologies. The analysis undertaken in this section differs from that undertaken in Section 3 insofar as it allows for a tailored analysis of the determinants of reported household choices for a variety of energy-related decisions. For example, although having access to outdoor space may not be a relevant determinant of some investment decisions (e.g. energy-efficient windows), it may be relevant for others (e.g. heat pumps). The findings issuing from this analysis can therefore yield insights that can inform the design of approaches to influence specific household behaviour. Section 4.2 describes the methodology used for the analyses and Sections 4.3 and 4.4 evaluate the determinants of engagement in different types of energy conservation behaviour and decisions to invest in low-emissions technologies, respectively.

## 4.2. Methodology

The analysis investigates the role of socioeconomic characteristics, residential features, as well as psychological factors may play in determining household energy decisions. With respect to psychological factors, the analysis considers both general attitudes as well as specific psychological barriers that individuals may face with respect to reducing household energy use. The analysis also considers two measures of energy poverty.

Table 4.1 describes the construction of the attitudinal variables, based on work in the literature on environmental psychology (van Valkengoed, Abrahamse and Steg, 2022[10]; Dunlap et al., 2000[68]; Stern, Dietz and Guagnano, 1995[69]; Gifford, 2011[49]). *Environmental concern* reflects whether a respondent is considered to have a high or low concern about the environment. *Perceived vulnerability* captures the extent to which respondents expect climate change to negatively impact their lives in the future.[23] *Environmental motivation* reflects the extent to which respondents express feeling responsible for the environmental consequences of their choices.[24]

[23] A recent review identifies this psychological construct as a key determinant of pro-environmental behaviours (van Valkengoed, Abrahamse and Steg, 2022[10]). Referred to as risk perception in the literature, it is considered to reflect "an individuals evaluation of the likelihood and severity of a particular environmental hazard."

[24] Also identified as a key determinant of pro-environmental behaviours (van Valkengoed, Abrahamse and Steg, 2022[10]), this construct is referred to as ascription of responsibility in the literature and is considered to reflect "the extent to which people personally feel responsible for the (negative) environmental consequences of their actions."

### Table 4.1 Construction of attitudinal variables

| Attitudinal construct | Unit of measure | Survey items | Construction |
|---|---|---|---|
| Environmental concern | Binary | On a scale of 1 to 5, how important is the following to you personally?<br>Climate change (e.g. rising average temperatures, extreme weather events) or other environmental issues (e.g. pollution) | Respondents who answered that these issues were either “important” or “very important” are considered to have a high level of environmentally concern; all others are considered to have a low level of concern. |
| Perceived vulnerability | Index (0 to 1) | How do you expect climate change (e.g. rising average temperatures, changes in extreme weather events) or other environmental issues to impact the following:<br>• Your job security<br>• Your health<br>• Miscellaneous aspects of your quality of life (e.g. leisure activities, living environment) | Each response takes 1 point if the respondent answered “negatively” or “very negatively”. Responses are aggregated to 0 to 3. An index reflecting the average is created by dividing this metric by 3. |
| Environmental motivation | Index (0 to 1) | Please indicate your agreement to the following statements regarding approaches to address environmental issues:<br>• I am willing to make compromises in my current lifestyle for the benefit of the environment<br>• Environmental issues should be resolved mainly through public policies<br>• Environmental policies introduced by the government should not cost me extra money<br>• Environmental issues will be resolved mainly through individuals voluntarily changing their behaviour | The variable is constructed by summing the responses to each statement, where 1 reflects ‘strongly disagree’ and 5 reflects ‘strongly agree’. The scale is reversed for the middle two statements, for which higher values reflect greater environmental motivation. A score is calculated by dividing the sum of responses by the maximum possible response pattern. |

Table 4.2 describes the construction of several variables reflecting the specific psychological barriers that individuals may face with respect to reducing their household energy use. Respondents reporting that they did not always engage in all types of energy conservation behaviours were asked to select from among nine possible reasons why this was the case. Five types of psychological barriers are constructed from these statements, specifically *change unnecessary, conflicting goals and aspirations, interpersonal relations,* and *knowledge*. In addition to these psychological barriers, two measures of energy poverty are also considered.

## Table 4.2. Construction of psychological barrier variables

| Psychological barrier | Metric | Survey items | Construction |
|---|---|---|---|
| Change unnecessary | Binary | • I don't believe a serious environmental problem related to energy consumption exists<br>• I feel confident that technological innovations will solve environmental problems | Variable is equal to 1 if the respondent indicates that any of the statements apply to them, and 0 otherwise. |
| Conflicting goals | Binary | • I am willing to change my habits but I forget to do so<br>• Environmental issues are important to me but it's too difficult to change my habits<br>• I won't see any personal benefit from changing my behaviour | Variable is equal to 1 if the respondent indicates that any of the statements apply to them, and 0 otherwise. |
| Interpersonal | Binary | • Others in my household would not cooperate or I would receive criticism from those around me | Variable is equal to 1 if the respondent indicates that any of the statements apply to them, and 0 otherwise. |
| Knowledge[1] | Binary | • I don't know how to decrease my energy consumption further | Variable is equal to 1 if the respondent indicates that any of the statements apply to them, and 0 otherwise. |

Note: [1] Because this survey item for this variable asks respondents to report agreement with the statement "I do not know how to reduce my energy consumption *further*," those that express agreement are likely to be those that already have a considerable amount of knowledge about how to conserve energy. As a result, this variable is considered to reflect a relative abundance of knowledge rather than a lack thereof.

Table 4.3 describes the construction of two variables related to reported energy poverty among households. 'Objective energy poverty' reflects whether a household both i) reports not being able to meet its energy needs due to the high cost and ii) is below the poverty line. 'Subjective energy poverty' reflects whether a household reports not being able to meet its energy needs due to the high cost, but is above the poverty line.

## Table 4.3. Construction of the energy poverty variable

| Variable | Metric | Survey items | Construction |
|---|---|---|---|
| Objective energy poverty | Binary | • I/we cannot use as much as I/we need due to the high cost | Variable is equal to 1 if the respondent indicates that this statement applies to them and belongs to a household that falls below the poverty line, and 0 otherwise.[25] |
| Subjective energy poverty | Binary | • I/we cannot use as much as I/we need due to the high cost | Variable is equal to 1 if the respondent indicates that this statement applies to them and belongs to a household which does not fall below the poverty line, and 0 otherwise. |

Box 4.1 provides an overview of the econometric model used for the analysis in Section 4.3. Further are provided in the Annex.

[25] Poverty line criteria are taken from government definitions. Per-capita income levels of surveyed households are determined by dividing total reported household income by reported household size adjusted to reflect economies of scale in consumption (Health and Human Services Department, 2021[166]).

## Box 4.1. Econometric models for energy conservation and investment in low-emissions energy technologies

### Investment in low-emissions energy technologies

$P(y = 1|x) = G(\beta x) = p(x)$ is defined as the probability of a respondent having installed a low-emissions energy technology given a set of control variables. This probability is a function of control variables, $x$. A cumulative distribution function $G(\cdot)$ maps the index function $\beta x$ to the response probability $P$. $G(\cdot)$ can be derived from a latent variable model:

$$y^* = x'\beta + \varepsilon$$

where $y^*$ is a latent variable. The latent variable model is defined as follows:

$$y = 1 \text{ if } y^* > 0$$
$$y = 0 \text{ if } y^* \leq 0$$

Assuming a distribution for the error term, then:

$$P(y = 1|x) = P(y^* > 0|x) = P(\varepsilon > -x'\beta|x)$$

If the distribution is symmetric around zero, then $G(\cdot)$ can be recovered as follows:

$$P(y = 1|x) = P(\varepsilon < x'\beta|x) = G(x'\beta)$$

As a result, the model estimates the effects of the determinants $x$ on the probability of installation by assuming the distribution of the error term of the latent variable model, $\varepsilon$. Maximum Likelihood Estimation is used to estimate the $\beta$ parameters.

### Energy conservation

In the case of energy saving behaviour, the dependent variable takes the values “1” (‘never’), “2” (‘occasionally’), “3” (‘often’) and “4” (‘always’). Ordered response models are therefore used to estimate the impact of determinants $x$ on the dependent variable $y$. A latent variable $y^*$ is defined with respect to a thresholds $\mu$ as follows:

$$y = 1 \quad \text{if } y^* \leq 0$$
$$y = 2 \quad \text{if } 0 < y^* \leq \mu_1$$
$$y = 3 \quad \text{if } \mu_1 < y^* \leq \mu_2$$
$$y = 4 \quad \text{if } \mu_2 < y^*$$

As a result, the associated probabilities of observing each outcome are given by:

$$P(y = 1|x) = G(-x'\beta)$$
$$P(y = 2|x) = G(\mu_1 - x'\beta) - G(-x'\beta)$$
$$P(y = 3|x) = G(\mu_2 - x'\beta) - G(\mu_1 - x'\beta)$$
$$P(y = 4|x) = 1 - G(\mu_2 - x'\beta)$$

Assuming the shape of the cumulative distribution function $G(\cdot)$ allows for the prediction of each outcome $P$. Maximum Likelihood Estimation is used to estimate the $\beta$ parameters.

Note: Further details are provided in the Annex.

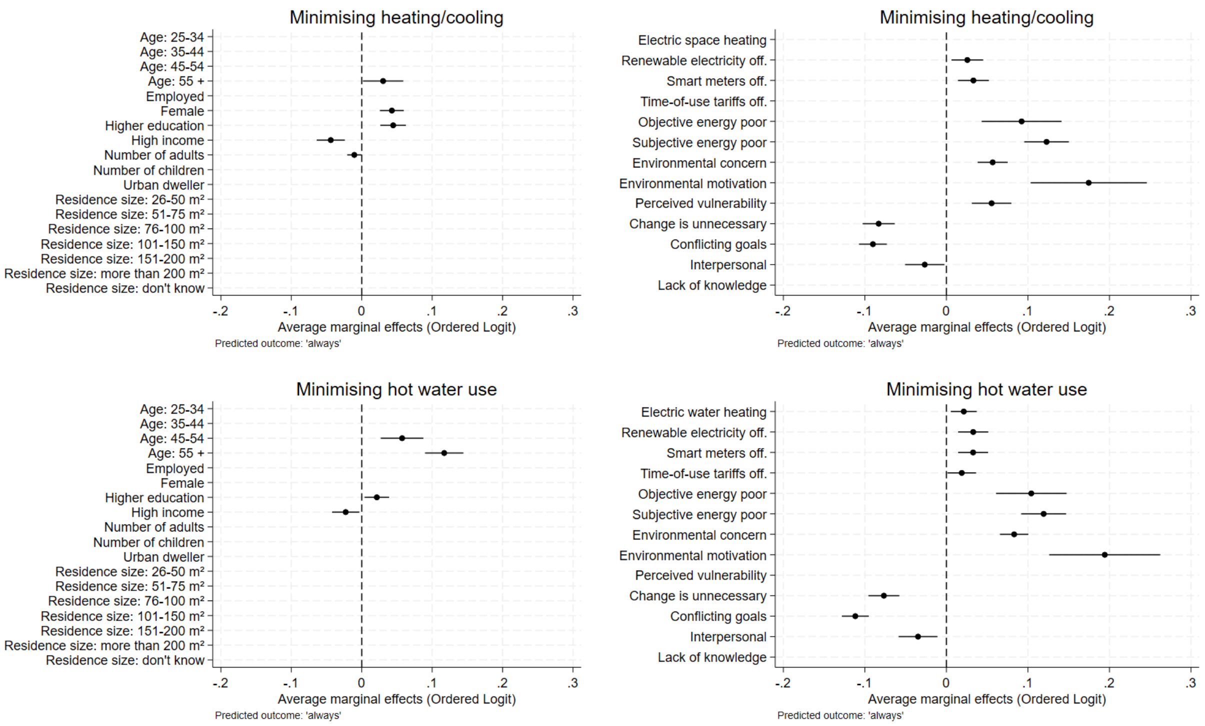
## 4.3. Engagement in energy conservation behaviours

This section examines the role of socioeconomic and attitudinal factors, as well as residential features in explaining engagement in energy conservation. The socioeconomic characteristics considered include age, sex, employment status, income and education. The attitudinal factors include those described in Table 4.1, Table 4.2 and Table 4.3.

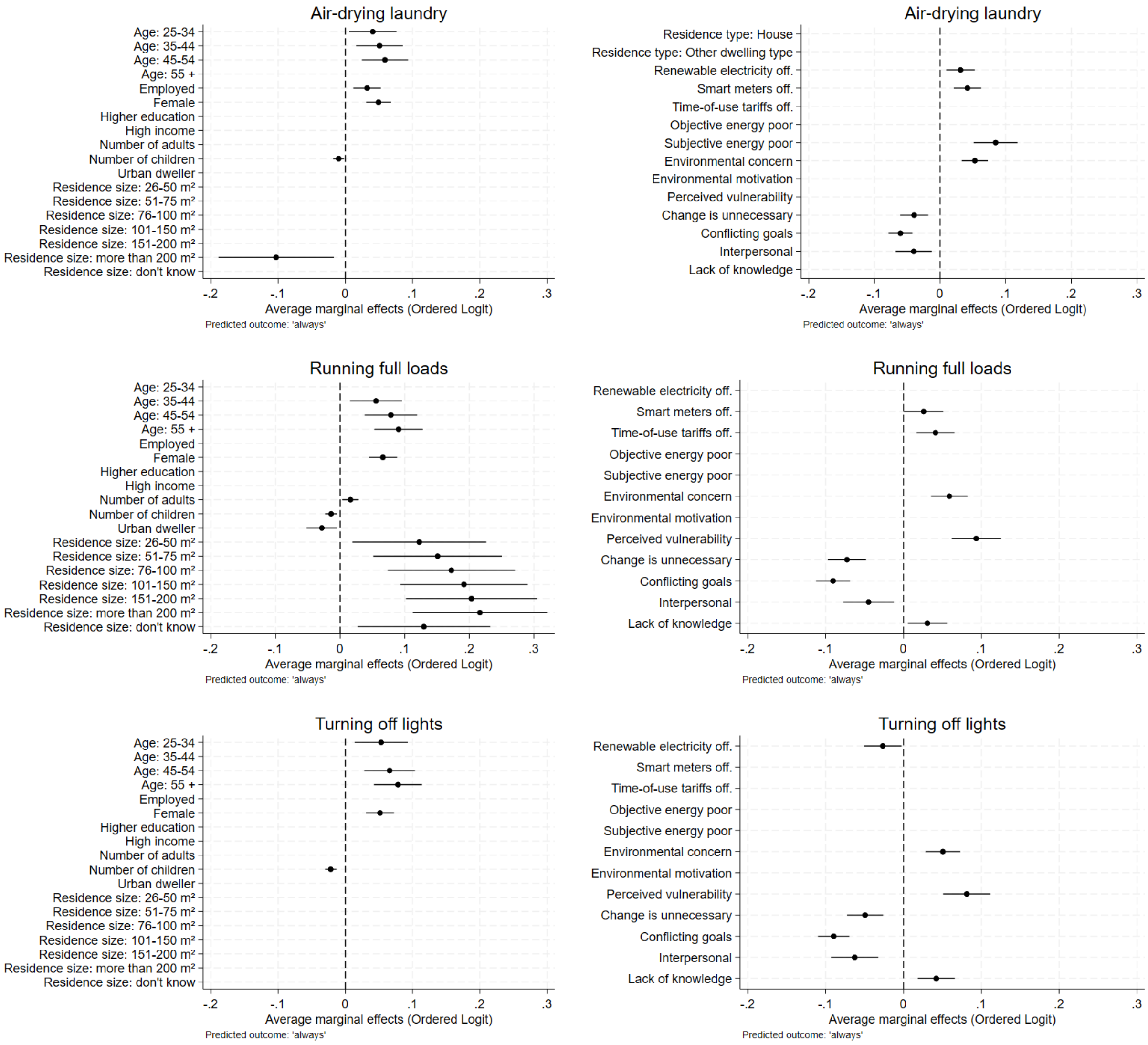
In addition to the variables described above, two energy-related household attributes are also considered with respect to their impact on engagement in energy conservation behaviours: whether the household has been offered green electricity options and whether the household uses electricity for heating, cooking and hot water use. Country fixed effects are included to control for country-level effects such as country-level policies or economic conditions (Perino and Schwirplies, 2022[70]).[26]

Figure 4.1 reports the impact of the included determinants on the probability that households indicate that they always engage in the target energy conservation behaviour. Two panels per behaviour are shown in order to display all relevant determinants. Coefficients should be interpreted as the marginal or differential effect of the control variable on the probability that the respondent always engages in a given behaviour. For example, environmental motivation can be said to increase the likelihood of always minimising heating and cooling by 18%. A lower probability of always engaging can be considered to reflect less frequent reported engagement in the activity of interest.

### Figure 4.1 Determinants of energy conservation behaviours




[26] Further details on the summary statistics, econometric model and estimation method are provided in the Annex. Full results, including country parameter estimates for country-level fixed effects are provided in Table A.10 in the Annex.




Note: This figure displays the average effect of control variables on the probability to always engage in energy conservation behaviours. Dependent variable reflects responses to the question: "How often do you do the following in your daily life?" Response options included never, occasionally, often, always and not applicable. For brevity, only marginal effects of the control variables that are significantly associated with the outcome 'always' are shown. Average marginal effects (dots) are reported with a 95% confidence interval (line) based on the pooled sample. Two panels are shown per behaviour in order to display all determinants included in the model; values displayed for significant coefficients only. Sample size is 6,825 observations. Full numeric results and information about the reference groups for each variable are provided in Table A.10 in the Annex.

With respect to the impact of socioeconomic variables, respondents with higher incomes are less likely to always engage in energy conservation, notably minimising heating and cooling and minimising hot water use. This could be explained by the fact that most of the energy-saving practices considered also save money, which may be less of a priority for high-income households relative to low-income households. Women and older respondents are generally more likely to always engage in energy conservation behaviours. Education also appears to play a role in minimising space heating/cooling and hot water use. Residence size is correlated with a higher likelihood of washing only full loads of laundry and dishes. With the exception of air-drying laundry, employment status overall does not appear to play a significant role in energy conservation. Apart from running full loads of laundry/dishes, location in a rural compared to urban area does not appear to have a significant impact on energy conservation.

Regarding the role of attitudes on conservation behaviour, households that are environmentally concerned are more likely to always engage in all energy conservation behaviours, with impacts ranging from 5% (switching off lights) to 8% (minimising hot water use). Respondents that report being environmentally motivated are more likely to report always minimising space heating and cooling as well as minimising hot water use, with impacts of 18% and 19%, respectively. Respondents that report feeling vulnerable to climate change are also more likely to always engage in energy conservation behaviours. The impact of this construct increases the likelihood that households report always air drying laundry by 3%, switching off lights by 8%, minimising space heating by 6% and washing only full loads of laundry and dishes by 9%. It is worth noting that those who report being environmentally concerned, feeling vulnerable to climate change and being environmentally motivated are also those who may be most subject to cognitive dissonance if they didn't report engaging in energy conservation behaviours. As a result, the observed impact of attitudes on reported behaviour should be considered an upper bound estimate.

In general, the psychological barriers to energy conservation have negative impacts on energy conservation.[27] 'Interpersonal issues' reduce the likelihood of always engaging in energy conservation by between -3% (minimising heating and cooling) and 6% (switching off the lights). 'Change unnecessary' reduces this likelihood by between 4% (air drying laundry) and 8% (minimising heating and cooling). 'Conflicting goals' has the largest impact on conservation behaviour, reducing the likelihood of always minimising hot water use by 11%, and minimising heating and cooling, air drying laundry, and running full loads of washing by 9%. Preferences that depend on existing habits and an aversion to losses could contribute to explaining the significance of this construct (reflecting forgetfulness, difficulty to change one's habits, and a lack of personal benefit to doing so) in determining engagement in energy conservation. Households may, for example, be concerned about a potential decrease in comfort if they significantly adjust their home heating or cooling temperatures. As is expected, having *knowledge* about how to reduce energy use is positively associated with engagement in energy conservation (Bosone, Chevrier and Zenasni, 2022[71]; Diekmann and Preisendörfer, 2003[72]; Gifford, 2011[49]).

Respondents identified as objectively or subjectively energy poor are more likely to conserve energy. The provision of green electricity options, i.e. renewable electricity, smart meters or time-of-use tariffs, are generally associated with greater energy conservation, with impacts ranging from 2% (time-of-use tariffs) to 4% (smart meters). This is in line with previous literature showing that the information on energy use provided by smart meters can decrease energy demand (e.g. Rivers et al., (2018[73]); EEA, (2013[74]); Carroll, Lyons and Denny, (2014[75]); Batalla-Bejerano, Trujillo-Baute, Villa-Arrieta (2020[76])).

Overall the relevance of income with respect to some energy saving behaviours suggests that financial benefits of energy conservation may be incentivizing to households in lower income quintiles. The results also suggest that environmental concern, environmental motivation, perceived vulnerability to climate change, and knowledge about how to reduce energy use all appear to be important factors in decisions related to household energy use. These findings suggest that measures to improve the financial benefits that stand to be gained from energy conservation, as well as to alleviate the psychological barriers to engagement, may be effective in encouraging more sustainable household decisions in this regard. Box 4.2 provides examples of demand-side policy measures that have been implemented to encourage energy conservation among households in different countries. The policy considerations of these findings are discussed at greater length in Section 6.2.

[27] Specifically, the psychological barriers reduce the probability that households report 'always' engaging in these energy conservation behaviours.

### Box 4.2. Examples of measures to encourage conservation behaviour

**Inclined block rate (i.e. tiered) pricing for household electricity use in Ontario, Canada (2004)**

In Canada, the Ontario Energy Board has implemented tiered electricity rates since 2004 (Ontario Energy Board, 2024[77]). As of November 2023, the higher tier price (above 600kWh during the summer and 1000kWh during the winter) is 32% greater than the lower tier price. In addition to tiered pricing, electricity in Ontario is priced according to time-of-use tariffs and an ultra-low overnight tariff.

**Minimising air conditioning through the Cool Biz campaign in Japan (2005)**

The campaign was initiated by the Ministry of Environment and encourages a more casual dress code during the summer in government offices in order to decrease the need for air conditioning. Estimated emissions avoided amount to 460,000 tonnes of CO2 emissions in 2005, and 1.14 million tonnes in 2006 (Japan Times, 2007[78]). Although implemented in an office context, this strategy demonstrates the behavioural potential that is also relevant for residential energy use.

**Smart-meter rollout through the Clean Energy for all Europeans EU initiative (2009)**

The European Union prioritises the uptake of smart meters in EU member countries, with the objective of expanding household access (JRC SES, 2023[79]). In compliance with the provisions set out in the Third Energy Package, Member States were requested to proceed with the roll-out for a minimum of 80% of the electricity end-users by the year 2020, provided a supportive ex-ante cost-benefit analysis.

**Reducing energy use at home and at work with the All actions matter campaign in France (2022)**

In response to the energy crisis in 2022, this information campaign aims to raise household awareness of best practices for reducing energy consumption (Ministères Écologie Énergie Territoires, 2022[80]). "Lower, turn off, switch" is the slogan to promote energy-saving habits. For example, the government called on households and businesses to lower heating to 19°C during the winter 2022, public swimming pools were required to lower the water temperature by 1°C, and public offices were required to turn off hot water in bathrooms. Although temperatures were mild over the winter season, energy savings resulting from these measures have been estimated at 10% (French Government, 2023[81]).

## 4.4. Investment in low-emissions energy technologies

This section assesses the determinants of nine low-emissions energy technologies: the seven that are included in the analysis of Section 2, as well as the installation of low energy light bulbs and highly energy-efficient appliances. The latter two were not included in the LCA analysis because they did not contribute to a clear interpretation of the resulting groups. Estimations are carried out using binary logit regressions in which the dependent variable is 1 if households report having installed the equipment and 0 otherwise.[28] It should be noted that the dependent variable in this section, i.e. reported investment in low-emissions energy technologies, differs from reported engagement in energy conservation insofar as reported

[28] Further details on the econometric model are provided in the Annex.

investment in technologies is less likely to be subject to reporting errors due to various stated preference biases.

In addition to the socioeconomic and attitudinal characteristics described in Section 4.2, this section examines the role of several additional variables considered to be relevant to investing in low-emissions energy technologies. Tenure status (i.e. ownership of primary residence), the number of adults and children[29] in the household, as well as the size and location of the residence (urban vs. rural) are used as determinants in models when a theoretical justification exists for their inclusion (Fraser, 2023[82]; Jacobsen and Stewart, 2022[83]; Kim, Lee and Jang, 2022[84]; Li, Wang and Zhang, 2023[85]; Matsumoto, 2016[86]; Zhang et al., 2022[87]). Dummy variables for residence type (apartment, house or other) are also included, as well as a dummy variable identifying households with access to outdoor space in their primary residence. Country fixed effects are included to control for country-level effects (Perino and Schwirplies, 2022[70]).

The sample in this analysis excludes households that indicate that installing a given piece of equipment is not possible (i.e. it is not feasible and/or their landlord would have to install it). As a result, the analysis sheds light on the determinants of installation among households for whom installation is feasible. An important policy issue, however, pertains to the drivers of this feasibility. Table 4.4 shows that feasibility of installation of all technology types is significantly higher among households that own their home vs. rent it, as well as among those who live in a detached house vs. those who live in apartments. These results demonstrate the critical importance of alleviating barriers to the installation of low-emissions technologies that are associated with home ownership and residence type. This appears to be particularly true for higher-cost technologies and technologies that may be more complicated to install, such as thermal insulation, solar PV, solar water heating, and heat pumps.

## Table 4.4. Feasibility of technology installation across household tenure status and residence type

Percentage of respondents reporting that installing a given technology is not possible

| Technology | Tenure status | | Residence type | |
|---|---|---|---|---|
| | Owner | Renter | House | Apartment |
| Highly energy efficient appliances | 2% | 24% | 3% | 19% |
| Energy-efficient windows | 5% | 37% | 7% | 29% |
| Thermal insulation | 10% | 49% | 9% | 43% |
| Solar PV | 18% | 59% | 16% | 56% |
| Solar water heating | 17% | 57% | 17% | 51% |
| Battery storage | 12% | 53% | 14% | 45% |
| Heat pump | 17% | 56% | 17% | 50% |

The literature on the energy-efficiency gap identifies a number of mechanisms that can explain these findings (Gillingham and Palmery, 2014[88]; Frederiks, Stenner and Hobman, 2015[23]). Various forms of market failures can notably contribute to explaining the evident financial and structural barriers to investing in low-emissions energy technologies. The importance of home ownership in determining investment can, for example, reflect principal-agent issues in residential rental markets, i.e. differences in the information and incentives that are available to landlords and renters when it comes to the installation of low-emissions energy technologies. This problem occurs when landlords have little incentive to invest in low-emissions energy technologies because they will not be able to recover the energy savings resulting from these investments. The importance of income in determining investment can reflect the presence of credit constraints for lower-income households, which can serve to limit their ability to make upfront investments

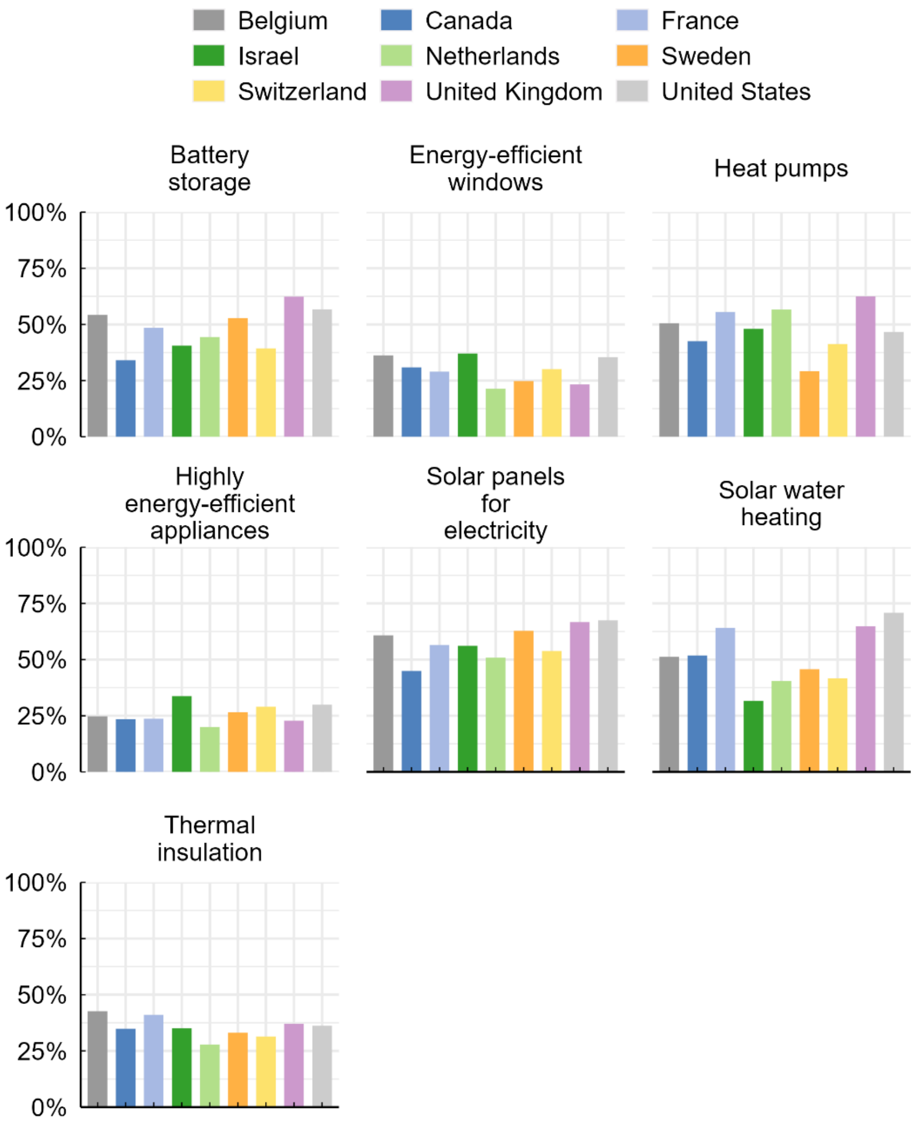
[29] Outliers consist of observations indicating 11 to 26 children.

in higher cost technologies to electrify and improve the efficiency of their energy use. Low-income households may also face additional hidden investment costs to the extent that income may be correlated with lower quality housing stock. Various transaction costs, such as the disruption involved during installation and potential administrative burdens, e.g. relevant permitting and applications for financial support, can also act as transactional barriers to investment. The fact that higher income is associated with lower engagement in energy conservation may also indicate that the cost savings from lower energy use are not sufficiently motivating to high-income households. A comparison of household characteristics across groups reporting that installation of low-emissions technologies is possible vs. not possible confirms these findings, showing that education, income and home ownership rates differ considerably across these groups.

The survey provides some information about the extent to which government support encouraged respondents to invest in low-emissions energy technologies (Figure 4.2). From these results, it appears that financial support has been most effective in encouraging households to install solar panels for electricity, heat pumps, battery storage, and solar water heating systems. Considerable cross-country variation exists, with a higher percentage of household in the United Kingdom, the United States, France and Belgium typically reporting that government financial support has encouraged them to make energy-related investments. As this information is only available for households that installed a given technology, it does not provide information of the extent to which households may not be aware of the availability of such financial support.

## Figure 4.2. Use of government support when investing in energy-related equipment

Percentage of respondents who report that government financial support has encouraged them to invest in low-emissions energy technologies

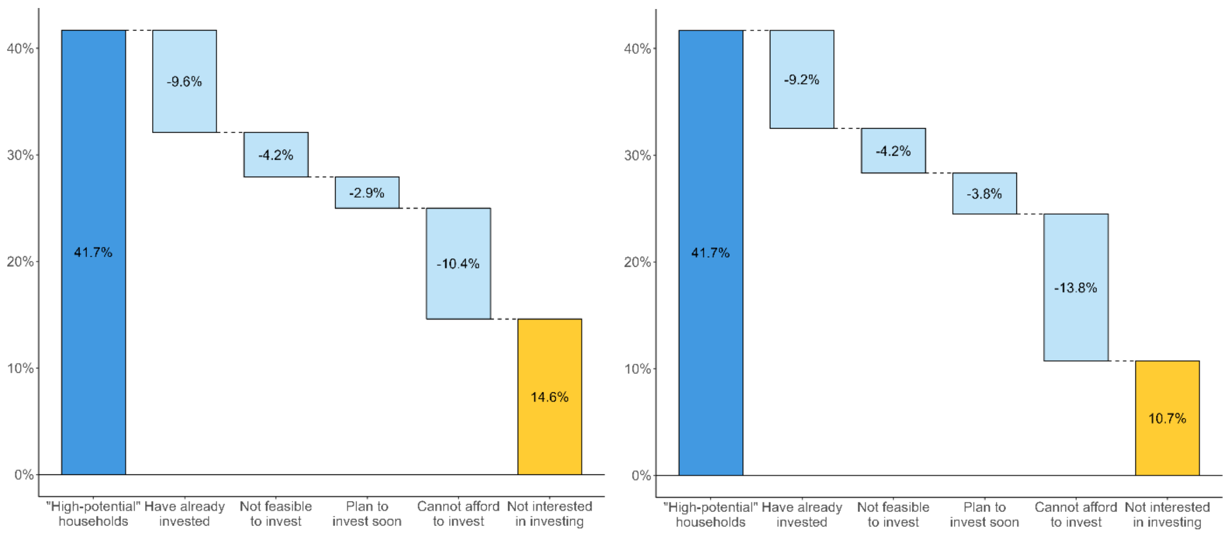



Note: These figures are based on the following survey item, which was only asked of respondents who reported installing a given technology: "Has governmental financial support (e.g. grants, loans with below-market interest rates, tax exemption) encouraged you to install any of the following items in your residence?". For each item, respondents could answer by "Yes", "No" or "Don't know". This question is a follow-up to a previous survey item asking respondents: "Have you installed any of the following items over the past ten years in your current primary residence?". Only respondents who answered "Yes" to this survey item answered the survey item about government support.

Data from the EPIC Survey can provide an indication of the potential for additional investments in various low-emissions energy technologies.[30] Figure 4.3 displays one measure of market potential, namely the portion of households that do not face physical barriers to clean energy investments. "High potential" households are considered to be households that own (rather than rent) their residence, live in a detached or semi-detached house (rather than a multi-unit apartment building) and have access to an outdoor space at home. Figure 4.3 indicates that the proportion of households that have yet to invest in clean technologies, and therefore could be receptive to information and policy, is about 28% for both heat pumps and solar panels[31]. The data suggest that similar figures apply for battery storage and solar water heating whereas the potential for thermal insulation and thermostats, having been subject to energy efficiency policy for a longer period of time, is about half of that for heat pumps. These findings suggest significant remaining potential to increase investments through information provision. In particular, those that report not installing technologies because they are not interested or cannot afford it may be susceptible to adopt such technologies if they were better informed about their financial and/or environmental benefits, the possible financial and administrative support available for their installation, and/or the extent to which other relevant household groups have adopted the technology.

### Figure 4.3. Market potential of investments in selected low-emissions energy technologies among high potential households

Heat pumps (left) and solar panels (right)




Note: "High potential" households are considered to be households that own (rather than rent) their residence, live in a detached or semi-detached house (rather than a multi-unit apartment building) and have access to an outdoor space at home.

Figure 4.4 reports the estimated determinants of households' investment in low-emissions energy technologies.[32] Two panels per technology are shown in order to display all relevant determinants. Coefficients should be interpreted as the marginal or differential effect of the control variable on the probability that the household has installed a given technology. Environmental motivation, for example, increases the likelihood having installed a heat pump by 14%.

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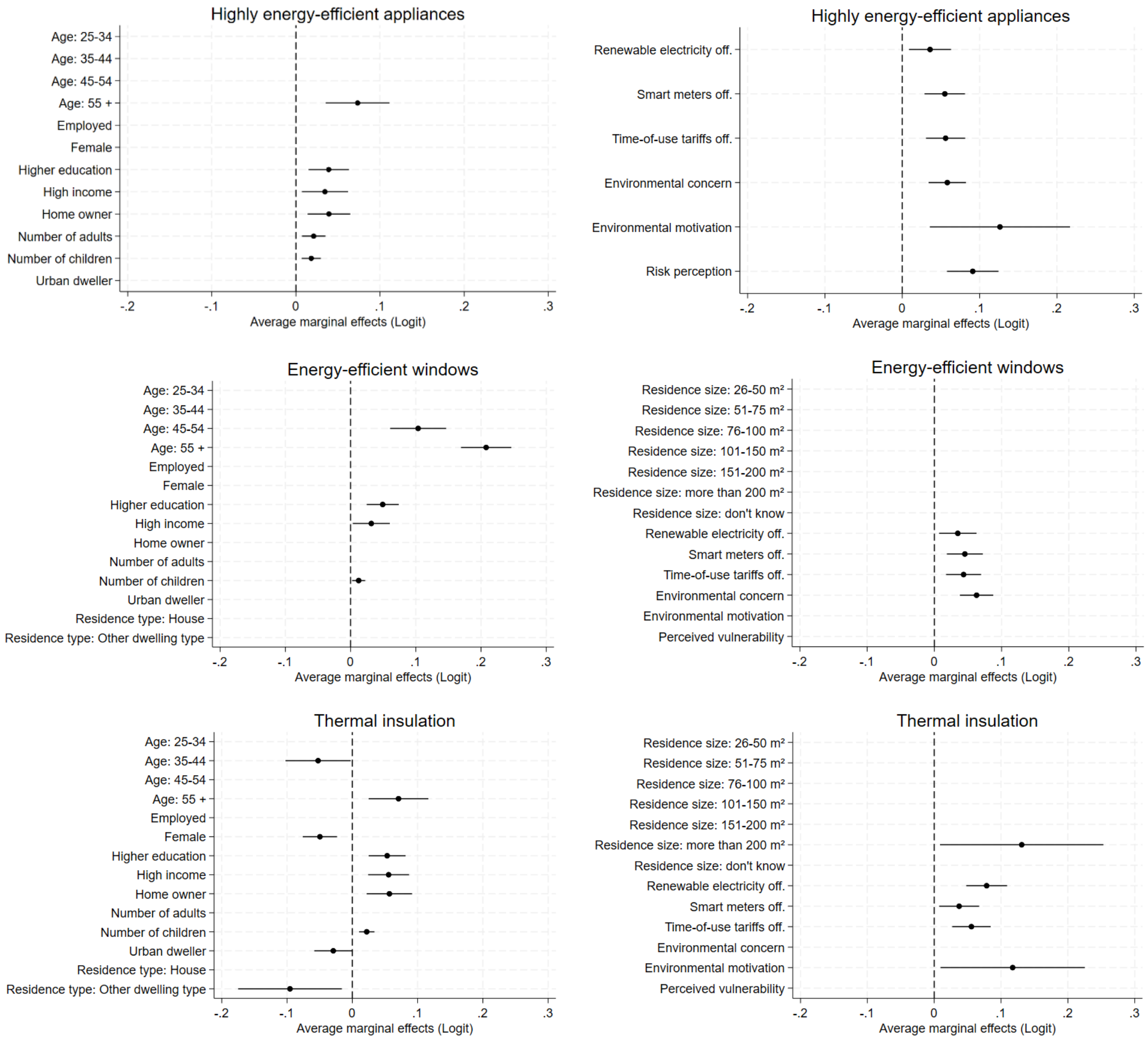
[30] Market potential refers to "adoption/diffusion rates, as influenced by policy implementation, market barriers (e.g., access to capital), technical/economic barriers not otherwise accounted for (e.g., asbestos or other conditions making upgrades difficult), and market drivers such as comfort, aesthetics, and other non-financial motivation for energy efficiency improvements" (Eric Wilson et al., 2017[180]). Market potential can be contrasted with technical potential ("the theoretical potential savings resulting from energy efficiency upgrades using available technology") and economic potential ("the subset of technical potential for upgrades that meet cost-effectiveness criteria").

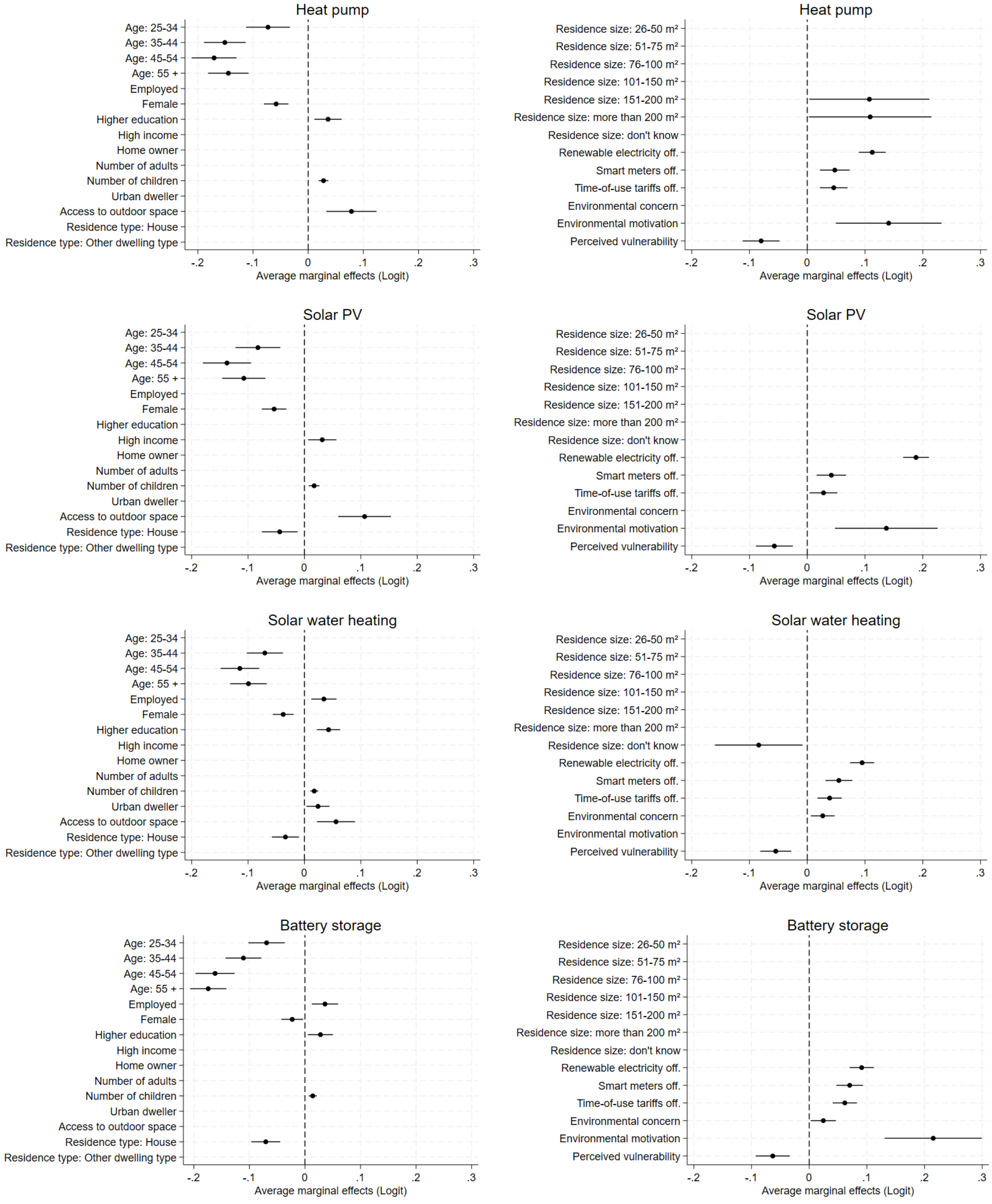
[31] i.e. summing the categories Plan to invest soon, Cannot afford to Invest, and Not interested in investing

[32] Full results, including country parameter estimates for country-level fixed effects are provided in Table A.11 and Table A.12 in the Annex

Some differences are apparent in the determinants of technologies that require high installation costs compared to those with lower installation costs. While age is positively associated with the installation of equipment such as energy-efficient windows and appliances, it is negatively associated with higher cost and newer technologies, such as heat pumps and solar panels. Additionally, although environmental concern appears to play a role in the installation of lower-cost technologies, it does not appear to be a significant driver of higher cost technologies. This could reflect the fact households' primary motivation for installing lower-cost types of equipment is not related to the environment, but rather to saving energy costs over the long term. These results could also arise due to the fact that in addition to the financial costs of installation, higher-cost technologies may be more disruptive and administratively burdensome to install than lower cost technologies.

## Figure 4.4 Determinants of investment in low-emissions energy technologies






Note: This figure displays average marginal effect of various control variables on the probability to always engage in energy conservation behaviours. The dependent variable reflects responses to the question: "Have you installed any of the following items over the past ten years in your current primary residence?" Response options included yes, no and don't know. The dependent variable equals 1 if the household response is "yes." Average marginal effects (dots) are reported with a 95% confidence interval (line). Two panels are shown per behaviour in order to display all determinants included in the model; values displayed for significant coefficients only. Sample sizes ranges from 5,267 to 6,922 observations across technologies. Full numeric results and information about the reference groups for each variable are available in Table A.11 and Table A.12 in the Annex.

With respect to socioeconomic characteristics, households in the highest income quintile are more likely to install most types of low-emissions energy technologies. Respondents with higher education are also more likely to install these technologies, and female respondents are less likely to install higher-cost technologies. The results also suggest that, among households for whom installation of these technologies is possible, those living in a detached house are less likely to have installed them compared to those living in apartments. This finding could reflect the possibility that it may be more costly to install these technologies in older houses and/or that these households have not yet been sufficiently incentivised to make such installations to more recently built houses.[33] Overall, the findings are in line with previous evidence regarding the role of socioeconomic characteristics and environmental and dwelling factors on energy-saving behaviours (Trotta, 2018[89]; Balaskas et al., 2021[90]), including a cross-national survey of 22 European countries (Umit et al., 2019[91]).

A general explanation for underinvestment in low-emissions energy technologies that have a positive net present value is a tendency to undervalue future benefits that accrue from these investments in the long term. Budgetary constraints that ultimately result in households prioritising expenditures that generate greater utility (e.g. spending money on vacations rather than on replacing a gas boiler with a heat pump) could also contribute to explaining a lack of investment in such technologies. Environmental motivation increases the likelihood of installing most technologies, with impacts ranging from 7% (solar water heating) to 22% (battery storage). Households that report having been offered green electricity options are more likely to install low-emissions energy technologies. Larger residences are associated with a higher likelihood of having installed heat pumps and thermal insulation. Households with access to outdoor space are also more likely to have installed solar PV (11%), solar water heating 6%) and heat pumps (8%).

Overall, these results suggest that decisions regarding whether to install technologies – especially those with higher installation costs or that have structural requirements – are less affected by attitudinal factors than decisions regarding whether to conserve energy. Instead, education level and income play a larger role in determining such decisions. The fact that income has opposite effects on investment and conservation decisions confirms previous work suggesting that high-income respondents are more amenable to technical improvements, while those with lower incomes tend to prefer behavioural measures (Poortinga et al., 2003[92]), a difference that is likely to be motivated in part by financial constraints. Box 4.3 provides examples of demand-side policy measures that have been implemented to encourage investment in low-emissions energy technologies across countries. The policy-relevant considerations of these findings are discussed further in Section 6.2.

[33] It should be noted that the sample for this analysis is households that did not indicate that installing these items was not possible. As a result, this variable may also partially reflect the impact of rural location, as households in rural areas are more likely to live in a detached house. Thus, the estimate associated with living in a detached house, within the sample of households for whom installation is assumed to be possible, could also conceivably reflect the impact of factors correlated with rural location that are not otherwise controlled for in the analysis, e.g. political views. In models including all households, the impact of residence type was very strong and in intuitive directions in all cases where significant.

### Box 4.3. Examples of measures to encourage investment in low-emissions energy technologies

**Subsidies for the installation of small-scale renewable energy in the Netherlands (2016)**

In this programme, households can receive an allowance for the purchase of heat pumps, biomass boilers, solar water heaters, pellet stoves and small wood-fired boilers. The budget for the programme increased to EUR 100 million in 2017 and 2018 relative to EUR 70 million in 2016 (Ministry of Economic Affairs and Climate Policy, 2023[93]).

**Support for retrofits and energy efficiency improvements in Sweden (2016)**

Under this programme, financial support is provided to homeowners for energy efficiency investments, amounting to up to 5% of the total cost for projects that improve energy performance by at least 20%. Financial support for renovation provides 20% of the cost of renovation projects. Support for renovation projects accrues to tenants through a rent reduction over a seven-year period (IEA, 2019[94]).

**Community Energy Efficiency financing in Canada (2020)**

This initiative provides support to municipalities to offer financing options for residential buildings. Examples of financing models include Property Assessed Clean Energy (PACE), utility on-bill financing and third-party lending partnerships (Green Municipal Fund, 2023[95]).

**Minimum Energy Efficiency Standards for the private rented sector in the United Kingdom (2018)**

This initiative establishes a minimum level of energy efficiency for privately rented property in England and Wales. Before granting a new tenancy to new or existing tenants, landlords must achieve an Energy Performance Certificate rating of E or better (BEIS, 2023[96]).

**Incentive schemes for energy performance in the rented sector in the Netherlands (2014)**

The Energy Savings Fund for the Rental Sector offers low-interest loans for landlords to make their rental properties more energy-efficient. Energy Performance Incentive Scheme for the Rental Sector also enables landlords to improve the energy performance of their rental properties. For eligible homeowners, the initiative also provides grants and low-interest loans for investments in thermal insulation, energy efficient windows, solar water heating, heat pumps, energy efficient ventilation, and solar panels (Government of the Netherlands, 2016[97]).

**Eco Point Program in Japan (2009)**

This campaign provided households with Eco Points for the purchase of energy-efficient electronic appliances. Eco Points were worth roughly one yen each and could be exchanged for coupons and prepaid cards, energy-efficient products, or products that promote regional economies. More points could be gained for a small fee by returning old products when upgrading to a new more energy efficient appliance. The program increased demand for the approximately 2,000 energy efficient electronics that were labelled as eligible for the program. The program also helped households to undertake energy conservation by providing information on specific actions that can be taken (UN ESCAP, 2011[98])

# 5. Preferences for lower emissions-intensive electricity

## 5.1. Overview

In addition to the conservation and investment decisions that were considered in Section 4, the emissions intensity of the electricity that households use will become an increasingly important determinant of their environmental footprint, especially in light of the continued electrification of residential energy use. This section analyses a discrete choice experiment implemented as part of the EPIC Survey to explore household preferences regarding choice of electricity provider (see Box 4.1). The objective of this experiment is to estimate how much households may be willing to pay for reductions in the greenhouse gas emissions intensity of their electricity consumption, and to estimate how changes in electricity prices relative to their carbon content could shift households' choices of electricity providers.

In light of the environmental relevance of the choice of electricity provider, a considerable number of studies have investigated household preferences via choice experiments in order to shed light on how to accelerate a shift to renewable electricity sources (Nakai, Okubo and Kikuchi, 2018[99]; Kalkbrenner, Yonezawa and Roosen, 2017[100]; Huh et al., 2015[101]; Morita and Managi, 2015[102]; Vecchiato and Tempesta, 2015[103]; Kaenzig, Heinzle and Wüstenhagen, 2013[104]). The experimental designs, geographic scope and analytical approaches of these analyses differ widely. Departing from existing work, the analysis in this paper implements a uniform experimental design to representative samples in the nine survey countries, enabling a comparison of willingness-to-pay estimates across country contexts. This work therefore contributes novel evidence to the existing literature insofar as it calculates separate willingness to pay estimates for nine countries, controlling for socioeconomic and attitudinal characteristics.

### Box 5.1. Using discrete choice experiments to a better understand decision-making

In discrete choice experiments, subjects are asked to make hypothetical choices by selecting a preferred alternative from a menu of options (Bateman et al., 2002[59]; OECD, 2018[58]). Stated preference data generated by discrete choice experiments enable an estimation of how much respondents value the various characteristics of the options presented. These characteristics could relate to products (e.g. the price of, or GHG emissions from, energy supply); actions (e.g. convenience of using disposable rather than refillable containers); or elements directly affected by environmental policies (e.g. the cost and convenience of owning an electric car).

Despite the challenges of survey-based research noted in Section 2.3, stated preference approaches offer a number of significant advantages over revealed preference approaches when it comes to ex-ante policy evaluation (OECD, 2018[58]). Discrete choice experiments, for example, are well-suited to analysing choice in the context of relatively complex, multi-dimensional issues (Bateman et al., 2002[59]; OECD, 2018[58]). Flexibility to define decision scenarios allows for an evaluation of the impact of hypothetical policy interventions. Stated preference approaches also generate valuations of changes in health status and environmental quality that provide critical input into cost-benefit analyses.

Discrete choice experiments also generate data that provide a richer picture of preferences than simpler stated preference elicitation methods. The data generated by choice experiments allow for an estimation of how much respondents value the characteristics of the options being considered, also known as willingness-to-pay. Examples include travel time, travel cost, and comfort for transport mode options, or cost and convenience for waste reduction practices. The data can also provide insights into how respondents make trade-offs between these characteristics and how sensitive their choices are to changes in the characteristics of the options presented. The EPIC Survey data allow for disaggregation at the household level to understand how these values and sensitivities vary across the population according to location or socioeconomic variables such as age, income and gender.

## 5.2. Methodology

The discrete choice experiment allows for the estimation of household willingness to pay for decarbonised electricity by asking respondents to make hypothetical choices between several electricity providers that differ in terms of price and greenhouse gas emissions intensity.[34] In the experiment, respondents are asked to choose between their current electricity provider and two other electricity providers. Respondents are given two pieces of information about providers: the price (local currency per kWh) and greenhouse gas emissions intensity (g $CO_2$/kWh). Their current provider is characterised by the average price and emissions intensity of a kWh of electricity production in the country where they live. The alternate providers each offer electricity at a higher price but a lower emissions intensity relative to the current provider.[35] Respondents were asked to assume that all other characteristics other than what was shown in choice sets were the same among the three providers and completed three choice tasks each.

[34] Discrete choice experiments have been widely used to evaluate products, services and policies in a range of fields, including electricity choices (e.g., Lehmann et al. (2023[169]), Mengelkamp et al. (2019[170]), Ruokamo et al. (2019[114]), Byryk et al. (2015[167])).

[35] As a result, this is a partially labelled experiment with a grey status-quo alternative and two greener alternatives. Additional details regarding the design of the experiment, including an example choice set, can be found in the Annex.

Attributes and attribute levels (Table 5.1) are selected based on related studies[36] and results from two pilot studies implemented as part of the EPIC Survey.[37] Price and $CO_2$ emissions have been included as characteristics of choice alternatives in experiments in previous studies,[38] to elicit households' preferences towards less carbon-intensive electricity. Further details regarding the design of the experiment, including an example choice set, the econometric model used to estimate preference parameters, as well as estimation results are provided in the Annex.

## Table 5.1. Discrete choice experiment attribute levels

| Country | Average price (local currency per kWh) | 5% increase | 10% increase | 20% increase | Average GHG emissions intensity (g $CO_2$e/kWh) | 10% decrease | 30% decrease | 50% decrease |
|---|---|---|---|---|---|---|---|---|
| Belgium | EUR 0.28 | EUR 0.29 | EUR 0.30 | EUR 0.33 | 161 | 145 | 113 | 81 |
| Canada | CAD 0.14 | CAD 0.146 | CAD 0.153 | CAD 0.17 | 140 | 126 | 98 | 70 |
| France | EUR 0.19 | EUR 0.20 | EUR 0.21 | EUR 0.22 | 54 | 49 | 38 | 27 |
| Israel | NIS 0.55 | NIS 0.58 | NIS 0.60 | NIS 0.66 | 580 | 522 | 406 | 290 |
| Netherlands | EUR 0.14 | EUR 0.15 | EUR 0.16 | EUR 0.17 | 441 | 397 | 309 | 221 |
| Sweden | SEK 1.55 | SEK 1.63 | SEK 1.71 | SEK 1.86 | 13 | 12 | 9 | 7 |
| Switzerland | CHF 0.20 | CHF 0.21 | CHF 0.22 | CHF 0.24 | 153 | 138 | 107 | 77 |
| United Kingdom | GBP 0.17 | GBP 0.18 | GBP 0.19 | GBP 0.21 | 250 | 225 | 175 | 125 |
| United States | USD 0.13 | USD 0.14 | USD 0.15 | USD 0.16 | 386 | 347 | 270 | 193 |

Note: Country-specific electricity prices in 2020 come from IEA (2021[105]). Values for GHG emissions intensity in 2020 come from EEA (2023[106]) (Belgium, France, the Netherlands and Sweden) and Electricity Maps (2024[107]) (Canada, Israel, Switzerland, the United Kingdom, and the United States).

In addition to socioeconomic characteristics, attitudes and energy-related household characteristics are included as determinants of choice of electricity provider. Specifically, these include general environmental concern and whether the household uses electricity as its primary energy source for cooking, heating and cooling. Country-level effects are also included in order to account for systematic differences in household preferences that may be observed across countries. Box 5.2 provides an overview of the econometric model used for the analysis of the discrete choice experiment.

[36] See e.g. Kim, Lee and Jang (2022[84]), Contu, Strazzera and Mourato (2016[168]), Murakami et al. (2015[156]), Newell and Siikamäki (2015[172]), Newell and Siikamäki (2014[171]), Scarpa and Willis (2010[173]).

[37] Two pilot studies with 270 observations (30 observations per country) were conducted between April and May 2022 in order to refine attribute levels.

[38] See e.g. Byun and Lee (2017[109]); Morita and Managi (2015[102]); Murakami et al. (2015[156]), Komarek et al., (2011[113]), along with renewable energy (Mengelkamp et al. (2019[170]), (Nakai, Okubo and Kikuchi (2018[99]), Huh et al. (2015[101]), Vecchiato and Tempesta (2015[103]), (Kaenzig, Heinzle and Wüstenhagen (2013[104]).

### Box 5.2 Overview of the discrete choice model

A conditional logit model is used for estimating preferences towards attributes. Respondents were asked to choose their preferred option from a set of three hypothetical alternatives. This was repeated three times, enabling an estimation of the utility functions. According to the random utility theory (McFadden, 1973[108]), respondent *n* (*n*= 1,…, *N*) is considered to obtain utility for choosing provider *i* (*i* = 1, … , 3) as follows:

$$U_{ni} = V_{ni} + \varepsilon_{ni}$$

Indirect utility $V_{ni}$ consists of the observable utility of the price and GHG emissions attributes, $V_{ni}$, and the stochastic component of utility, $\varepsilon_{ni}$, which is identically and independently distributed and follows a Type-I extreme value distribution. The probability that alternative (provider) $i$ is chosen by respondent $n$ can be expressed as the following:

$$P_{ni}\left(U_{ni} > U_{nj}, \forall j \in C, i \neq j\right) = \frac{exp(\mu V_{ni})}{\sum_{j \in C} exp(\mu V_{nj})}$$

where $\mu$ is a scale parameter. A linear model for $V_{ni}$ including four interaction terms is defined by:

$$\begin{aligned} U_{ni} = ASC + \beta_1 Price_{ni} + \beta_2 GHG\ Emission_{ni} \\ + ASC * \boldsymbol{Socioeconomics}_{ni} + ASC * Environmental\ concern_{ni} \\ + Price * \boldsymbol{Country}_{ni} + GHG\ Emission * \boldsymbol{Country}_{ni} + \varepsilon_{ni} \end{aligned}$$

Marginal willingness-to-pay (MWTP) for emission reductions which can be estimated as follows:

$$MWTP = -\left(\frac{\beta_{GHG\ emission}}{\beta_{price}}\right)$$

Note: Additional details regarding alternative specifications and the calculation of willingness to pay are provided in the Annex.

## 5.3. Willingness to pay for reductions in GHG emissions intensity of electricity use

Econometric results of the discrete choice experiment show estimated parameters for price and GHG emission attributes are negative and statistically significant. This indicates that, all else equal, respondents prefer electricity that is supplied at a lower cost and has lower emissions intensity, in line with existing evidence (Byun and Lee, 2017[109]; Boeri and Longo, 2017[110]; Morita and Managi, 2015[111]; Murakami et al., 2015[112]; Komarek et al., 2011[113]). Table 5.2 shows the willingness to pay (WTP) results from this experiment, expressed as a percentage premium of the retail electric price for a given reduction of the emissions per kilowatt hour (kWh) of electricity. The results indicate that preferences for electricity provision differ across countries. Households in Switzerland, Israel, the United States and Canada appear to be most sensitive to both the price and the emissions intensity of the electricity provided.

The results also suggest that some households exhibit a preference for remaining with the status quo option regardless of the price and GHG emissions intensity of the alternative options.[39] The inconveniences associated with switching providers, such as administrative requirements and potential service disruptions, constitute transaction costs that may deter households from switching providers.

[39] If all of the characteristics of the options are assumed to be observed, this result can be considered a status-quo bias and has been evidenced in other work (e.g. Brown and Krishna, 2004; Pichert and Katsikopoulos, 2008).

Specifically, the findings suggest that women, those over 55, those living by themselves, as well as those paying the most for electricity exhibit a tendency to remain with the current provider. On the other hand, those in high income households and respondents having obtained a higher education tend to be more likely to switch to a new provider than their counterparts. This finding is in line with previous results (Ruokamo et al., 2019[114]), including work that suggests that willingness-to-pay for electricity is higher if a household is able to outsource the switching process (Danne, Meier-Sauthoff and Musshoff, 2021[115]).

Willingness to pay estimates are presented in Table 5.2 and are calculated based on the country-specific parameter estimates for the detailed price and GHG emissions attributes of the model results provided in Table A.15 in the Annex.[40] Results indicate a positive price premium for reductions in the GHG emissions intensity of electricity consumption. Households indicate that they are willing to pay 1% and 9% more for a 10% reduction in greenhouse gas emissions intensity per kWh consumed.[41] This aligns with previous work showing small but positive price premiums for renewable energy (Kim, Park and Lee, 2018[35]; Van Rijnsoever, Van Mossel and Broecks, 2015[38]; Vecchiato and Tempesta, 2015[116]; Dugstad et al., 2020[117]; Murakami et al., 2015[112]).[42] For example, previous studies have found that households are willing to pay between USD 3 and USD 21 per month in Poland (Mamica, 2021[118]; Kowalska-Pyzalska, 2019[119]), EUR 26.5 per quarter in Greece (Ntanos et al., 2018[120]), and 16% more in Germany (Kaenzig, Heinzle and Wüstenhagen, 2013[121]). A meta-analysis estimated mean and median values of willingness-to-pay for green electricity were USD 13 and USD 11 per month, respectively (Sundt and Rehdanz, 2015[122]).

[40] Estimates are reported in Expanded Model 2 in the Annex.

[41] By way of comparison, the willingness-to-pay values in Table 5.2 (i.e. willingness-to-pay for reductions in GHG emissions intensity of electricity consumption in CO2e/kWh) were translated into USD/tonne CO2e. Some values, for example in Belgium (USD 167), Israel (USD 167), the United Kingdom (USD 174) and the United States (USD 162) are comparable to (albeit less than) existing social cost of carbon estimates such as USD 190/tonne CO2e (US EPA) and USD 185/tonne (Rennert et al). Other values, however, are considerably higher, and include estimated equivalents of USD 301 in Canada, USD 774 in France, and USD 1,073 and 1,226 in Sweden and Switzerland, respectively. Given the lower emissions intensity of electricity consumption in Sweden and Switzerland (e.g. relative to the United Kingdom and the United States), high values could be due to a combination of scope insensitivity (a general bias in stated preference elicitation methods by which respondents exhibit similar willingnesses-to-pay for different units of measurement) and differences in emissions intensity per kWh across countries. A 10% reduction in emissions intensity in countries with low emissions intensity (which translates to a small marginal change in CO2 emissions), if valued similarly as a 10% reduction in countries with greater emissions intensity (which translate to larger marginal changes in $CO_2$ emissions), will lead to an inflated WTP per tonne $CO_2$e in these countries. The equivalent willingness-to-pay in $CO_2$e/tonne in the Netherlands is much lower (USD 56/tonne).

[42] In a meta-analysis of willingness-to-pay estimates for renewable energy, Ma et al. (2015[123]) find that survey administration, design and model specification can have a significant impact on results. While online surveys tend to find lower willingness-to-pay than surveys by mail or phone, studies using discrete choice experiments generate higher willingness-to-pay estimates than contingent valuation studies. As a result, willingness-to-pay estimates from any single study should be interpreted with caution.

### Table 5.2. Willingness-to-pay (WTP) for lower GHG emissions intensity electricity

Percent change in WTP per kWh for 1%, 10% and 50% reductions in GHG emissions intensity

| | Reduction in GHG emissions per kWh | | |
|---|---|---|---|
| Country | 1% | 10% | 50% |
| Belgium | 0.09 % | 0.9 % | 4.6 % |
| Canada | 0.39 % | 3.9 % | 19.6 % |
| Israel | 0.59 % | 5.9 % | 29.5 % |
| France | 0.21 % | 2.1 % | 10.5 % |
| Netherlands | 0.17 % | 1.7 % | 8.4 % |
| Sweden[1] | 0.09 % | 0.9 % | 4.6 % |
| Switzerland | 0.90 % | 9.0 % | 44.8 % |
| United Kingdom | 0.21 % | 2.1 % | 10.4 % |
| United States | 0.48 % | 4.8 % | 24.1 % |

Note: 1 Willingness-to-pay in Sweden is not significantly different from the reference country, Belgium. Country-specific values are calculated based on the parameter estimates of Expanded Model 2 reported in the Annex. Values are equal to the sum of the price and GHG main effects with the country-specific interactions. Additional details are provided in the Annex.

Findings suggest that households in Switzerland are willing to pay the most of those in the sample, and that households in Belgium and Sweden are willing to pay the least. Observed differences in willingness-to-pay across countries could be driven by a number of factors that vary at the country level and are not separately controlled for in the analysis. One potential source of variation in willingness-to-pay across countries could be differences in the assumptions that households make regarding the source of the renewable electricity. Evidence suggests, for example, that willingness-to-pay for renewable energy is greater for solar, wind or generic renewable energy sources than for energy produced from biomass or hydro-energy (Ma et al., 2015[123]). To the extent that countries differ in the composition of their electricity mix and capacity to generate electricity from different types of renewables, differences in households' assumptions in this regard could drive differences in observed willingness-to-pay. The low willingness-to-pay in Sweden, for example, could reflect the fact that much of this electricity is generated by hydropower.

Another potential source of the variations in WTP could be the impact of Russia's war of aggression against Ukraine that started in 2022 and that resulted in dramatic electricity price increases for many European countries. Electricity prices in Belgium, for example, were 50% higher during the second half of 2022 compared to the same period in 2021. In contrast, this change was 9%, 5% and -7% in France, Sweden and the Netherlands, respectively (Eurostat, 2023[124]). Average changes in electricity prices over the same time frame were 12% in the United States (EIA, 2024[125]) and 55% in the United Kingdom (UK DESNZ, 2023[126]). Comparing electricity price fluctuations with willingness-to-pay values in Table 5.2, larger price increases appear to be correlated with lower willingness-to-pay for reductions in emissions intensity of electricity. This is evident, for example with respect to Belgium and the UK, which experienced price increases of 50% and 55%, respectively, and where households express a lower willingness-to-pay than other countries in the sample. In contrast, the country with the highest willingness-to-pay, Switzerland, experienced a 2% increase in electricity prices over this time period (Swiss Federal Office of Energy, 2024[127]).

Differences across countries in terms of their climate, housing stock characteristics and electricity mixes also contribute to differences in the shares of home energy expenditure by average household income. Households in France and the United Kingdom spend on average nearly 5% of their average household income on home energy expenditure in 2022 (IEA, 2023[128]), with households in each country exhibiting similar willingness-to-pay for reductions in emissions intensity of electricity of about 2% respectively. Households in the United States and Canada, which spend on average about 3% of their income on energy use, are willing to pay more, 5% and 4% respectively to reduce the GHG emissions intensity of their electricity consumption by 10% per kWh.

Differing levels of existing GHG emissions intensity of electricity production across countries could also contribute to observed differences in willingness-to-pay for additional marginal reductions. This could contribute to explaining the low willingness-to-pay in Sweden, for example, which is characterised by electricity supply that is already relatively decarbonised. The high level of willingness to pay observed in Switzerland could be in part explained by the demonstrated importance of the acceptance of green energy, social norms and moral obligations (Hojnik et al., 2021[129]). Data from other areas of the EPIC Survey indeed indicate that households in Switzerland expressed higher levels of environmental awareness and concern, as well as engagement in a variety of environmentally-relevant behaviours (OECD, 2023[11]).

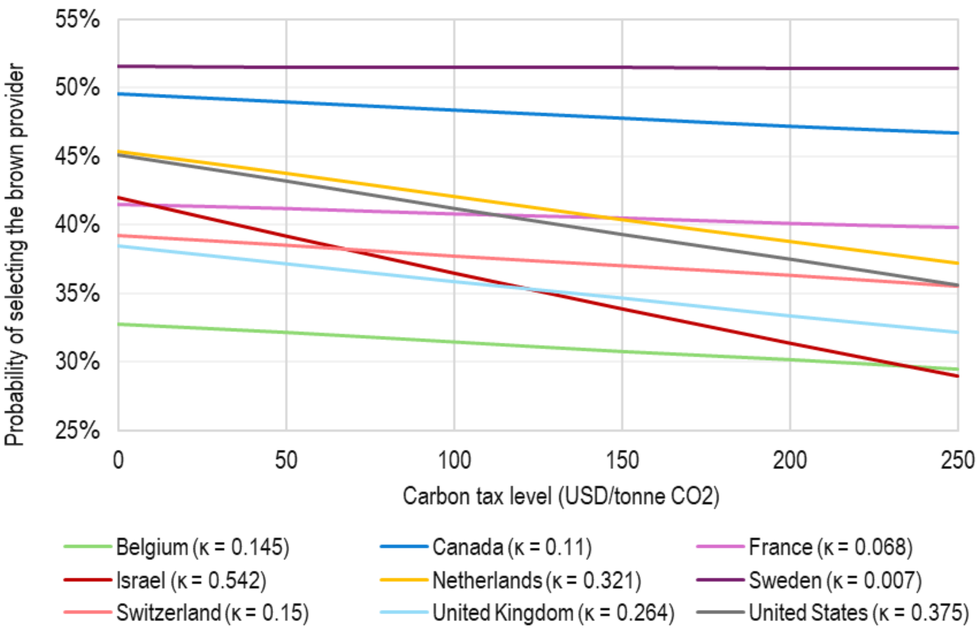
Variation could also be correlated with existing levels of government support for the development of renewable energy, which has been shown to impact willingness-to-pay for renewables (Ntanos et al., 2018[120]). With the lowest willingness-to-pay of the sample, Belgium is also characterised by the lowest share of renewables in its electricity mix (13%) in 2022 (EEA, 2023[130]), signalling a relatively lower level of government support than in other countries. Households in the Netherlands, which saw a nearly 15-fold increase in solar electricity generation between 2015 and 2022 (ACER - CEER, 2023[64]), in contrast, appear willing to pay almost twice as much as those in Belgium. Differences across countries could also be due to differences in social norms, public education and information. A combination of the above factors is likely to explain variation in willingness-to-pay observed across countries, and could be explored further in future work.

## 5.4. Impact of a carbon tax on household choice of electricity provider: A scenario analysis

This section provides an assessment of the impact that a carbon tax could have on households' propensity to choose greener electricity options. This analysis is based on the results of the conditional logit model estimated in Section 5.3, which incorporates various individual-level and country-specific factors as determinants of choice of electricity provider.[43] Figure 5.1 shows the effect in each country of different levels of carbon taxes on the probability of choosing greener electricity options. The results demonstrate that higher carbon taxes would reduce the probability of choosing "brown" electricity over greener options in all countries, but that impacts differ markedly across countries.

[43] Specifically, the scenario analysis is based on Expanded Model 2 reported in Table A.15. This model includes coefficients for price sensitivity, greenhouse gas (GHG) emissions effects, an alternative specific constant (ASC), and interactions of the ASC with various demographic and socioeconomic variables like gender, age, income, education, household composition, environmental concern, and high electricity cost. Country-specific data used for the scenario analysis includes the baseline electricity price used in the choice experiment, the average emissions intensity of electricity per kWh in 2022 and fixed values for individual control variables across different countries. For each country and each specified carbon tax level, the total utility of selecting the status quo was calculated and transformed into a probability using the logistic function. The resulting probabilities are then plotted against varying levels of carbon tax for each country, depicting how the likelihood of maintaining the status quo changes with the tax.

## Figure 5.1. Likelihood of choosing the brown electricity provider for varying carbon tax levels




Note: Kappa ($\kappa$) reflects the carbon intensity of electricity generation in a given country in $\frac{kg\ CO_2}{kWh}$. The impact of a carbon tax on choice probabilities here captures the effect of both carbon intensity and price sensitivity combined.

Figure 5.1 shows changes in the predicted probability that the average household in each country chooses the brown alternative (i.e. the status quo alternative) as the carbon tax varies between zero and USD PPP 250 per tonne.[44] Differences in the predicted probabilities shown can be considered to be equivalent to potential changes in the market share of electricity provider uptake. A negative slope in all countries indicates that increases in the carbon tax level reduce the likelihood that households choose the brown provider, which is characterised by the highest emissions intensity of electricity supply among the alternatives. This is due to the fact that an increase in the carbon tax increases the price of the brown alternative to a greater extent vis-à-vis the greener options, resulting in an increase in the likelihood of choosing one of the greener providers instead. Differing slopes indicate differing household responses to increases in the carbon tax level. Two main drivers underlie the observed differences in responses to a carbon tax across countries. First, differences in the carbon intensity of electricity across countries means

[44] The scenario analysis assumes a tax of $\tau$ that ranges between 0 and 250 $\frac{USD}{tonne\ CO_2}$. This carbon tax is converted into a country-specific increase in electricity price by multiplying $\tau$ by the country-specific carbon intensity of the electricity mix $\kappa_C$ (expressed in $\frac{tonne\ CO_2}{kWh}$). The country-specific increase in electricity price $i_C$ as a result of a given carbon tax level t, is then $i_C(\tau) = \tau \times \kappa_C$ (expressed in $\frac{USD}{kWh}$). $i_C(\tau)$ indicates that the country-specific electricity tax depends on the carbon tax level $\tau$. Next, $i_C(\tau)$ is added to the country-specific price of electricity from the status-quo provider, $p_C$. The total electricity price in the presence of a carbon tax $\tau$ is then: $P_C(\tau) = p_C + i_C(\tau)$. The choice probability of the status-quo alternative (one line for each country) is plotted for $0 < \tau < 250$, fixing $\mathbf{x}$ (i.e. the individual-specific explanatory variables, gender, income, age, ... etc) to the country average, $\overline{\mathbf{x}_c}$. The probability that the average respondent in country $c$ (of characteristics $\overline{\mathbf{x}_c}$) chooses the status-quo alternative in country $c$ is: $\mathrm{Prob}_{SQ}(\tau|\overline{\mathbf{x}_c})$.

that a carbon tax will have different impacts on the price of electricity in each country.[45] Second country-specific price elasticities may differ, meaning that households may be more or less sensitive to price changes across countries.

Figure 5.1 demonstrates that households' choice of provider in some countries appears to be quite insensitive to the application of a carbon tax. In Sweden, for example, an increase in the carbon tax from 0 USD/tonne $CO_2e$ to 250 USD/tonne $CO_2e$ reduces the probability of choosing the brown provider by only 1 percentage point. In other countries, such as Israel, however, results suggest that the same change in the carbon tax level would reduce the probability of choosing the status-quo provider by 13 percentage points.[46]

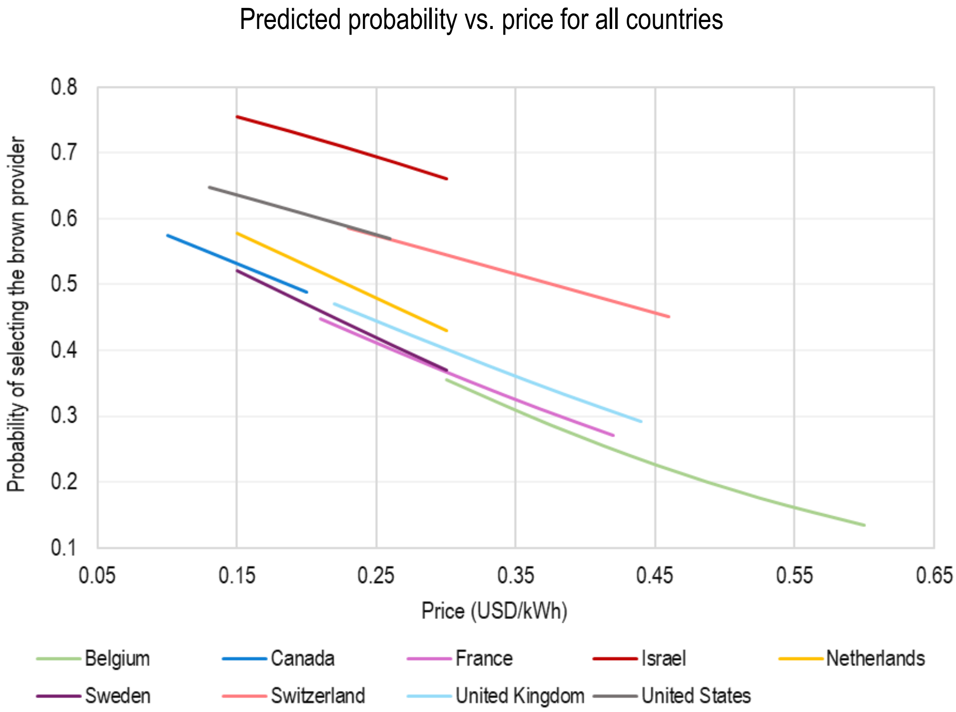
Figure 5.2 isolates price sensitivity as a driver of household responsiveness to a carbon tax, reporting the predicted probability of choosing the status quo provider at different prices (rather than carbon tax levels) across countries.[47] This figure shows that countries are characterised by different baseline propensities to choose the status quo provider at varying baseline price levels (evidenced by the differing heights of the left point of the curves). Beyond these differences, however, Figure 5.2 demonstrates that households across countries are relatively similar in terms of how sensitive they are to changes in the price of electricity, as evidenced by their similar slopes. Differences in price sensitivities could arise due to differences in historical prices and expectations about future prices, the relative thermal efficiency of the housing stock climatic conditions or public acceptance of renewable energy, for example.

[45] Note that $\frac{USD}{kWh} = \frac{USD}{tonne\ CO_2} \times \frac{tonnes\ CO_2}{kWh}$.

[46] Numerical results for all countries are provided in Table A A.17 in the Annex.

[47] Numerical results for all countries are provided in Table A A.18 in the Annex.

## Figure 5.2. Predicted probability of choosing the brown electricity provider at varying price levels




Note: Predicted probabilities displayed for only the price range covering $[p_c, 2p_c]$ where $p_c$ is the average price of electricity in USD per kWh in country $c$. Country-specific baseline electricity prices in 2020 come from IEA (2021[105]).

Taken together, the results of this exercise suggest that the main source of variation in the predicted effectiveness of a carbon tax across countries is differences in the carbon intensity of electricity generation, which imply different changes in the price of electricity due to a given carbon tax across countries. Whereas a carbon tax of 200 USD/tonne $CO_2$ increases the baseline price of electricity in Canada by 22%, the same carbon tax leads to a 6% increase in the price of electricity in France. Such large differences in the implications of a given carbon tax for electricity prices could be expected to explain differences in the acceptability of a carbon tax across countries. To the extent that electricity providers respond to a household shift toward electricity with fewer GHG emissions by sourcing more electricity from renewable sources, the implementation of a carbon tax could also be expected to have an effect on the carbon intensity of electricity generation in the long run.

# 6. Demand-side policy considerations for an effective energy transition

## 6.1. Overview of findings

Table 6.1 and Table 6.2 provide a summary of findings from the econometric analysis of the determinants of households' energy-related choices. The unique features of this analysis, namely its inclusion of a broad range of determinants of household choice and its cross-country nature helps to shed light on the relative impact of a range of determinants of behaviour, which is useful for understanding which policy objectives and measures could be prioritised. Second, it demonstrates the importance of country context, i.e. macroeconomic, institutional and social factors, in determining household decisions.

The results demonstrate that the drivers of choice are not uniform across behaviours and point to significant cross-country differences in energy-related behaviours and preferences. This suggests that tailored approaches will be more effective in encouraging energy conservation and investment in low-emissions energy technologies. Specifically, while the results suggest that the barriers to energy conservation tend to be attitudinal or behavioural in nature (e.g. low environmental concern or forgetfulness), they suggest that the greatest barriers to investing in energy equipment tend to be structural or financial. Financial barriers pertain to the financial costs of adopting a technology and affordability-related constraints, whereas structural barriers pertain to obstacles to installation that may exist even in the absence of financial barriers (e.g. the feasibility of installing solar PV in multi-unit buildings). Since measures to improve affordability do not address the structural barriers to installation that can be prohibitive for some households, this analysis makes an important contribution insofar as it points to the criticality of strengthening efforts to address structural constraints that currently constitute an obstacle to reducing the environmental impacts of the residential energy sector.

Results from the discrete choice experiment also suggest that a given carbon tax is likely to have different impacts on household choices across countries, but that this is mainly due to cross-country variation in the emissions intensity of electricity generation rather than differences in households' price sensitivities. This highlights the importance of considering the effectiveness of carbon pricing in a local context and illustrates the potential benefits of improved cost-effectiveness of emissions trading markets. Similarly, significant cross-country differences in the propensity to make energy-related choices signal the importance of considering local factors in policy approaches to both conservation and investment behaviour alike. In contrast, the fact that environmental concern and environmental motivation are generally drivers of household decisions across choices and countries, points to a role for efforts to improve environmental awareness and knowledge across contexts.

## Table 6.1. Determinants of energy conservation behaviours

| | | Minimising heating and cooling | Minimising hot water use | Air-drying laundry | Running only full loads of laundry/dishes | Turning off the lights |
|---|---|---|---|---|---|---|
| Socioeconomic and household characteristics | Female | + | | + | ++ | ++ |
| | Age (55+) | + | +++ | ++ | ++ | ++ |
| | Employed | | | + | | |
| | Income (highest quintile) | - | - | - | | |
| | Education | + | + | | | |
| | Number of adults | | | | | |
| | Number of children | | | | | |
| | Urban dweller | | | | | |
| | Green electricity options | | | | | |
| | Renewable electricity | + | + | + | | - |
| | Smart meter | + | + | + | + | |
| | Time of use tariffs | | + | | + | |
| | Residence size (200+ m2) | | | | | |
| Attitudinal factors | Environmental concern | ++ | ++ | + | + | ++ |
| | Environmental motivation | ++++ | +++ | | +++ | |
| | Perceived energy poverty | +++ | +++ | ++ | - | |
| | Objective energy poverty | ++ | ++ | | | |
| | Perceived vulnerability | + | | | ++ | ++ |
| | Change unnecessary | - | - | | - | - |
| | Knowledge | ++ | + | + | ++ | ++ |
| | Conflicting goals | - | - - | - | - - | - - |
| Country-level effects (Base = Belgium) | Canada | - - | - - | - - - - | | |
| | Israel | - - - | - - | ++ | - - | - - |
| | France | - - | - - | ++++ | + | |
| | Netherlands | - - | - | | - - | - - |
| | Sweden | - - - - | - - - | - | - - - | - - - - |
| | Switzerland | - - - | - - | | - - | |
| | United Kingdom | ++ | | - - - | | - - |
| | United States | - - | - - | - - - - | - - | - - |

Note: +, ++, +++, and ++++ indicate positive average marginal effects of less than 5 percentage points, 5-10 percentage points, 10-15 percentage points, and 15-30 percentage points significant at the 5% level. The inverse is true for the negative effects. The absence of sign indicates that the effect is not significant. Full results available in the Annex.

## Table 6.2. Drivers of investment in select low-emissions energy technologies

| | | Heat pumps | Thermal insulation | Energy-efficient windows | Highly energy-efficient appliances | Solar PV |
|---|---|---|---|---|---|---|
| Socio-demographic and household characteristics | Female | - - | - | | | - - |
| | Age (55+) | - - - | ++ | +++ | ++ | - - - |
| | Employed | | | | | |
| | Income (highest quintile) | | ++ | + | + | + |
| | Education | + | ++ | + | + | |
| | Number of adults | | | | + | |
| | Number of children | + | + | + | + | + |
| | Urban location | | - | | | |
| | Green electricity options | | | | | |
| | Renewable electricity | +++ | ++ | + | + | +++ |
| | Smart meters | + | + | + | ++ | + |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Time-of-use tariffs | + | ++ | + | ++ | + |
| | Residence size (200+ m2) | ++ | +++ | | n/a | |
| | Homeowner | | ++ | | + | |
| | Access to outdoor space | ++ | n/a | n/a | n/a | +++ |
| | Living in a house | | | | n/a | - |
| Attitudinal factors | Environmental concern | | | ++ | ++ | |
| | Environmental motivation | +++ | +++ | | +++ | +++ |
| | Perceived vulnerability | - - | | | ++ | - - |
| Country-level effects (Base = Belgium) | Canada | | - - - | - - - - | | - - - - |
| | Israel | | - - - - | - - - - | +++ | - - - - |
| | France | | | - - | - - - | - - - - |
| | Netherlands | | | | | ++ |
| | Sweden | ++++ | - - - | - - | | - - - - |
| | Switzerland | ++++ | | | ++ | - - |
| | United Kingdom | | | | | - - - - |
| | United States | ++ | - - - | - - - - | | - - - - |

Note: +, ++, +++, and ++++ indicate positive average marginal effects of less than 5 percentage points, 5-10 percentage points, 10-15 percentage points, and 15+ percentage points significant at the 5% level. The absence of sign indicates that the effect is not significant. Full results available in the Annex.

Across the analyses in this report, the findings point to four groups of households relevant for demand-side energy policies. The first group consists of households that are already taking steps towards more sustainable choices within their financial, structural and institutional constraints. This includes households that, independent of income level, already engage to the greatest extent in energy conservation (e.g. minimising their energy use), and that have invested in the low-emissions energy technologies that are physically and financially feasible for them.

The second group is comprised of households that experience barriers to making more sustainable choices related to energy use. For energy conservation, this group constitutes mainly low-income households that indicate that they are not able to meet their energy needs due to high costs. This group may be more likely to encompass households that rely on fossil-fuel based energy sources and may be living in lower quality housing, which could increase their vulnerability to energy price increases. For investments in low-emissions energy technologies, this group is constituted by households that cannot afford to install such equipment, either due to a lack of disposable income or lack of access to credit. It is also comprised of households for whom the installation of these technologies is not possible due to building characteristics or the fact that they rent rather than own their residence.

A third group consists of high-income, high energy-intensity households that have yet to undertake significant energy investments or engage in conserving behaviours. Improving the energy-related choices of this group represents an area of opportunity for new or enhanced policies. Interventions to shift the behaviour of these households will require a consideration of the unique factors that may be most motivating to them (e.g. leveraging peer comparison).

The fourth group of households is comprised of households on the margin of making changes to their energy-related decisions. These are households that may have the financial and physical capacity for change, and who may indeed hold pro-environmental attitudes and express a willingness to change, but for whom psychological and/or financial barriers still exist. Based on the survey, this includes households that, for example, may have expressed willingness to change their energy use habits, but may forget to do so, or lack information on how to do so. It also includes households for whom installing low-emissions energy technologies may be affordable with government financial support (e.g. subsidies), but unaffordable without. Households in this group can also include renters and landlords who may be interested in installing energy-related equipment but lack the legal or institutional mechanisms to do so. Policy interventions to address these barriers should be expected to lead to shifts in household choices at the extensive margin.

Given the range of household groups and behavioural determinants identified in this analysis, policy approaches to pursue the energy transition should consider where the opportunities for change lie and take into account households' constraints and capacities for such changes. The policy considerations presented in this section offer several guidelines for policymakers reflecting the evidence in this report.

## 6.2. Policy considerations

### *Address remaining barriers for renters and apartment dwellers to install low-emissions energy technologies*

Differences in the feasibility of installation across tenure status and residence type suggest that structural barriers may impede investments in low-emissions energy technologies. Structural barriers may, for example, make installing heat pumps or solar PV infeasible for households in multi-unit apartment buildings or households that rent their primary residence. The persistence of these barriers over time suggests that novel approaches are needed to overcome barriers and accelerate the deployment of low emissions technologies.

Addressing constraints to the installation of low-emissions energy technologies in residential rental markets should notably involve reducing differences in the incentives and information available to renters and landlords. While ensuring that renters and landlords have access to the same information (e.g. about investment opportunities and tax incentives for investment) is important, measures that align the financial incentives of each party will also be required in order to fully address split-incentive problems. Examples of instruments that have been implemented to address split-incentive problems include green leases (in which tenants commit to energy conservation in exchange for incentives), environmental upgrade agreements, on-bill financing (i.e. drawing on utility bills as a repayment vehicle for energy efficiency loans), energy efficiency mortgages and energy efficiency standards for rented units (French Public Service, 2023[131]; Department of the Environment and Energy, 2013[132]; Bird and Hernández, 2012[133])). One-stop-shops connect households to energy advisory services and technology providers in order to provide households with information options for energy improvements and available financing instruments. These services have been shown to bridge the gap between supply and demand of residential energy improvements (Boza-Kiss and Bertoldi, 2018[134]).

### *Provide sufficient and targeted financial incentives for the installation of low-emissions technologies*

Among households for whom the installation of such technologies may be technically feasible and cost effective from a society perspective, the cost of installation of low-emissions energy technologies may nevertheless be prohibitive, as evidenced by the importance of income in determining the installation of some types of technologies. These constraints can be alleviated through measures such as subsidies and credit provisions to assist financing among middle- and low-income households. Enabling more attractive loan conditions, increasing household literacy regarding such loans and preventing predatory loan practices, can also contribute to reducing financial constraints. The level of financial support available to households should take into account not only the means of the household in question, but also the costs and quality of the equipment being installed in order to address potential disparities in the quality of housing stock across household groups that can affect installation costs.

Examples of financial incentives that have been implemented include renewable energy tax credits in the United States (IRS, 2023[26]), grants for retrofits in Canada (Natural Resources Canada, 2023[27]) and property tax exemptions for energy efficiency investments in France (IEA, 2022[28]).[48] In addition to setting energy efficiency requirements for rented units, offering renters as well as landlords incentives for the installation of low-emissions energy technologies could increase their use in residential rental markets. While financial incentives remains an important tool for addressing financial barriers, it is also important to design incentives to ensure that they reach households who would not invest otherwise, minimising financial payouts for households that would invest even in the absence of such incentives (aka minimising free riding).

For some households (e.g. those with little or no financial constraints), incentives such as subsidies may not be effective in motivating investments in low-emissions energy technologies. The results in this report suggest that price-based disincentives such as tiered electricity rates could be effective in encouraging investment in electrification and energy efficiency among such households. Given the demonstrated importance of social norms with respect to environmental behaviours (e.g. Guo et al. (2018[135]), Allcott et al. (2011[136])), peer effects could also be leveraged among higher-income households by providing information about how households compare with respect to their investment in low-emissions energy technologies.

### *Improve awareness of energy use and increase the financial benefits of saving energy*

Although energy saving actions can be taken with little to no financial cost, the analysis suggests that attitudes and psychological barriers can also hamper energy conservation. Information provision, such as improving households' understanding of potential cost savings, can improve decision-making by helping them to account for the future benefits of energy conservation in the form of lower electricity bills. Information on how to save energy as well as reminders to do so could also mitigate households' lack of knowledge and forgetfulness with respect to taking energy-saving measures. Expanding the provision of energy feedback can also enable households to better monitor and conserve their energy use. Smart meters and smart home devices, such as thermostats and batteries can also be combined with automated price or conservation signals from the electricity provider to help consumers automate cost savings based on pre-defined settings such as electricity prices or a grid alert. Evidence based on observed energy use at the household level indicates that feedback and social comparisons can indeed be effective in reducing household energy use (Rivers, 2018[73]; Allcott, 2011[136]; IEA, 2022[137]), and may be particularly effective among high-income households (List et al., 2017[138]).[49]

Improving the incentives for energy conservation implies an increase in the financial savings that households stand to gain from using less energy. Differentiated electricity rates, for example time-of-use and inclined block rate pricing (i.e. increasing the price with the level of consumption), could increase the potential savings that can be realised by reducing energy use (Batalla-Bejerano, Trujillo-Baute and Villa-Arrieta, 2020[76]; Bergaentzlé, Clastres and Khalfallah, 2014[22]).[50] Evidence suggests that the impacts of price-based measures are relatively more persistent than those of information provision and can moreover contribute to the formation of energy-saving habits (Ito, Ida and Tanaka, 2018[139]). Other evidence

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[48] See Box 4.2 for additional examples.

[49] See Box 4.3 for additional examples.

[50] Energy use thresholds applied in inclined block rate pricing should optimally be tailored to household characteristics such as residential size in order to ensure that overconsumption is accurately defined for a given household. In order for inclined block rate pricing to effectively discourage overconsumption, moreover, customers must be aware of the pricing scheme and of their consumption in real time (Ida, Ito and Tanaka, 2013[175]).

indicates that price- and non-price based measures can be highly complementary due to their effectiveness among households with lower and higher energy use, respectively (List et al., 2017[138]).

### *Expand environmental awareness to support greater energy saving and more investment in low-emissions energy technologies*

Attitudes towards the environment as well as environmental motivation play a consistent role in nearly all energy-related behaviours, suggesting that measures that support environmental awareness and cultivate a sense of responsibility can foster more sustainable energy use. The current analysis suggests that this is especially true for engagement in energy conservation and investment in low-emissions energy technologies that are less costly and easier to install. As a result, this policy approach can be considered to cast a wide net in terms of its potential impact on household energy use, at a relatively low financial cost.

Many examples of environmental awareness campaigns exist, with varying degrees of evidence for their effectiveness. The Winter Energy Conservation Initiative in Switzerland promotes energy saving measures by providing households with advice regarding energy saving measures (Swiss Federal Council, 2023[140]). A temperature-adjusted measure of residential energy use shows that demand for electricity has decreased in 2023 compared to the 5-year average (Swiss Federal Office of Energy, 2023[141]). In response to the energy crisis in 2022, the Swedish Energy Agency produced a guide for households containing information on how to reduce their energy use. Specific tips were also provided regarding daily actions, as well as thermal renovation and heating system maintenance (Swedish Energy Agency, 2022[142]). Households in the EPIC survey that report being offered green electricity options (renewable electricity, smart meters, or time of use tariffs) are more likely to engage in energy conservation and invest in low-emissions energy technologies. This result suggests that exposure to such options could serve as a mechanism for increasing household awareness of the environmental impacts of household energy use.

### *Adjust support to local policy contexts*

The significance of country-level effects with respect to engaging in energy conservation and investing in low-emissions energy equipment, as well as cross-country differences in willingness-to-pay for renewably generated electricity, signal a wide variation in household preferences and behaviours across contexts. The findings in this paper point to behaviours for which household engagement may be particularly low (e.g. air-drying laundry in the United States and Canada), or in contrast already fairly high (e.g. installation of solar PV systems in Israel), providing an indication of where policy efforts may be more or less needed, as well as more or less effective. These observations also point to areas where households may be less receptive to price-based measures or information provision and thus where alternative policies could be considered, such as equipment performance standards aimed at improving energy efficiency. Understanding existing levels of engagement in conservation behaviour in specific contexts will be important for local policy approaches to expand engagement in already prevalent behaviours, as well as to shift existing behavioural patterns that may be less tractable.

Differences in willingness to pay for renewable energy across countries indicates that different strategies may be needed to successfully increase the share of renewable electricity in different country contexts. A higher willingness-to-pay indicates a high preference for renewable electricity and thus potentially greater scope for increasing its provision through market-based mechanisms. In contexts with lower willingness-to-pay, increasing renewable electricity uptake may require targeted policy efforts such as renewable energy mandates. In such contexts, targeting supply-side actors and other sources of GHG emissions may indeed be more effective than targeting the voluntary uptake of renewably generated electricity. For example, a number of countries have set renewable energy standards on the wholesale level by limiting GHG emissions content and establishing renewable energy credits. To the extent that market-based mechanisms and renewable energy mandates may entail higher electricity prices, these approaches should be accompanied by a consideration of how to ensure the affordability of renewable electricity options for low-income households.

The finding in Section 5 that certain socioeconomic groups exhibit a tendency to remain with the status quo suggests that establishing a green default option could be an effective approach for increasing household uptake of renewable electricity (Liebe, Gewinner and Diekmann, 2021[25]; Kaiser et al., 2020[143]; Ebeling and Lotz, 2015[144]).[51] Even with greater provision of electricity from renewable sources, this finding indicates the simultaneous importance of reducing the transaction costs of switching providers. If households that report being offered green electricity options are more likely to engage in energy conservation and invest in low-emissions energy technologies, as the findings suggest, the provision of renewable electricity could moreover be expected to be associated with a positive spillover effect in the form of greater engagement in energy saving measures. Effective policy approaches to influencing energy-related behaviour should therefore take into account the relevant infrastructural, institutional and societal context.

[51] It should be noted that existing evidence is based on a limited set of countries. Further research on the effectiveness of green default options will be useful in indicating the extent to which these findings apply to contexts with different economic, political and cultural characteristics.

# References


ACER - CEER (2023), *Energy Retail and Consumer Protection: 2023 Market Monitoring Report*, European Union Agency for the Cooperation of Energy Regulators and the Council of European Energy Regulators, https://acer.europa.eu/Publications/2023_MMR_Energy_Retail_Consumer_Protection.pdf (accessed on 3 December 2023). [64]

Allcott, H. (2011), "Social norms and energy conservation", *Journal of Public Economics*, Vol. 95/9, pp. 1082-1095, https://econpapers.repec.org/article/eeepubeco/v_3a95_3ay_3a2011_3ai_3a9_3ap_3a1082-1095.htm. [136]

Allcott, H. and M. Greenstone (2012), "Is There an Energy Efficiency Gap?", *Journal of Economic Perspectives*, Vol. 26/1, pp. 3-28, https://doi.org/10.1257/jep.26.1.3. [50]

Allcott, H. and N. Wozny (2014), "Gasoline Prices, Fuel Economy, and the Energy Paradox", *Review of Economics and Statistics*, Vol. 96/5, pp. 779-795, https://doi.org/10.1162/REST_a_00419. [51]

Arimura, T., H. Katayama and M. Sakudo (2016), "Do Social Norms Matter to Energy-Saving Behavior? Endogenous Social and Correlated Effects", *Journal of the Association of Environmental and Resource Economists*, Vol. 3/3, pp. 525-553, https://doi.org/10.1086/686068. [42]

Arimura, T. et al. (2012), "Cost-effectiveness of electricity energy efficiency programs", *Energy Journal*, Vol. 33/2, pp. 63-99, https://doi.org/10.5547/01956574.33.2.4. [18]

Balaskas, A. et al. (2021), "Energy poverty in the mountainous town of Metsovo, Greece", *Journal of Mountain Science*, Vol. 18/9, pp. 2240-2254, https://doi.org/10.1007/S11629-020-6436-1/METRICS. [90]

Batalla-Bejerano, J., E. Trujillo-Baute and M. Villa-Arrieta (2020), "Smart meters and consumer behaviour: Insights from the empirical literature", *Energy Policy*, Vol. 144, p. 111610, https://doi.org/10.1016/j.enpol.2020.111610. [76]

Bateman, I. et al. (2002), "Economic valuation with stated preference techniques: a manual.", *Economic valuation with stated preference techniques: a manual.*. [59]

BEIS (2023), *Domestic private rented property: minimum energy efficiency standard: Landlord guidance*, https://www.gov.uk/guidance/domestic-private-rented-property-minimum-energy-efficiency-standard-landlord-guidance (accessed on 9 November 2023). [96]

Bergaentzlé, C., C. Clastres and H. Khalfallah (2014), "Demand-side management and European environmental and energy goals: An optimal complementary approach", *Energy Policy*, Vol. 67, pp. 858-869, https://doi.org/10.1016/J.ENPOL.2013.12.008. [22]

Bertsch, V. et al. (2016), "Public acceptance and preferences related to renewable energy and grid expansion policy: Empirical insights for Germany", *Energy*, Vol. 114, pp. 465-477, https://doi.org/10.1016/j.energy.2016.08.022. [36]

Bird, S. and D. Hernández (2012), "Policy options for the split incentive: Increasing energy efficiency for low-income renters", *Energy policy*, Vol. 48, p. 506, https://doi.org/10.1016/J.ENPOL.2012.05.053. [133]

Boeri, M. and A. Longo (2017), "The importance of regret minimization in the choice for renewable energy programmes: Evidence from a discrete choice experiment", *Energy Economics*, Vol. 63, pp. 253-260, https://doi.org/10.1016/j.eneco.2017.03.005. [155]

Boeri, M. and A. Longo (2017), "The importance of regret minimization in the choice for renewable energy programmes: Evidence from a discrete choice experiment", *Energy Economics*, Vol. 63, pp. 253-260, https://doi.org/10.1016/j.eneco.2017.03.005. [110]

Boomsma, C. et al. (2019), "Do psychological factors relate to energy saving behaviours in inefficient and damp homes? A study among English social housing residents", *Energy Research & Social Science*, Vol. 47, pp. 146-155, https://doi.org/10.1016/j.erss.2018.09.007. [41]

Bosone, L., M. Chevrier and F. Zenasni (2022), "Consistent or inconsistent? The effects of inducing cognitive dissonance vs. cognitive consonance on the intention to engage in pro-environmental behaviors", *Frontiers in Psychology*, Vol. 13, https://doi.org/10.3389/fpsyg.2022.902703. [71]

Botetzagias, I., C. Malesios and D. Poulou (2014), "Electricity curtailment behaviors in Greek households: Different behaviors, different predictors", *Energy Policy*, Vol. 69, pp. 415-424, https://doi.org/10.1016/J.ENPOL.2014.03.005. [148]

Boza-Kiss, B. and P. Bertoldi (2018), *One-stop-shops for energy renovations of buildings*, European Commission. [134]

Brown, C. and A. Krishna (2004), "The Skeptical Shopper: A Metacognitive Account for the Effects of Default Options on Choice", *Journal of Consumer Research*, Vol. 31/3, pp. 529-539, https://doi.org/10.1086/425087. [157]

Buryk, S. et al. (2015), "Investigating preferences for dynamic electricity tariffs: The effect of environmental and system benefit disclosure", *Energy Policy*, Vol. 80, pp. 190-195, https://doi.org/10.1016/j.enpol.2015.01.030. [167]

Byun, H. and C. Lee (2017), "Analyzing Korean consumers' latent preferences for electricity generation sources with a hierarchical Bayesian logit model in a discrete choice experiment", *Energy Policy*, Vol. 105, pp. 294-302, https://doi.org/10.1016/J.ENPOL.2017.02.055. [109]

California Public Utilities Commission (2022), *2022 Distributed Energy Resources Avoided Cost Calculator Documentation*, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-side-management/acc-models-latest-version/2022-acc-documentation-v1a.pdf (accessed on 26 October 2023). [163]

Carroll, J., S. Lyons and E. Denny (2014), "Reducing household electricity demand through smart metering: The role of improved information about energy saving", *Energy Economics*, Vol. 45, pp. 234-243, https://doi.org/10.1016/j.eneco.2014.07.007. [75]

CER (2022), *Canada's Renewable Power: Ontario*, https://www.cer-rec.gc.ca/en/data-analysis/energy-commodities/electricity/report/canadas-renewable-power/provinces/renewable-power-canada-ontario.html (accessed on 26 April 2023). [164]

Chen, C., X. Xu and J. Day (2017), "Thermal comfort or money saving? Exploring intentions to conserve energy among low-income households in the United States", *Energy Research & Social Science*, Vol. 26, pp. 61-71, https://doi.org/10.1016/J.ERSS.2017.01.009. [149]

Contu, D., E. Strazzera and S. Mourato (2016), "Modeling individual preferences for energy sources: The case of IV generation nuclear energy in Italy", *Ecological Economics*, Vol. 127, pp. 37-58, https://doi.org/10.1016/j.ecolecon.2016.03.008. [168]

Danne, M., S. Meier-Sauthoff and O. Musshoff (2021), "Analyzing German consumers' willingness to pay for green electricity tariff attributes: a discrete choice experiment", *Energy, Sustainability and Society*, Vol. 11/1, pp. 1-16, https://doi.org/10.1186/S13705-021-00291-8/TABLES/4. [115]

Department for Energy Security and Net Zero (2023), *£1.8 billion awarded to boost energy efficiency and cut emissions of homes and public buildings across England - GOV.UK*, https://www.gov.uk/government/news/18-billion-awarded-to-boost-energy-efficiency-and-cut-emissions-of-homes-and-public-buildings-across-england (accessed on 8 November 2023). [29]

Department of the Environment and Energy (2013), *Factsheet: Overcoming Split Incentives*, Commonwealth of Australia, https://www.environment.gov.au/system/files/energy/files/hvac-factsheet-split-incentives.pdf (accessed on 31 October 2023). [132]

Diekmann, A. and P. Preisendörfer (2003), "Green and Greenback", *Rationality and Society*, Vol. 15/4, pp. 441-472, https://doi.org/10.1177/1043463103154002. [72]

Ding, Z. et al. (2017), "Research on differences in the factors influencing the energy-saving behavior of urban and rural residents in China–A case study of Jiangsu Province", *Energy Policy*, Vol. 100, pp. 252-259, https://doi.org/10.1016/j.enpol.2016.10.013. [31]

Dugstad, A. et al. (2020), "Acceptance of wind power development and exposure – Not-in-anybody's-backyard", *Energy Policy*, Vol. 147, p. 111780, https://doi.org/10.1016/j.enpol.2020.111780. [117]

Dunlap, R. et al. (2000), "New Trends in Measuring Environmental Attitudes: Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale", *Journal of Social Issues*, Vol. 56/3, pp. 425-442, https://doi.org/10.1111/0022-4537.00176. [68]

Ebeling, F. and S. Lotz (2015), "Domestic uptake of green energy promoted by opt-out tariffs", *Nature Climate Change*, Vol. 5/9, pp. 868-871, https://doi.org/10.1038/nclimate2681. [144]

EEA (2023), *Greenhouse gas emission intensity of electricity generation in Europe*, https://www.eea.europa.eu/en/analysis/indicators/greenhouse-gas-emission-intensity-of-1 (accessed on 29 April 2024). [106]

EEA (2023), *Share of energy consumption from renewable sources in Europe*, https://www.eea.europa.eu/en/analysis/indicators/share-of-energy-consumption-from?activeAccordion=ecdb3bcf-bbe9-4978-b5cf-0b136399d9f8 (accessed on 11 January 2024). [130]

EEA (2013), *Achieving energy efficiency through behaviour change: what does it take?*, https://www.eea.europa.eu/publications/achieving-energy-efficiency-through-behaviour (accessed on 7 December 2023). [74]

EIA (2024), *Average retail price of electricity*, https://www.eia.gov/electricity/data/browser/#/topic/7?agg=0,1&geo=g&endsec=8&linechart=ELEC.PRICE.US-RES.Q&columnchart=ELEC.PRICE.US-RES.Q&map=ELEC.PRICE.US-RES.Q&freq=Q&ctype=linechart&ltype=pin&rtype=s&pin=&rse=0&maptype=0 (accessed on 15 March 2024). [125]

Electricity Maps (2024), *$CO_2$ emissions of electricity consumption*, https://app.electricitymaps.com/map (accessed on 29 April 2024). [107]

Eliason, S. and J. Hagenaars (1990), “Categorical Longitudinal Data: Log-Linear Panel, Trend, and Cohort Analysis”, *Journal of Educational and Behavioral Statistics*, Vol. 20/1, p. 103, https://doi.org/10.2307/1165391. [67]

Environment and Climate Change Canada (2023), *National Inventory Report 1990 –2021: Greenhouse Gas Sources and Sinks in Canada*, https://publications.gc.ca/collections/collection_2023/eccc/En81-4-2021-3-eng.pdf (accessed on 7 May 2024). [159]

Eric Wilson et al. (2017), *Energy Efficiency Potential in the U.S. Single-Family Housing Stock*, National Renewable Energy Laboratory, https://www.nrel.gov/docs/fy18osti/68670.pdf (accessed on 30 April 2024). [180]

Eurostat (2023), *Electricity prices for household consumers*, https://ec.europa.eu/eurostat/databrowser/view/nrg_pc_204/default/table?lang=en&category=nrg.nrg_price.nrg_pc (accessed on 15 March 2024). [124]

Fraser, A. (2023), “Success, Failure, and Information: How Households Respond to Energy Conservation Goals”, *Journal of the Association of Environmental and Resource Economists*, Vol. 10/1, pp. 95-120, https://doi.org/10.1086/721094. [82]

Frederiks, E., K. Stenner and E. Hobman (2015), “Household energy use: Applying behavioural economics to understand consumer decision-making and behaviour”, *Renewable & Sustainable Energy Reviews*, Vol. 41, pp. 1385-1394, https://doi.org/10.1016/j.rser.2014.09.026. [23]

Frederiks, E., K. Stenner and E. Hobman (2015), “The Socio-Demographic and Psychological Predictors of Residential Energy Consumption: A Comprehensive Review”, *Energies*, Vol. 8/1, pp. 573-609, https://doi.org/10.3390/en8010573. [32]

French Government (2023), *Économisons l’énergie*, https://www.gouvernement.fr/reduire-notre-consommation-denergie (accessed on 2 April 2024). [81]

French Ministry of Environment (2023), *Commercialisation de l’électricité*, https://www.ecologie.gouv.fr/commercialisation-lelectricite (accessed on 19 April 2024). [177]

French Public Service (2023), *The most energy-intensive housing can no longer be offered for rent*, https://www.service-public.fr/particuliers/actualites/A14608?lang=en (accessed on 9 November 2023). [131]

Gifford, R. (2011), "The Dragons of Inaction: Psychological Barriers That Limit Climate Change Mitigation and Adaptation", *American Psychologist*, Vol. 66/4, pp. 290-302, https://doi.org/10.1037/A0023566. [49]

Gillingham, K., R. Newell and K. Palmer (2009), "Energy Efficiency Economics and Policy", *Annual Review of Resource Economics and Policy*, Vol. 1/1, pp. 597-620, https://doi.org/10.1146/ANNUREV.RESOURCE.102308.124234. [19]

Gillingham, K., R. Newell and K. Palmer (2006), "Energy Efficiency Policies: A Retrospective Examination", *Annual Review of Environment and Resources*, Vol. 31, pp. 161-192, https://doi.org/10.1146/ANNUREV.ENERGY.31.020105.100157. [20]

Gillingham, K. and K. Palmery (2014), "Bridging the Energy Efficiency Gap: Policy Insights from Economic Theory and Empirical Evidence", *https://doi.org/10.1093/reep/ret021*, Vol. 8/1, pp. 18-38, https://doi.org/10.1093/REEP/RET021. [88]

Goodman, L. (1974), "The Analysis of Systems of Qualitative Variables When Some of the Variables Are Unobservable. Part I-A Modified Latent Structure Approach", *American Journal of Sociology*, Vol. 79/5, pp. 1179-1259, https://www.jstor.org/stable/2776792 (accessed on 28 September 2023). [66]

Government of the Netherlands (2016), *Central government promotes energy savings*, https://www.government.nl/topics/renewable-energy/central-government-promotes-energy-savings (accessed on 9 November 2023). [97]

Gram-Hanssen, K. (2011), "Understanding change and continuity in residential energy consumption", *Journal of Consumer Culture*, Vol. 11/1, pp. 61-78, https://doi.org/10.1177/1469540510391725. [16]

Gram-Hanssen, K. (2011), "Understanding change and continuity in residential energy consumption", *Journal of Consumer Culture*, Vol. 11/1, pp. 61-78, https://doi.org/10.1177/1469540510391725. [44]

Green Municipal Fund (2023), *Community Efficiency Financing*, https://greenmunicipalfund.ca/community-efficiency-financing (accessed on 9 November 2023). [95]

Guerra Santin, O., L. Itard and H. Visscher (2009), "The effect of occupancy and building characteristics on energy use for space and water heating in Dutch residential stock", *Energy and Buildings*, Vol. 41/11, pp. 1223-1232, https://doi.org/10.1016/J.ENBUILD.2009.07.002. [15]

Guo, Z. et al. (2018), "Residential electricity consumption behavior: Influencing factors, related theories and intervention strategies", *Renewable and Sustainable Energy Reviews*, Vol. 81, pp. 399-412, https://doi.org/10.1016/j.rser.2017.07.046. [33]

Guo, Z. et al. (2018), "Residential electricity consumption behavior: Influencing factors, related theories and intervention strategies", *Renewable and Sustainable Energy Reviews*, Vol. 81, pp. 399-412, https://doi.org/10.1016/J.RSER.2017.07.046. [135]

Han, X. and C. Wei (2021), "Household energy consumption: state of the art, research gaps, and future prospects", *Environment, Development and Sustainability*, Vol. 23/8, pp. 12479-12504, https://doi.org/10.1007/s10668-020-01179-x. [4]

Health and Human Services Department (2021), *Federal Register: Annual Update of the HHS Poverty Guidelines*, https://aspe.hhs.gov/2021-poverty-guidelines (accessed on 3 November 2023). [166]

Hello Watt (2024), *Liste complète fournisseurs électricité verte : prix et avis 2024*, https://www.hellowatt.fr/electricite-verte/fournisseurs (accessed on 19 April 2024). [178]

Hojnik, J. et al. (2021), "What you give is what you get: Willingness to pay for green energy", *Renewable Energy*, Vol. 174, pp. 733-746, https://doi.org/10.1016/J.RENENE.2021.04.037. [129]

Huebner, G. et al. (2016), "Understanding electricity consumption: A comparative contribution of building factors, socio-demographics, appliances, behaviours and attitudes", *Applied Energy*, Vol. 177, pp. 692-702, https://doi.org/10.1016/j.apenergy.2016.04.075. [152]

Huh, S. et al. (2015), "What do customers want from improved residential electricity services? Evidence from a choice experiment", *Energy Policy*, Vol. 85, pp. 410-420, https://doi.org/10.1016/j.enpol.2015.04.029. [101]

Ida, T., K. Ito and M. Tanaka (2013), *Using dynamic electricity pricing to address energy crises: Evidence from randomized field experiments*, https://scholar.google.com/scholar?cluster=4556245280623506183&hl=en&oi=scholarr (accessed on 11 April 2024). [175]

IEA (2023), *CO2 Emissions in 2022*, https://www.iea.org/reports/co2-emissions-in-2022 (accessed on 27 October 2023). [2]

IEA (2023), *End-Use Prices*, https://www.iea.org/data-and-statistics/data-tools/end-use-prices-data-explorer?tab=Overview (accessed on 15 March 2024). [128]

IEA (2023), *Greenhouse Gas Emissions from Energy Data Explorer*, https://www.iea.org/data-and-statistics/data-tools/greenhouse-gas-emissions-from-energy-data-explorer (accessed on 15 February 2024). [1]

IEA (2022), *Brussels zero interest green loan for residential sector*, https://www.iea.org/policies/6435-brussels-zero-interest-green-loan-for-residential-sector (accessed on 8 November 2023). [30]

IEA (2022), *Empowering people to act: How awareness and behaviour campaigns can enable citizens to save energy during and beyond today's energy crisis*, https://www.iea.org/commentaries/empowering-people-to-act-how-awareness-and-behaviour-campaigns-can-enable-citizens-to-save-energy-during-and-beyond-today-s-energy-crisis. [137]

IEA (2022), *Property tax exemption*, https://www.iea.org/policies/8729-property-tax-exemption (accessed on 8 November 2023). [28]

IEA (2021), *Key World Energy Statistics 2021*, https://www.iea.org/reports/key-world-energy-statistics-2021/final-consumption (accessed on 8 September 2022). [165]

IEA (2021), *Key World Energy Statistics 2021*, https://www.iea.org/reports/key-world-energy-statistics-2021/final-consumption (accessed on 8 September 2022). [105]

IEA (2021), *Key World Energy Statistics 2021*, https://www.iea.org/reports/key-world-energy-statistics-2021/final-consumption (accessed on 8 September 2022). [179]

IEA (2021), *Net Zero by 2050 A Roadmap for the Global Energy Sector*, https://www.iea.org/reports/net-zero-by-2050 (accessed on 13 October 2023). [14]

IEA (2019), *Support for retrofits and energy efficiency in certain areas*, https://www.iea.org/policies/8742-support-for-retrofits-and-energy-efficiency-in-certain-areas (accessed on 9 November 2023). [94]

IEA/4E TCP (2021), *Achievements of Energy Efficiency Appliance and Equipment Standards and Labelling Programmes*, https://www.iea.org/reports/achievements-of-energy-efficiency-appliance-and-equipment-standards-and-labelling-programmes (accessed on 17 October 2023). [21]

IPCC (2022), "Buildings", https://doi.org/10.1017/9781009157926.011. [3]

IPCC (2022), *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, https://doi.org/10.1017/9781009157926. [13]

IRS (2023), *Home Energy Tax Credits*, https://www.irs.gov/credits-deductions/home-energy-tax-credits (accessed on 2 November 2023). [26]

Ito, K., T. Ida and M. Tanaka (2018), "Moral Suasion and Economic Incentives: Field Experimental Evidence from Energy Demand", *American Economic Journal: Economic Policy*, Vol. 10/1, pp. 240-67, https://doi.org/10.1257/POL.20160093. [139]

Jacobsen, G. and J. Stewart (2022), "How do consumers respond to price complexity? Experimental evidence from the power sector", *Journal of Environmental Economics and Management*, Vol. 116, p. 102716, https://doi.org/10.1016/j.jeem.2022.102716. [83]

Japan Times (2007), *Cool Biz helped reduce CO 2 by 1.4 million tons*, https://www.japantimes.co.jp/news/2007/11/22/national/cool-biz-helped-reduce-co-2-by-1-4-million-tons/ (accessed on 17 October 2023). [78]

Jones, R. and K. Lomas (2015), "Determinants of high electrical energy demand in UK homes: Socio-economic and dwelling characteristics", *Energy and Buildings*, Vol. 101, pp. 24-34, https://doi.org/10.1016/j.enbuild.2015.04.052. [153]

JRC SES (2023), *Smart Metering deployment in the European Union*, https://ses.jrc.ec.europa.eu/smart-metering-deployment-european-union (accessed on 7 December 2023). [79]

Kaenzig, J., S. Heinzle and R. Wüstenhagen (2013), "Whatever the customer wants, the customer gets? Exploring the gap between consumer preferences and default electricity products in Germany", *Energy Policy*, Vol. 53, pp. 311-322, https://doi.org/10.1016/j.enpol.2012.10.061. [104]

Kaenzig, J., S. Heinzle and R. Wüstenhagen (2013), "Whatever the customer wants, the customer gets? Exploring the gap between consumer preferences and default electricity products in Germany", *Energy Policy*, Vol. 53, pp. 311-322, https://doi.org/10.1016/j.enpol.2012.10.061. [121]

Kaiser, M. et al. (2020), "The Power of Green Defaults: The Impact of Regional Variation of Opt-out Tariffs on Green Energy Demand in Germany", *Ecological Economics*, Vol. 174, p. 106685, https://doi.org/10.1016/j.ecolecon.2020.106685. [143]

Kalkbrenner, B., K. Yonezawa and J. Roosen (2017), “Consumer preferences for electricity tariffs: Does proximity matter?”, *Energy Policy*, Vol. 107, pp. 413-424, https://doi.org/10.1016/j.enpol.2017.04.009. [100]

Kim, J., S. Lee and H. Jang (2022), “Lessons from residential electricity demand analysis on the time of use pricing experiment in South Korea”, *Energy Economics*, Vol. 113, p. 106224, https://doi.org/10.1016/j.eneco.2022.106224. [84]

Kim, J., S. Park and J. Lee (2018), “Do people really want renewable energy? Who wants renewable energy?: Discrete choice model of reference-dependent preference in South Korea”, *Energy Policy*, Vol. 120, pp. 761-770, https://doi.org/10.1016/j.enpol.2018.04.062. [35]

Kollmuss, A. and J. Agyeman (2002), “Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior?”, *Environmental Education Research*, Vol. 8/3, pp. 239-260, https://doi.org/10.1080/13504620220145401. [55]

Komarek, T. et al. (2011), “Valuing energy policy attributes for environmental management: Choice experiment evidence from a research institution”, *Energy Policy*, Vol. 39/9, pp. 5105-5115, https://doi.org/10.1016/j.enpol.2011.05.054. [113]

Kowalska-Pyzalska, A. (2019), “Do Consumers Want to Pay for Green Electricity? A Case Study from Poland”, *Sustainability*, Vol. 11/5, p. 1310, https://doi.org/10.3390/su11051310. [119]

Kuhe, A. and D. Bisu (2019), “Influence of situational factors on household’s energy consumption behaviour”, *International Journal of Energy Sector Management*, Vol. 14/2, pp. 389-407, https://doi.org/10.1108/IJESM-03-2019-0017. [48]

Lacroix, K., R. Gifford and A. Chen (2019), “Developing and validating the Dragons of Inaction Psychological Barriers (DIPB) scale”, *Journal of Environmental Psychology*, Vol. 63, pp. 9-18, https://doi.org/10.1016/J.JENVP.2019.03.001. [53]

Lazarsfeld, P. (1950), “The Logical and Mathematical Foundations of Latent Structure Analysis”, *Measurement and Prediction*, pp. 362-412. [65]

Le Médiateur National de l’Energie (2023), *Qu’est-ce qu’une offre d’électricité “verte” ? - énergie-info*, https://www.energie-info.fr/fiche_pratique/quest-ce-quune-offre-delectricite-verte/ (accessed on 11 April 2024). [62]

Lehmann, N. et al. (2023), “The motivational drivers behind consumer preferences for regional electricity – Results of a choice experiment in Southern Germany”, *Energy Economics*, Vol. 120, p. 106585, https://doi.org/10.1016/j.eneco.2023.106585. [169]

Liebe, U., J. Gewinner and A. Diekmann (2021), “Large and persistent effects of green energy defaults in the household and business sectors”, *Nature Human Behaviour 2021 5:5*, Vol. 5/5, pp. 576-585, https://doi.org/10.1038/s41562-021-01070-3. [25]

Li, H., Z. Wang and B. Zhang (2023), “How social interaction induce energy-saving behaviors in buildings: Interpersonal & passive interactions v.s. public & active interactions”, *Energy Economics*, Vol. 118, p. 106515, https://doi.org/10.1016/j.eneco.2023.106515. [85]

Linzer, D. and J. Lewis (2011), “poLCA: An R Package for Polytomous Variable Latent Class Analysis”, *Journal of Statistical Software*, Vol. 42/10, pp. 1-29, https://doi.org/10.18637/JSS.V042.I10. [146]

List, J. et al. (2017), “Harnessing Policy Complementarities to Conserve Energy: Evidence from a Natural Field Experiment”, https://doi.org/10.3386/W23355. [138]

Longhi, S. (2015), “Residential energy expenditures and the relevance of changes in household circumstances”, *Energy Economics*, Vol. 49, pp. 440-450, https://doi.org/10.1016/j.eneco.2015.03.018. [154]

Lorenzoni, I., S. Nicholson-Cole and L. Whitmarsh (2007), “Barriers perceived to engaging with climate change among the UK public and their policy implications”, *Global Environmental Change*, Vol. 17/3-4, pp. 445-459, https://doi.org/10.1016/J.GLOENVCHA.2007.01.004. [54]

Lu, Y. et al. (2020), “A Critical Review of Sustainable Energy Policies for the Promotion of Renewable Energy Sources”, *Sustainability 2020, Vol. 12, Page 5078*, Vol. 12/12, p. 5078, https://doi.org/10.3390/SU12125078. [57]

Lynn, P. and S. Longhi (2011), *Environmental attitudes and behaviour: who cares about climate change?. Early Findings from the First Wave of the UK’s Household Longitudinal Study*. [37]

MacGregor (2016), *Go ask ‘Gladys’: Why gender matters in energy consumption research*, https://archive.discoversociety.org/2016/01/05/go-ask-gladys-why-gender-matters-in-energy-consumption-research/ (accessed on 9 November 2023). [40]

Ma, C. et al. (2015), “Consumers’ willingness to pay for renewable energy: A meta-regression analysis”, *Resource and Energy Economics*, Vol. 42, pp. 93-109, https://doi.org/10.1016/J.RESENEECO.2015.07.003. [123]

Madden, T., P. Ellen and I. Ajzen (1992), “A Comparison of the Theory of Planned Behavior and the Theory of Reasoned Action”, *Personality and Social Psychology Bulletin*, Vol. 18/1, pp. 3-9, https://doi.org/10.1177/0146167292181001. [46]

Magidson, J. and J. Vermunt (2004), “Latent class models”, in Kaplan, D. (ed.), *The Sage handbook of quantitative methodology for the social sciences*, Sage. [145]

Mamica, Ł. (2021), “Willingness to pay for the renewable energy sources of the residents of Kraków and their perception of the actions aimed at reducing the level of environmental pollution”, *Polityka Energetyczna – Energy Policy Journal*, Vol. 24/2, pp. 117-136, https://doi.org/10.33223/epj/135830. [118]

Matsumoto, S. (2016), “How do household characteristics affect appliance usage? Application of conditional demand analysis to Japanese household data”, *Energy Policy*, Vol. 94, pp. 214-223, https://doi.org/10.1016/j.enpol.2016.03.048. [86]

McFadden, D. (1973), “Conditional Logit Analysis of Qualitative Choice Behavior”, in Zarembka, P. (ed.), *Frontiers in Econometrics*, Academic Press. [108]

McFadden, D. (1973), “Conditional Logit Analysis of Qualitative Choice Behavior”, in Zarembka, P. (ed.), *Frontiers in Econometrics*, Academic Press. [151]

Mengelkamp, E. et al. (2019), “The value of local electricity - A choice experiment among German residential customers”, *Energy Policy*, Vol. 130, pp. 294-303, https://doi.org/10.1016/j.enpol.2019.04.008. [170]

Ministères Écologie Énergie Territoires (2022), *Economiser l’énergie : agir, réduire*, https://www.ecologie.gouv.fr/chaque-geste-compte (accessed on 7 December 2023). [80]

Ministre de l’économie et des finances and Ministre de l’écologie (2013), *Arrêté du 26 juillet 2013 relatif aux tarifs réglementés de vente de l’électricité - Légifrance*, https://www.legifrance.gouv.fr/loda/id/JORFTEXT000027778284 (accessed on 11 April 2024). [63]

Ministry of Economic Affairs and Climate Policy (2023), *Apply for a subsidy for sustainable energy and energy saving for owner-occupied homes (ISDE)*, https://www.government.nl/topics/sustainable-energy-at-home/apply-for-a-subsidy-for-sustainable-energy-and-energy-saving-for-owner-occupied-homes-isde (accessed on 9 November 2023). [93]

Morita, T. and S. Managi (2015), “Consumers’ willingness to pay for electricity after the Great East Japan Earthquake”, *Economic Analysis and Policy*, Vol. 48, pp. 82-105, https://doi.org/10.1016/j.eap.2015.09.004. [102]

Morita, T. and S. Managi (2015), “Consumers’ willingness to pay for electricity after the Great East Japan Earthquake”, *Economic Analysis and Policy*, Vol. 48, pp. 82-105, https://doi.org/10.1016/j.eap.2015.09.004. [111]

Mundaca, L., D. Ürge-Vorsatz and C. Wilson (2019), *Demand-side approaches for limiting global warming to 1.5 °C*, Springer Netherlands, https://doi.org/10.1007/s12053-018-9722-9. [12]

Murakami, K. et al. (2015), “Consumers’ willingness to pay for renewable and nuclear energy: A comparative analysis between the US and Japan”, *Energy Economics*, Vol. 50, pp. 178-189, https://doi.org/10.1016/j.eneco.2015.05.002. [156]

Murakami, K. et al. (2015), “Consumers’ willingness to pay for renewable and nuclear energy: A comparative analysis between the US and Japan”, *Energy Economics*, Vol. 50, pp. 178-189, https://doi.org/10.1016/j.eneco.2015.05.002. [112]

Nakai, M., T. Okubo and Y. Kikuchi (2018), “A socio-technical analysis of consumer preferences about energy systems applying a simulation-based approach: A case study of the Tokyo area”, *Energy Research & Social Science*, Vol. 46, pp. 52-63, https://doi.org/10.1016/j.erss.2018.06.004. [99]

Natural Resources Canada (2023), *Canada Greener Homes Grant*, https://natural-resources.canada.ca/energy-efficiency/homes/canada-greener-homes-initiative/canada-greener-homes-grant/canada-greener-homes-grant/23441 (accessed on 2 November 2023). [27]

Newell, R. and J. Siikamäki (2015), “Individual Time Preferences and Energy Efficiency”, *American Economic Review*, Vol. 105/5, pp. 196-200, https://doi.org/10.1257/aer.p20151010. [172]

Newell, R. and J. Siikamäki (2014), “Nudging Energy Efficiency Behavior: The Role of Information Labels”, *Journal of the Association of Environmental and Resource Economists*, Vol. 1/4, pp. 555-598, https://doi.org/10.1086/679281. [171]

Newell, R. and J. Siikamäki (2013), “Nudging Energy Efficiency Behavior: The Role of Information Labels”, *SSRN Electronic Journal*, https://doi.org/10.2139/ssrn.2292023. [39]

Ntanos, S. et al. (2018), “Public Perceptions and Willingness to Pay for Renewable Energy: A Case Study from Greece”, *Sustainability*, Vol. 10/3, p. 687, https://doi.org/10.3390/su10030687. [120]

OECD (2023), *How Green is Household Behaviour?: Sustainable Choices in a Time of Interlocking Crises*, OECD Studies on Environmental Policy and Household Behaviour, OECD Publishing, Paris, https://doi.org/10.1787/2bbbb663-en. [11]

OECD (2023), *Why governments should target support amidst high energy prices*, https://www.oecd.org/ukraine-hub/policy-responses/why-governments-should-target-support-amidst-high-energy-prices-40f44f78/ (accessed on 7 December 2023). [7]

OECD (2018), *Cost-Benefit Analysis and the Environment: Further Developments and Policy Use*, OECD Publishing, Paris, https://doi.org/10.1787/9789264085169-en. [58]

OECD (2017), *Tackling Environmental Problems with the Help of Behavioural Insights*, OECD Publishing, Paris, https://doi.org/10.1787/9789264273887-en. [24]

OECD (2013), *Greening Household Behaviour: Overview from the 2011 Survey*, OECD Publishing, Paris, https://doi.org/10.1787/9789264181373-en. [60]

OECD (2011), *Greening Household Behaviour: The Role of Public Policy*, OECD Studies on Environmental Policy and Household Behaviour, OECD Publishing, Paris, https://doi.org/10.1787/9789264096875-en. [61]

Ontario Energy Board (2024), *Historical electricity rates*, https://www.oeb.ca/consumer-information-and-protection/electricity-rates/historical-electricity-rates#tiered (accessed on 23 January 2024). [77]

Osunmuyiwa, O. et al. (2020), “I cannot live without air conditioning! The role of identity, values and situational factors on cooling consumption patterns in India”, *Energy Research & Social Science*, Vol. 69, p. 101634, https://doi.org/10.1016/j.erss.2020.101634. [47]

Perino, G. and C. Schwirplies (2022), “Meaty arguments and fishy effects: Field experimental evidence on the impact of reasons to reduce meat consumption”, *Journal of Environmental Economics and Management*, Vol. 114, p. 102667, https://doi.org/10.1016/j.jeem.2022.102667. [70]

Pichert, D. and K. Katsikopoulos (2008), “Green defaults: Information presentation and pro-environmental behaviour”, *Journal of Environmental Psychology*, Vol. 28/1, pp. 63-73, https://doi.org/10.1016/J.JENVP.2007.09.004. [158]

Poortinga, W. et al. (2003), “Household preferences for energy-saving measures: A conjoint analysis”, *Journal of Economic Psychology*, Vol. 24/1, pp. 49-64, https://doi.org/10.1016/S0167-4870(02)00154-X. [92]

Poortinga, W. et al. (2019), “Climate change perceptions and their individual-level determinants: A cross-European analysis”, *Global Environmental Change*, Vol. 55, pp. 25-35, https://doi.org/10.1016/J.GLOENVCHA.2019.01.007. [147]

Rivers, N. (2018), “Leveraging the Smart Grid: The Effect of Real-Time Information on Consumer Decisions”, *OECD Environment Working Papers*, No. 127, OECD Publishing, Paris, https://doi.org/10.1787/6ad4d5e3-en. [73]

Ruokamo, E. et al. (2019), “Towards flexible energy demand – Preferences for dynamic contracts, services and emissions reductions”, *Energy Economics*, Vol. 84, p. 104522, https://doi.org/10.1016/j.eneco.2019.104522. [114]

Scarpa, R. and K. Willis (2010), "Willingness-to-pay for renewable energy: Primary and discretionary choice of British households' for micro-generation technologies", *Energy Economics*, Vol. 32/1, pp. 129-136, https://doi.org/10.1016/j.eneco.2009.06.004. [173]

Schot, J., L. Kanger and G. Verbong (2016), "The roles of users in shaping transitions to new energy systems", *Nature Energy 2016 1:5*, Vol. 1/5, pp. 1-7, https://doi.org/10.1038/nenergy.2016.54. [8]

Shrestha, B. et al. (2021), "Review on the Importance of Gender Perspective in Household Energy-Saving Behavior and Energy Transition for Sustainability", *Energies 2021, Vol. 14, Page 7571*, Vol. 14/22, p. 7571, https://doi.org/10.3390/EN14227571. [176]

Sorrell, S., B. Gatersleben and A. Druckman (2020), "The limits of energy sufficiency: A review of the evidence for rebound effects and negative spillovers from behavioural change", *Energy Research & Social Science*, Vol. 64, p. 101439, https://doi.org/10.1016/J.ERSS.2020.101439. [150]

Steg, L. (2008), "Promoting household energy conservation", *Energy Policy*, Vol. 36/12, pp. 4449-4453, https://doi.org/10.1016/j.enpol.2008.09.027. [45]

Stern, P., T. Dietz and G. Guagnano (1995), "The New Ecological Paradigm in Social-Psychological Context", *http://dx.doi.org/10.1177/0013916595276001*, Vol. 27/6, pp. 723-743, https://doi.org/10.1177/0013916595276001. [69]

Sundt, S. and K. Rehdanz (2015), "Consumers' willingness to pay for green electricity: A meta-analysis of the literature", *Energy Economics*, Vol. 51, pp. 1-8, https://doi.org/10.1016/j.eneco.2015.06.005. [122]

Swedish Energy Agency (2022), *The house guide - for those who want to make your house more energy efficient*, https://www.energimyndigheten.se/energieffektivisering/husguiden---for-dig-som-vill-energieffektivisera-ditt/ (accessed on 9 November 2023). [142]

Swim, J. et al. (2009), "Psychology & Global Climate Change: Addressing a multifaceted phenomenon and set of challenges memberS", http://www.apa.org/science/about/publications/climate-change.aspx (accessed on 7 December 2023). [52]

Swiss Federal Council (2023), *Énergie: le Conseil fédéral établit la planification budgétaire pour l'Initiative économies d'énergie Hiver*, https://www.admin.ch/gov/fr/accueil/documentation/communiques.msg-id-93447.html (accessed on 9 November 2023). [140]

Swiss Federal Office of Energy (2024), *Energy prices*, https://opendata.swiss/en/dataset/energiedashboard-ch-energiepreise/resource/102b18e2-1014-4274-b823-8a6dbdb17336 (accessed on 15 March 2024). [127]

Swiss Federal Office of Energy (2023), *Energie-Dashboard Bundesamt für Energie*, https://energiedashboard.admin.ch/strom/minder-mehrverbrauch (accessed on 9 November 2023). [141]

Trotta, G. (2018), "Factors affecting energy-saving behaviours and energy efficiency investments in British households", *Energy Policy*, Vol. 114, pp. 529-539, https://doi.org/10.1016/J.ENPOL.2017.12.042. [89]

UK Department for Energy Security and Net Zero (2023), *Electricity marginal emissions factors to 2100, kgCO2e/kWh*, https://assets.publishing.service.gov.uk/media/6567994fcc1ec5000d8eef17/data-tables-1-19.xlsx (accessed on 7 May 2024). [160]

UK DESNZ (2023), *Quarterly Energy Prices: March 2023*, https://www.gov.uk/government/statistics/quarterly-energy-prices-march-2023 (accessed on 15 March 2024). [126]

Umit, R. et al. (2019), "The role of income in energy efficiency and curtailment behaviours: Findings from 22 European countries", *Energy Research & Social Science*, Vol. 53, pp. 206-214, https://doi.org/10.1016/J.ERSS.2019.02.025. [91]

UN ESCAP (2011), *Incentive programmes aimed at rewarding the greening of houses can encourage a higher uptake of efficient measures for residential retrofitting projects: What was done?*, http://www.mof.go.jp/english/budget/budget/fy2011/11sb03.pdf (accessed on 7 December 2023). [98]

US EIA (2019), *Demand-side management programs save energy and reduce peak demand*, https://www.eia.gov/todayinenergy/detail.php?id=38872 (accessed on 17 October 2023). [162]

US Environmental Protection Agency (2024), *Subregion Output Emission Rates*, https://www.epa.gov/system/files/documents/2024-01/egrid2022_summary_tables.pdf (accessed on 7 May 2024). [161]

Users TCP and IEA (2020), *Behavioural insights for demand-side energy policy and programmes: An environment scan*, https://doi.org/10.47568/6OR105. [174]

Van Rijnsoever, F., A. Van Mossel and K. Broecks (2015), "Public acceptance of energy technologies: The effects of labeling, time, and heterogeneity in a discrete choice experiment", *Renewable and Sustainable Energy Reviews*, Vol. 45, pp. 817-829, https://doi.org/10.1016/J.RSER.2015.02.040. [38]

van Valkengoed, A., W. Abrahamse and L. Steg (2022), "To select effective interventions for pro-environmental behaviour change, we need to consider determinants of behaviour", *Nature Human Behaviour 2022 6:11*, Vol. 6/11, pp. 1482-1492, https://doi.org/10.1038/s41562-022-01473-w. [10]

Vecchiato, D. and T. Tempesta (2015), "Public preferences for electricity contracts including renewable energy: A marketing analysis with choice experiments", *Energy*, Vol. 88, pp. 168-179, https://doi.org/10.1016/j.energy.2015.04.036. [103]

Vecchiato, D. and T. Tempesta (2015), "Public preferences for electricity contracts including renewable energy: A marketing analysis with choice experiments", *Energy*, Vol. 88, pp. 168-179, https://doi.org/10.1016/j.energy.2015.04.036. [116]

Wang, S., S. Lin and J. Li (2018), "Exploring the effects of non-cognitive and emotional factors on household electricity saving behavior", *Energy Policy*, Vol. 115, pp. 171-180, https://doi.org/10.1016/j.enpol.2018.01.012. [43]

Warren, P. (2018), "Demand-side policy: Global evidence base and implementation patterns", *Energy & Environment*, Vol. 29/5, pp. 706-731, https://www.jstor.org/stable/90023919 (accessed on 18 May 2022). [17]

Whitmarsh, L., W. Poortinga and S. Capstick (2021), "Behaviour change to address climate change", *Current opinion in psychology*, Vol. 42, pp. 76-81, https://doi.org/10.1016/J.COPSYC.2021.04.002. [56]

Wilkinson, S. et al. (2020), "Is peer-to-peer electricity trading empowering users? Evidence on motivations and roles in a prosumer business model trial in Australia", *Energy Research & Social Science*, Vol. 66, p. 101500, https://doi.org/10.1016/J.ERSS.2020.101500. [9]

Wolske, K., K. Gillingham and P. Schultz (2020), "Peer influence on household energy behaviours", *Nature Energy*, Vol. 5/3, pp. 202-212, https://doi.org/10.1038/s41560-019-0541-9. [5]

Yang, S., Y. Zhang and D. Zhao (2016), "Who exhibits more energy-saving behavior in direct and indirect ways in china? The role of psychological factors and socio-demographics", *Energy Policy*, Vol. 93, pp. 196-205, https://doi.org/10.1016/j.enpol.2016.02.018. [34]

Zhang, S. et al. (2022), "Extreme temperatures and residential electricity consumption: Evidence from Chinese households", *Energy Economics*, Vol. 107, p. 105890, https://doi.org/10.1016/j.eneco.2022.105890. [87]

Zhou, K. and S. Yang (2016), "Understanding household energy consumption behavior: The contribution of energy big data analytics", *Renewable and Sustainable Energy Reviews*, Vol. 56, pp. 810-819, https://doi.org/10.1016/j.rser.2015.12.001. [6]

# Annex A. Supplementary material

## Table A.1. Descriptive statistics of socio-demographic characteristics

| Variable | Level | Belgium | Canada | France | Israel | The Netherlands | Sweden | Switzerland | United Kingdom | United States |
|---|---|---|---|---|---|---|---|---|---|---|
| Age category | 18-24 y.o. | 0.1 | 0.11 | 0.14 | 0.19 | 0.14 | 0.13 | 0.12 | 0.15 | 0.16 |
| | 25-34 y.o. | 0.16 | 0.17 | 0.14 | 0.18 | 0.14 | 0.17 | 0.18 | 0.16 | 0.17 |
| | 35-44 y.o. | 0.16 | 0.15 | 0.17 | 0.19 | 0.16 | 0.16 | 0.15 | 0.15 | 0.16 |
| | 45-54 y.o. | 0.16 | 0.18 | 0.14 | 0.16 | 0.16 | 0.15 | 0.17 | 0.16 | 0.15 |
| | 55 + y.o. | 0.42 | 0.38 | 0.41 | 0.29 | 0.4 | 0.39 | 0.37 | 0.38 | 0.37 |
| Education level | High school diploma at most | 0.56 | 0.6 | 0.46 | 0.55 | 0.47 | 0.52 | 0.6 | 0.48 | 0.52 |
| | Higher education | 0.44 | 0.4 | 0.54 | 0.45 | 0.53 | 0.48 | 0.4 | 0.52 | 0.48 |
| Employment status | Employed | 0.47 | 0.54 | 0.51 | 0.71 | 0.49 | 0.57 | 0.6 | 0.56 | 0.56 |
| | Unemployed | 0.53 | 0.46 | 0.49 | 0.29 | 0.51 | 0.43 | 0.4 | 0.44 | 0.44 |
| Home type | Apartment | 0.35 | 0.32 | 0.46 | 0.67 | 0.36 | 0.7 | 0.71 | 0.27 | 0.24 |
| | House | 0.64 | 0.66 | 0.52 | 0.32 | 0.55 | 0.28 | 0.26 | 0.69 | 0.7 |
| | Other | 0.01 | 0.03 | 0.01 | 0.01 | 0.09 | 0.01 | 0.03 | 0.04 | 0.06 |
| Income quintile | 1st income quintile | 0.22 | 0.19 | 0.2 | 0.19 | 0.21 | 0.21 | 0.18 | 0.2 | 0.19 |
| | 2nd income quintile | 0.18 | 0.2 | 0.19 | 0.2 | 0.2 | 0.2 | 0.22 | 0.2 | 0.21 |
| | 3rd quintile | 0.19 | 0.21 | 0.18 | 0.21 | 0.2 | 0.21 | 0.19 | 0.19 | 0.2 |
| | 4th quintile | 0.22 | 0.2 | 0.22 | 0.2 | 0.2 | 0.19 | 0.2 | 0.2 | 0.2 |
| | 5th quintile | 0.2 | 0.21 | 0.2 | 0.19 | 0.2 | 0.2 | 0.21 | 0.21 | 0.21 |
| Location | Rural | 0.53 | 0.18 | 0.51 | 0.24 | 0.44 | 0.48 | 0.62 | 0.37 | 0.24 |
| | Urban | 0.47 | 0.82 | 0.49 | 0.76 | 0.56 | 0.52 | 0.38 | 0.63 | 0.76 |
| Ownership status | Renter | 0.33 | 0.34 | 0.48 | 0.29 | 0.49 | 0.56 | 0.69 | 0.34 | 0.28 |
| | Owner | 0.67 | 0.66 | 0.52 | 0.71 | 0.51 | 0.44 | 0.31 | 0.66 | 0.72 |
| Sex | Female | 0.51 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.51 | 0.52 |
| | Male | 0.49 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.49 | 0.48 |
| Environmental concerns | No | 0.34 | 0.31 | 0.3 | 0.37 | 0.39 | 0.44 | 0.32 | 0.34 | 0.37 |
| | Yes | 0.66 | 0.69 | 0.7 | 0.63 | 0.61 | 0.56 | 0.68 | 0.66 | 0.63 |

Note: Table reports descriptive statistics of the sample that answered the energy-related items in the EPIC survey, i.e. 8486 respondents.

## Supplementary material for Section 3

### *The latent class model*

Magidson and Vermunt (2004[145]) provides a basic formalisation of latent class analysis models. In latent class models, the probability of obtaining response pattern $\boldsymbol{y}$, $P(\boldsymbol{Y} = \boldsymbol{y})$, is a weighted average of the $C$ class-specific probabilities $P(\boldsymbol{Y} = \boldsymbol{y}|X = x)$; that is,

$$P(\boldsymbol{Y} = \boldsymbol{y}) = \sum_{x=1}^{C} P(X = x)\, P(\boldsymbol{Y} = \boldsymbol{y}|X = x)$$

Where $P(X = x)$ denotes the proportion of people belonging to class $x$.

The above is combined with the assumption of local independence, by which the $L$ observed variables are assumed to be mutually independent within each class; that is,

$$P(Y = y|X = x) = \prod_{l=1}^{L} P(Y_l = y_l|X = x)$$

A comparison of conditional response probabilities $P(Y_l = y_l|X = x)$ between classes indicates how cases differ from each other and are the basis for their characterisation. Combining the above equations yields the following model for $P(Y = y)$:

$$P(\boldsymbol{Y} = \boldsymbol{y}) = \sum_{x=1}^{C} P(X = x) \prod_{l=1}^{L} P(Y_l = y_l|X = x)$$

The probability of belonging to class $x$ can be obtained by Bayes' rule:

$$P(\boldsymbol{Y} = \boldsymbol{y}|X = x) = \frac{P(X = x)P(\boldsymbol{Y} = \boldsymbol{y}|X = x)}{P(\boldsymbol{Y} = \boldsymbol{y})}$$

### *Model selection*

The selection of the number of classes to retain in latent class analysis is informed by both statistical and theoretical considerations. Tables A.1 and A.2 present two statistical measures of goodness of fit for latent class models assuming different numbers of classes. Table A.1 presents one, two and three class models for the characterization of household types by their energy conservation behaviour and Table A.2 presents 5, 6 and 7 class models for the characterization of household classes by their investment in low-emissions energy equipment. While the AIC and BIC are smaller for models with more classes, the 2-class model (for energy conservation) and the 6-class model (for investment in low-emissions energy technologies) produced classes that were more easily interpretable than models with a greater number of classes.

### Table A.1. Goodness-of-fit statistics for alternative latent class models for engagement in energy conservation

| Number of latent classes | AIC | BIC | Log-likelihood | Number of parameters | d.f. |
|---|---|---|---|---|---|
| 1 | 44955.87 | 44991.10 | -22472.94 | 5 | 26 |
| 2 | 42732.63 | 42810.14 | -21355.32 | 11 | 20 |
| 3 | 42636.37 | 42756.15 | -21301.18 | 17 | 14 |

Note: Total number of observations equals 8537; lower (higher) values of AIC and BIC (log-likelihood) indicate better goodness-of-fit. The degrees of freedom are calculated as the number of possible response patterns (i.e., number of cells in the contingency table formed by crossing all observed items) minus the number of freely estimated parameters minus one.

## Table A.2. Goodness-of-fit statistics for alternative latent class models for investment in low-emissions energy technologies

| Number of latent classes | AIC | BIC | Log-likelihood | Number of parameters | d.f. |
|---|---|---|---|---|---|
| 5 | 110457.3727 | 111226.0586 | -55119.68634 | 109 | 8428 |
| 6 | 109275.569 | 110199.4026 | -54506.7845 | 131 | |
| 7 | 108689.7651 | 109768.7463 | -54191.88254 | 153 | 8384 |

Note: Total number of observations equals 8537; lower (higher) values of AIC and BIC (log-likelihood) indicate better goodness-of-fit. The degrees of freedom are calculated as the number of possible response patterns (i.e., number of cells in the contingency table formed by crossing all observed items) minus the number of freely estimated parameters minus one.

Following Linzer and Lewis (2011[146]), each LCA was run with 500 simulations to confirm that the outcomes above reflect global maxima of the log-likelihood function of the latent class models rather than local maxima. In each case, the simulations converged on the distributions presented above.

## Table A.3. Statistics per indicator and class of conservation related LCA

Proportion of respondent per class who report that they often or always adopt conservation behaviours

| | Energy non-conservers | Energy conservers |
|---|---|---|
| Minimise heating and cooling | 0.29 | 0.86 |
| Minimise hot water use | 0.26 | 0.83 |
| Run full loads | 0.70 | 0.93 |
| Turn-off lights when leaving a room | 0.83 | 0.98 |
| Air dry laundry | 0.41 | 0.75 |

Note: The table should be read as follows: “Among non-conservers, 29% report minimising heating and cooling, while among conservers, 86% report minimising heating and cooling”.

## Table A.4. Probability of indicator responses per indicator and class for LCA on investment in low-emissions energy technologies

Proportion of respondents indicating investment responses for a particular technology by class

| Technology | Investment response | Classes | | | | | |
|---|---|---|---|---|---|---|---|
| | | ‘Super investor’ | ‘Invest when possible’ | ‘Low-cost investor’ | ‘Don’t invest’ | ‘Cannot invest’ | ‘Don’t know’ |
| Highly energy-efficient appliances | Yes | 0.83 | 0.72 | 0.78 | 0.46 | 0.32 | 0.37 |
| | No | 0.13 | 0.15 | 0.16 | 0.49 | 0.13 | 0.08 |
| | No, not possible | 0.02 | 0.08 | 0 | 0.01 | 0.5 | 0.05 |
| | Don't know | 0.02 | 0.05 | 0.06 | 0.04 | 0.05 | 0.5 |
| Energy-efficient windows | Yes | 0.75 | 0.75 | 0.87 | 0.19 | 0.15 | 0.29 |
| | No | 0.19 | 0.1 | 0.11 | 0.76 | 0.02 | 0.12 |
| | No, not possible | 0.04 | 0.13 | 0 | 0.04 | 0.8 | 0.08 |
| | Don't know | 0.02 | 0.02 | 0.02 | 0.01 | 0.03 | 0.51 |
| Thermal insulation | Yes | 0.74 | 0.49 | 0.72 | 0.09 | 0.01 | 0.14 |
| | No | 0.18 | 0.09 | 0.23 | 0.83 | 0.01 | 0.12 |
| | No, not possible | 0.05 | 0.34 | 0.01 | 0.06 | 0.95 | 0.08 |
| | Don't know | 0.03 | 0.07 | 0.05 | 0.02 | 0.03 | 0.65 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Solar for electricity | Yes | 0.74 | 0.65 | 0.8 | 0.29 | 0.16 | 0.26 |
| | No | 0.18 | 0.12 | 0.18 | 0.66 | 0.06 | 0.13 |
| | No, not possible | 0.04 | 0.22 | 0.01 | 0.03 | 0.75 | 0.05 |
| | Don't know | 0.04 | 0.01 | 0.01 | 0.02 | 0.03 | 0.56 |
| Battery storage | Yes | 0.83 | 0.12 | 0.17 | 0.24 | 0.05 | 0.21 |
| | No | 0.12 | 0.03 | 0.75 | 0.67 | 0.01 | 0.14 |
| | No, not possible | 0.03 | 0.83 | 0.08 | 0.08 | 0.93 | 0.15 |
| | Don't know | 0.03 | 0.01 | 0 | 0.01 | 0.01 | 0.49 |
| Heat pumps | Yes | 0.62 | 0.06 | 0.03 | 0.06 | 0.03 | 0.08 |
| | No | 0.27 | 0.23 | 0.92 | 0.89 | 0.1 | 0.18 |
| | No, not possible | 0.04 | 0.68 | 0.01 | 0.03 | 0.86 | 0.11 |
| | Don't know | 0.06 | 0.03 | 0.04 | 0.02 | 0.02 | 0.63 |
| Proportion of sample in each class | | 0.59 | 0.1 | 0.15 | 0.06 | 0.01 | 0.08 |

Note: The table should be read as follows: "Among 'Super investors, 83% report having installed energy efficient appliances. This figure is 72%, 78%, 46%, 32% and 37% for those in the 'Invest when possible,' 'Low-cost investor,' 'Don't invest,' 'Cannot invest,' and 'Don't know' classes, respectively.

### *Characteristics of household classes*

#### *Energy conservation*

## Table A.5. Descriptive statistics of energy conservation classes

Percent of energy conservation classes with specific household characteristics

| Variable | Outcome | Conservers | Non-conservers |
|---|---|---|---|
| **Age** | 18-24 | 11.7 | 16.8 |
| | 25-34 | 12.6 | 16.8 |
| | 35-44 | 16 | 15.2 |
| | 45-54 | 15.7 | 16 |
| | 55+ | 44 | 35.2 |
| **Household has children** | No | 72.5 | 70 |
| | Yes | 27.5 | 30 |
| **Environmental concern** | Low | 29.6 | 44.8 |
| | High | 70.4 | 55.2 |
| **Education** | High school diploma or less | 40.7 | 40.7 |
| | Higher education | 59.3 | 59.3 |
| **Household size** | 1 | 28.6 | 26.5 |
| | 2 | 35.1 | 33.3 |
| | 3 | 14.6 | 15.2 |
| | 4 | 13.5 | 13.7 |
| | 5+ | 8.3 | 11.4 |
| **Home type** | Apartment | 38.7 | 45.1 |
| | House | 58.3 | 51.4 |
| | Other | 3 | 3.5 |
| **Income quintile** | 1 | 11.4 | 12.6 |
| | 2 | 18.8 | 19.6 |
| | 3 | 21.3 | 21.2 |
| | 4 | 24.1 | 22.4 |
| | 5 | 24.4 | 24.2 |
| **Location** | Rural | 42 | 35.4 |

| | | | |
|---|---|---|---|
| | Urban | 58 | 64.6 |
| **Sex** | Female | 54.6 | 49.7 |
| | Male | 45.4 | 50.3 |

Note: This table displays the composition *within class*. The sum of outcome probabilities per variable *within class* equals 1. For example, results can be read as such: "In the *conserver* class, 42.5% of respondents live in rural area, while 57.5% of respondents live in urban area".

### *Determinants of class membership*

#### *Energy conservation*

The model takes the form of a logit regression, where the dependent variable, i.e. membership in the household class of conservers, is regressed on the determinants described above. The dependent variable takes the value 1 if a household belongs to the *conserver* class and 0 if it belongs to the *non-conserver* class.

The analysis also controls for investment behaviour, as household installation of low-emissions energy technologies could theoretically have an impact on efforts to conserve energy. On the one hand, a positive association between investment in low-emissions energy technologies and energy conservation behaviour could be expected insofar as conscientiousness surrounding energy use is likely to apply to both conservation and investment behaviours. However, a negative association between these two types of energy related behaviours could also be expected if households that invest in energy-efficient technologies feel licensed to make less efforts to reduce their energy use on a daily basis. The extent to which investment in low-emissions energy technologies impacts the cost and efficiency of household energy use can also conceivably have implications for engagement in energy conservation behaviour. If more efficient energy use (e.g. as a result of highly efficient energy appliances) implies lower costs, households consequently have a lower financial incentive to reduce energy use via behavioural changes. Finally, the model accounts for country fixed effects in order to capture factors that vary at the country level, such as climate, energy policies and energy prices.

The analysis identifies both socioeconomic and attitudinal variables as significant determinants of a household's membership in the *conserver* class. Generally speaking, attitudinal variables have a greater impact on class membership than socioeconomic variables. Those 55 or older are more likely to be *conservers* relative to those 18-24 years old. Similarly, respondents indicating that they have completed higher education are also more likely to fall into the *conserver* class. Living in a house, rather than an apartment, slightly increases the probability of being a *conserver*, while belonging to the highest income quintile slightly decreases the probability of being a *conserver*, compared to belonging to a lower income quintile. Men are less likely to be in the *conserver* class than women. Other socioeconomic characteristics, such as the presence of children in the household, being unemployed, living in an urban area and living in a larger residence do not appear to impact energy conservation behaviour, all else equal. The finding that income, age, gender and higher education are significant determinants of energy conservation is consistent with previous research (Poortinga et al., 2019[147]; Botetzagias, Malesios and Poulou, 2014[148]; MacGregor, 2016[40]).

Being concerned about the environment and being environmentally motivated have a positive and significant impact on the probability of being a *conserver*. Those reporting these attitudes are more likely to be *conservers*. Those that express feeling vulnerable to the impacts of climate change or other environmental issues are also more likely to engage in energy conservation behaviours. Several psychological barriers also have a significant impact on the probability of being a *conserver.* Respondents that believe that behaviour change is unnecessary and have conflicting goals are less likely to be *conservers*. The importance of psychological variables in shaping energy behaviours is also reflected in the literature (Chen, Xu and Day, 2017[149]; Botetzagias, Malesios and Poulou, 2014[148]).

Both subjective as well as objective energy poverty are associated with a greater likelihood of conservation behaviour. Both subjective and objective energy poverty impact household behaviour. This could reflect the fact that budgetary constraints are also faced by households above the poverty line. A closer examination of the category of households belonging to the *conserver* class alludes to the role of energy poverty in choices surrounding energy use. The fact that objective and perceived energy poverty are associated with greater conservation behaviour follows economic theory and indicates that energy conservation is a strategy for households to deal with the financial constraints imposed by energy costs. In the context of ensuring a just energy transition, it will therefore be important to identify those households that may be unable to satisfy their energy needs and provide adequate support to these households in the context of fluctuating energy prices.

The findings indicate that households who were offered renewable energy and smart meters by their electricity companies are more likely to fall into the *conserver* class. This observation aligns with research on perceived behavioural control, or the degree to which one feels agency over one's choices (Chen and Day 2017). To the extent that having a sense of control over one's energy consumption has been recognised as a strong predictor of energy conservation behaviours, these results point to the role that energy companies, housing collectives and landlords can play in offering households a greater degree of control over their energy consumption practices, for example through the provision of smart meters and flexible pricing schemes. This finding could also reflect the fact that households that are more aware of these options are also more likely to engage in conservation. Using electricity for cooking and for hot water heating slightly increases the likelihood of being a *conserver*, while using electricity for heating and cooling slightly decreases the probability of being a *conserver*. The positive impact reflects the fact that households that choose to use electricity for these purposes are also more likely to conserve energy, which could be driven in part by the context in which the survey was taken, namely high electricity prices. The negative impact of using electricity for heating and cooling could reflect a rebound effect to the extent that electric heating and cooling sources may be more efficient than alternatives (Sorrell, Gatersleben and Druckman, 2020[150]).

Finally, investment behaviour appears to play a role in conservation behaviour. Compared to those in the "*Don't invest*" class, those in the "*Super investor*", "*Invest when possible*" and "*Low-cost investor*" classes are more likely to engage in energy conservation by 8.3, 5 and 6.4%, respectively. Those belonging to the "*Cannot Invest*" and "*Don't know*" classes are not any more or less likely to adopt energy conservation behaviour compared to those in the "*Don't invest*" class. Insofar as this result suggests a positive association between investment in low-emissions energy technologies and engagement in energy conservation, it provides a rough indication that no negative rebound effect exists overall with respect to technology installation and the tendency to conserve energy.[52]

[52] Any factor that influences both investment and conservation that is not included as a covariate in the analysis could drive this result. Given that the analysis controls for environmental attitudes, knowledge about conservation strategies, as well as various socioeconomic factors, this possibility is reduced.

## Table A.6. Determinants of household membership in the *conserver* class

Average marginal effects on the probability of membership in the conserver (vs. non-conserver class)

| Variables | Level | Coefficient |
|---|---|---|
| ***Socio-demographic characteristics*** | | |
| Age (Base = 18-24.) | 25-34 | -0.001 |
| | 35-44 | 0.057*** |
| | 45-54 | 0.052*** |
| | 55+ | 0.088*** |
| Children in household (Base = No) | Yes | -0.006 |
| Education (Base = Low education) | Higher education | 0.022** |
| Employment (Base = Employed) | Unemployed | -0.005 |
| Household size (Base = 1, i.e. living alone) | 2 | -0.02 |
| | 3 | -0.015 |
| | 4 | -0.004 |
| | 5+ | -0.052** |
| Home size (Base = 1, i.e. less than 25 m² / 270 ft²) | 25m² (270ft²) – 50m² (540ft²) | 0.009 |
| | 51m² (541ft²) – 75m² (807ft²) | 0.033 |
| | 76m² (808ft²) – 100m² (1070ft²) | 0.05 |
| | 101m² (1071ft²) – 150m² (1610ft²) | 0.045 |
| | 151m² (1611ft²) – 200m² (2150ft²) | 0.016 |
| | > 200m² (2150ft²) | 0.008 |
| | Don't know | -0.002 |
| Home type (Base = Apartment) | House | 0.037*** |
| | Other | 0.018 |
| Income (imputed) (Base = first 4 income quintiles) | 5th quintile | -0.036*** |
| Location (Base = Rural) | Urban | -0.009 |
| Sex (Base = Female) | Male | -0.052*** |
| ***Attitudes*** | | |
| Environmental concern (Base = No) | Yes | 0.097*** |
| Environmental motivation (Base = No) | Yes | 0.186*** |
| Perceived vulnerability | | 0.043*** |
| Technological optimism (Base = No) | Yes | 0.013 |
| *Psychological barriers* | | |
| Change unnecessary (Base = No) | Yes | -0.081*** |
| Conflicting goals (Base = No) | Yes | -0.102*** |
| Interpersonal difficulties (Base = No) | Yes | -0.04** |
| Knowledge (Base = No) | Yes | 0.018 |
| ***Energy-related variables*** | | |
| Objectively energy poor (Base = No) | Yes | 0.085*** |
| Subjectively energy poor (Base = No) | Yes | 0.126*** |
| Use of electricity for cooking (Base = No) | Yes | 0.023* |
| Use of electricity for heating & cooling (Base = No) | Yes | -0.036*** |
| Use of electricity to heat water (Base = No) | Yes | 0.031*** |

| | | |
|---|---|---|
| Has been proposed time-of-use tariffs by energy provider (Base = No) | Yes | 0.003 |
| Has been proposed renewables by energy provider (Base = No) | Yes | 0.034*** |
| Has been proposed smart meter by energy provider (Base = No) | Yes | 0.052*** |
| ***Investment behaviour (Base = "Don't invest" class)*** | | |
| Super investor class | Yes | 0.083*** |
| Invest when possible class | Yes | 0.05*** |
| Low-cost investor class | Yes | 0.064*** |
| Cannot invest class | Yes | -0.005 |
| Don't knowers class | Yes | -0.02 |
| ***Country fixed effects*** | | |
| Country (Base = Belgium) | CA | -0.181*** |
| | CH | -0.064*** |
| | FR | -0.004 |
| | IL | -0.076*** |
| | NTH | -0.098*** |
| | SWE | -0.218*** |
| | UK | 0.072*** |
| | US | -0.178*** |

Note: Average marginal effects of a binary logit regression. * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level. Post-stratification survey weights are used in the estimation.

Overall these findings suggest that investing in low-emissions energy technologies when possible is associated with higher income and greater environmental awareness and environmental motivation regarding environmental issues.[53] While the former finding indicates the potential benefits of efforts to raise environmental awareness, another policy priority is to enable greater uptake among lower income households. This includes, for example, targeted subsidies for the installation of low-emissions energy technologies and thermal retrofits.

### *Investment in low-emissions energy technologies*

This analysis assesses the impact of socioeconomic, attitudinal and energy-related factors on the probability of belonging to an investment class. A logit model is used to assess the extent to which various factors can be considered to influence the dependent variable, class membership. The model only includes respondents who belong to either the "*Invest when possible*" class or to the "*Don't invest*" class because the primary objective of policies should be to incentivise these respondents who are able to invest to do so. These two classes are highlighted given that they comprise a large portion of the sample (39%) and are of considerable policy relevance. In the long term, policymakers should aim to reduce the proportion of the population in the Not possible class by making the structural and regulatory changes needed to facilitate the installation of low-emissions energy equipment to a wider share of households. In the near term, however, a primary policy challenge is inducing those who don't invest, i.e. the *Don't invest* class, to shift to the *Invest when possible* class. In addition to reducing the size of the *Not possible* class, another policy challenge includes shifting those in the *Low-cost investors* class to *Super investors* class. The dependent variable is a dummy equal to 1 if the respondent belongs to the "*Invest when possible*" class,

[53] Given large differences in the characteristics of households with respect to residence type and ownership status across the two classes compared in the regression, the results regarding these variables presented in Section 3 should be considered more reliable and a discussion of the implications of these factors will be focused there.

and 0 if they belong to the "*Don't Invest*" class. Table A.7 displays the impact of these factors on the probability of falling into either class. Because the data across countries is pooled and country-level fixed effects are controlled for, the results can be considered to reflect general dynamics of household behaviour across countries.

## Table A.7. Determinants of household type: investment in low-emissions energy technologies

Average marginal effects of independent variables on the probability of being in the "invest when possible" class vs. the "do not invest" class

| Variables | Outcome | Parameter estimate |
|---|---|---|
| *Socio-demographic characteristics* | | |
| Sex (Base = Female) | Male | -0.009 |
| Age (Base = 18-24) | 25-34 | 0.083*** |
| | 35-44 | 0.061** |
| | 45-54 | 0.135*** |
| | 55+ | 0.214*** |
| Education (Base = Low education) | Higher education | 0.034** |
| Employment (Base = Employed) | Retired | 0.058** |
| | Unemployed | -0.007 |
| Household situation (Base = Living alone) | Living married or as a couple, with or without children | 0.02 |
| | Living with parents or other relatives | -0.036 |
| | Living as single parent | 0.013 |
| | Sharing house/flat with non-family members | -0.032 |
| | Other | -0.061 |
| Home size (Base = 1, i.e. 25 sqm / 270 sqf or less) | 25m² (270ft²) – 50m² (540ft²) | 0.049 |
| | 51m² (541ft²) – 75m² (807ft²) | 0.023 |
| | 76m² (808ft²) – 100m² (1070ft²) | 0.061 |
| | 101m² (1071ft²) – 150m² (1610ft²) | 0.056 |
| | 151m² (1611ft²) – 200m² (2150ft²) | 0.088 |
| | > 200m² (2150ft²) | 0.02 |
| | Don't know | -0.056 |
| Home type (Base = Apartment) | House | -0.239*** |
| | Other | -0.113*** |
| Income (imputed) (Base = first income quintile) | 2nd quintile | 0.037 |
| | 3rd quintile | 0.039 |
| | 4th quintile | 0.083*** |
| | 5th quintile | 0.097*** |
| Location (Base = Rural) | Urban | -0.029* |
| Number of adults[1] | | -0.009 |
| Number of children (Base = No children) | 1 | -0.005 |
| | 2 | -0.025 |
| | 3 | -0.007 |
| | 4 | -0.191** |
| | 5+ | -0.018 |
| Outdoor space in residence (Base = No) | Yes | 0.014 |
| Ownership status (Base = Renter) | Owner | -0.152*** |
| *Attitudes* | | |
| Environmental concern (Base = Low) | High | 0.083*** |
| Environmental motivation[1] | | 0.127** |
| Perceived vulnerability[1] | | 0.101*** |

| | | | |
|---|---|---|---|
| Technological optimism (Base = No) | Yes | -0.019 | |
| *Energy-related variables* | | | |
| Objectively energy poor (Base = No) | Yes | -0.055 | |
| Subjectively energy poor (Base = No) | Yes | -0.039 | |
| Electricity for heating & cooling (Base = No) | Yes | -0.035* | |
| Electricity to heat water (Base = No) | Yes | 0.004 | |
| Has been offered time-of-use tariffs (Base = No) | Yes | 0.051*** | |
| Has been offered renewable energy (Base = No) | Yes | 0.01 | |
| Has been offered smart meter (Base = No) | Yes | 0.016 | |
| ***Country fixed effects*** | | | |
| Country (Base = Belgium) | Canada | -0.096** | |
| | France | -0.1*** | |
| | Israel | -0.33*** | |
| | Netherlands | 0.05 | |
| | Sweden | -0.12*** | |
| | Switzerland | 0 | |
| | United Kingdom | 0.1** | |
| | United States | -0.179*** | |

Note: This table displays average marginal effects. Stars indicate their level of significance, in particular: * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level. [1] indicates a continuous variable with no base category.

In contrast to the analysis on conservation classes, socioeconomic and structural variables are appear to be important than attitudinal variables in determining investment. Results suggest that age impacts the probability of being in the *invest when possible* class. Those who are 55 or older are 21 % more likely to be in the *invest when possible class* than those who are 18-24. Having obtained a higher education slightly increases the probability of belonging to the *invest when possible* class compared to having no higher education. Living in a house and being a homeowner are associated with a lower likelihood of belonging to the *invest when possible* class compared to living in an apartment and being a renter. This result could mask heterogeneity of this impact across rural and urban areas. While in rural areas living in a house may be associated with a lower likelihood of investment, in urban areas it may be associated with a higher likelihood of investment. This result could also be due in part to the fact that the *invest when possible* class is comprised of 34% of those living in a house and 49% homeowners, whereas these proportions for the *don't invest* class are 61% and 70%, respectively.  Given the large differences in the distribution of residence types for the *invest when possible* versus *do not invest* classes, the effect of house type and ownership status on class membership should not be interpreted as the impact of home type on investment more generally.[54]

Being retired increases the probability of being in the *invest when possible* class by 5.8 % relative to being employed. Belonging to the fourth- and fifth-income quintiles increases the probability of being in the *invest when possible* class compared to belonging to any of the three lower income quintiles. Living in an urban area slightly decreases the probability of belonging to the *invest when possible* class relative to living in rural area. Other socioeconomic characteristics such as household situation, household size, having

[54] Note that the dependent variable reflects having invested when investment is possible, which excludes all those (e.g. renters, those who live in apartment buildings) for whom investment is not possible. The impact of home type and ownership status on investment can be more reliably interpreted in the regression results for specific types of low-emissions energy technologies in Section 3.

access to outdoor space and living in a larger residence do not appear to have an impact on investment behaviour, all else equal.

With respect to attitudinal variables, both being concerned about the environment as well as being environmentally motivated increase the likelihood of being in the *invest when possible* class. Feeling vulnerable to the possible impacts of climate change also increases the probability of belonging to the *invest when possible* class. Being optimistic about technologies to solve environmental problems does not appear to impact this likelihood. These results confirm previous findings (Trotta, 2018; Umit et al., 2019) underscoring the significance of initiatives such as awareness campaigns and the cultivation of environmental consciousness among households.

Households that have been proposed time-of-use tariffs by their energy provider are slightly more likely to belong to the *invest when possible* class relative to those that have not. Assuming that not all households are aware that they may have this option, this impact could reflect differences in the characteristics of households that are aware (e.g. because they have sought out this information) versus those that are not. Using electricity for heating and cooling is associated with a slightly lower likelihood of investing in low-emissions energy equipment when possible relative to those that don't invest. Both objective and subjective measures of energy poverty, using electricity for hot water heating and having been proposed renewable energy and smart meters by a household's energy provider do not appear to have a significant impact on the likelihood of being in one versus the other of these investment classes.

As a complement to the LCA regression results presented in Table A.7, Table A.8 presents the results of an OLS regression using an investment index as a dependent variable.[55] This index ranges between 0 and 1, where 0 corresponds to a household that did not report investing in any type of equipment, and 1 corresponds to a household that reported investing in every type of equipment. This model therefore includes all respondents who completed the energy section of the survey, rather than the 39% of the sample that fell into categories *invest when possible* or *don't invest*, above.

Regressors include socioeconomic characteristics, attitudinal variables, energy-related variables as well an index which indicates the degree of feasibility of investment per household. This index ranges from 0 to 1, 0 corresponding to households that are able to invest in all types of equipment (i.e. that have not indicated otherwise), while 1 corresponds to households reporting that it is not possible to invest in any type of equipment.[56]

## Table A.8. Investment in low-emissions energy technologies: Index of investment

| Variables | Outcome | Coefficient |
|---|---|---|
| Intercept | // | 0.132*** |
| ***Socio-demographic characteristics*** | | |
| Age | 25-34 | -0.033*** |
| | 35-44 | -0.059*** |
| | 45-54 | -0.058*** |
| | 55+ | -0.025*** |
| Country fixed effect (Base = BEL) | CA | -0.081*** |
| | CH | -0.003 |
| | FR | -0.06*** |
| | IL | 0 |

[55] Rather than the probability of investment in specific equipment, this dependent variable provides a measure of the total number of technologies that households have invested in.

[56] Unfeasibility refers to cases when it is not possible to invest because the landlord would need to do it, or because house type or location do not allow it. It does not account for unfeasibility because of budget constraint.

| | | |
|---|---|---|
| | NTH | 0.014 |
| | SWE | -0.037*** |
| | UK | -0.012 |
| | US | -0.07*** |
| Education (Base = Low education) | Higher education | 0.022*** |
| Employment (Base = Employed) | Retired | 0.018** |
| | Unemployed | -0.011* |
| Household situation (Base = living alone) | Living married or as a couple, with or without children | 0.02*** |
| | Living with parents or other relatives | -0.03** |
| | Living as single parent | -0.008 |
| | Sharing house/flat with non-family members | -0.003 |
| | Other | 0.019 |
| Home size (Base = 25 m² / 270 ft² or less) | 25-50 m² (270-540 ft²) | 0.032* |
| | 51-75 m² (541-807sqft²) | 0.029* |
| | 76-100 m² (808-1070sqft²) | 0.034** |
| | 101-150 m² (1071-1610 ft²) | 0.056*** |
| | 151-200 m² (1611-2150 ft²) | 0.079*** |
| | More than 200 m² (2151 ft²) | 0.08*** |
| | Don't know | -0.01 |
| Home type (Base = Apartment) | House | -0.013** |
| | Other | -0.04*** |
| Income (Base = first income quintile) | 2nd quintile | 0.01 |
| | 3rd quintile | 0.008 |
| | 4th quintile | 0.022*** |
| | 5th quintile | 0.03*** |
| Location (Base = Rural) | Urban | -0.002 |
| Number of adults | // | 0.003 |
| Number of children (Base = No children) | 1 | 0.029*** |
| | 2 | 0.056*** |
| | 3 | 0.04*** |
| | 4 | 0.054** |
| | 5+ | 0.12*** |
| Outdoor space in residence (Base = No) | Yes | 0.043*** |
| Ownership status (Base = Renter) | Owner | 0.06*** |
| Sex (Base = Female) | Male | 0.028*** |
| ***Attitudes*** | | |
| Climate change concerns (Base = No) | Yes | 0.028*** |
| Environmental motivation | // | 0.103*** |
| Perceived vulnerability | // | -0.016** |
| Technological optimism (Base = No) | Yes | 0.023*** |
| ***Energy-related variables*** | | |
| Objectively energy poor (Base = No) | Yes | 0.016 |
| Subjectively energy poor (Base = No) | Yes | 0.033*** |
| Electricity for heating & cooling (Base = No) | Yes | 0.005 |
| Electricity to heat water (Base = No) | Yes | 0.009* |
| Has been proposed time-of-use tariffs by energy provider (Base = No) | Yes | 0.049*** |
| Has been proposed renewable energy by energy provider (Base = No) | Yes | 0.086*** |
| Has been proposed smart meter by energy provider (Base = No) | Yes | 0.05*** |
| No possible investment Index | // | -0.035*** |

Note: This table displays marginal effects of the logit regression. Some factor outcomes have been tailored to avoid noise and provide a better specification of the model. Stars indicate their level of significance, in particular: * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level. Post-stratification weights are used in the estimation.

Most regression results using an investment index as a dependent variable appear to be consistent with the results from the LCA regression using class membership in the *invest when possible* class as the dependent variable. Noticeable differences between the two models are the effects of residence size, home ownership and technological optimism, which are all positive and significant in determining the extent of investment in low-emissions energy technologies, but which were not significant in determining the likelihood of being in the *invest when possible* class versus the *don't invest* class. Although age had a positive effect on this probability, it appears to have a negative effect on the number of low-emissions energy technologies installed.

## Supplementary material for Section 4

### *Econometric model*

$P(y = 1|x) = G(\beta x) = p(x)$ is defined as the probability of a respondent having installed a low-emissions energy technology given a set of control variables. This probability is a function of control variables, $x$. A cumulative distribution function $G(\cdot)$ maps the index function $\beta x$ to the response probability $P$. $G(\cdot)$ can be derived from a latent variable model:

$$y^* = x'\beta + \varepsilon \tag{3.1}$$

where $y^*$ is a latent variable. The latent variable model is defined as follows:

$$\begin{aligned} y &= 1 \text{ if } y^* > 0 \\ y &= 0 \text{ if } y^* \leq 0 \end{aligned} \tag{3.2}$$

Assuming a distribution for the error term in (3.1), then:

$$P(y = 1|x) = P(y^* > 0|x) = P(\varepsilon > -x'\beta|x) \tag{3.3}$$

If the distribution is symmetric around zero, then $G(\cdot)$ can be recovered as follows:

$$P(y = 1|x) = P(\varepsilon < x'\beta|x) = G(x'\beta) \tag{3.4}$$

As a result, the model estimates the effects of the determinants $x$ on the probability of installation by assuming the distribution of the error term of the latent variable model, $\varepsilon$. Equation (3.5) provides the logistic distribution of the error term:

$$G(z) = \frac{e^z}{1+e^z} \tag{3.5}$$

The average partial effect of the continuous variable $x_i$ on the binary response variable $y$ is given by:

$$\hat{\beta}^K \times \left[N^{-1} \sum_{i=1}^{N} \frac{dG}{dx_i\hat{\beta}}(x_i\hat{\beta})\right] \tag{3.6}$$

In the case of energy saving behaviour, the dependent variable takes the values "1" ('never'), "2" ('occasionally'), "3" ('often') and "4" ('always'). Ordered logit models are therefore used to estimate the impact of determinants $x$ on the dependent variable $y$. A latent variable $y^*$ is defined with respect to a thresholds $\mu$ as follows:

$$\begin{aligned} y &= 1 \quad \text{if } y^* \leq 0 \\ y &= 2 \quad \text{if } 0 < y^* \leq \mu_1 \\ y &= 3 \quad \text{if } \mu_1 < y^* \leq \mu_2 \end{aligned}$$

$$y = 4 \quad \text{if } \mu_2 < y^* \tag{3.7}$$

As a result, the associated probabilities of observing each outcome are given by:

$$P(y = 1|x) = G(-x'\beta)$$
$$P(y = 2|x) = G(\mu_1 - x'\beta) - G(-x'\beta)$$
$$P(y = 3|x) = G(\mu_2 - x'\beta) - G(\mu_1 - x'\beta)$$

$$P(y = 4|x) = 1 - G(\mu_2 - x'\beta) \tag{3.8}$$

Assuming the shape of the cumulative distribution function $G(\cdot)$ allows for the prediction of each outcome $P$. The average marginal effect of each control variable $x$ on the outcome $y$ is obtained in the same manner as described in (3.6). Maximum Likelihood Estimation is used to estimate the $\beta$ parameters.

### *Descriptive statistics*

Table A.9 provides summary statistics regarding the dependent and independent variables used in the analysis in Section 3. Panel A shows the summary statistics of binary dependent variables, that will be used in the Logit models. The statistics reveal a high variation in installation levels, from 15% for battery storage to 87% for low-energy light bulb. Respondents who indicated that installation of said equipment was not feasible in their residence are excluded from this analysis.

Panel B shows dependent variables that represent the frequency of energy saving behaviour undertaken by respondents. We consider five types of behaviours: switching off lights in empty rooms, minimising space heating, washing full loads of laundry or dishwasher, minimising hot water usage and air-drying laundry. In the survey, respondents were asked about the frequency in which they undertook said behaviours, and could choose between “never”, “occasionally”, “often” and “always”. We create a corresponding numeric variable for each question, and each option is represented by “1”, “2”, “3” and “4”, respectively.

## Table A.9. Summary Statistics: Dependent and independent variables

| **Panel A. Dependent variables of binary logit models (installation of low-emissions energy technologies)** | | | | | |
|---|---|---|---|---|---|
| Name | Observations | Mean | Standard Deviation | Minimum | Maximum |
| Installed energy efficient appliance | 8,389 | 0.66 | 0.47 | 0 | 1 |
| Installed low-energy light bulb | 8,389 | 0.86 | 0.34 | 0 | 1 |
| Installed energy efficient windows | 8,389 | 0.57 | 0.50 | 0 | 1 |
| Installed thermal insulation | 8,389 | 0.43 | 0.50 | 0 | 1 |
| Installed solar PV | 8,389 | 0.16 | 0.37 | 0 | 1 |
| Installed solar water | 8,389 | 0.17 | 0.37 | 0 | 1 |
| Installed battery storage | 8,389 | 0.13 | 0.33 | 0 | 1 |
| Installed heat pump | 8,389 | 0.16 | 0.37 | 0 | 1 |
| **Panel B. Dependent variables of ordered logit models (Energy conservation behaviours)** | | | | | |
| Switches off light | 8,450 | 3.62 | 0.67 | 1 | 4 |
| Minimises heating | 8,450 | 2.86 | 0.95 | 1 | 4 |
| Washes full load of laundry | 8,450 | 3.38 | 0.87 | 1 | 4 |
| Minimises hot water usage | 8,450 | 2.79 | 0.99 | 1 | 4 |
| Air dries laundry | 8,450 | 2.84 | 1.12 | 1 | 4 |
| **Panel C. Independent variables** | | | | | |
| Age: 18-24 | 8,450 | 0.14 | 0.34 | 0 | 1 |
| Age: 25-34 | 8,450 | 0.14 | 0.35 | 0 | 1 |
| Age: 35-44 | 8,450 | 0.16 | 0.36 | 0 | 1 |
| Age: 45-54 | 8,450 | 0.16 | 0.37 | 0 | 1 |
| Age: 55 + | 8,450 | 0.41 | 0.49 | 0 | 1 |
| Higher education | 8,450 | 0.62 | 0.49 | 0 | 1 |
| Employed | 8,450 | 0.62 | 0.49 | 0 | 1 |
| Female | 8,450 | 0.53 | 0.5 | 0 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| High income | 8,450 | 0.24 | 0.43 | 0 | 1 |
| Number of children | 8,450 | 0.56 | 1.17 | 0 | 10 |
| Number of adults | 8,450 | 1.97 | 0.92 | 1 | 5 |
| House ownership | 8,450 | 0.63 | 0.48 | 0 | 1 |
| Residence size (25m² or less) | 8,450 | 0.02 | 0.12 | 0 | 1 |
| Residence size (26-50m²) | 8,450 | 0.08 | 0.27 | 0 | 1 |
| Residence size (51-75m²) | 8,450 | 0.16 | 0.36 | 0 | 1 |
| Residence size (76-100m²) | 8,450 | 0.2 | 0.4 | 0 | 1 |
| Residence size (101-150m²) | 8,450 | 0.24 | 0.43 | 0 | 1 |
| Residence size (150-200m²) | 8,450 | 0.11 | 0.31 | 0 | 1 |
| Residence size (More than 200m2) | 8,450 | 0.07 | 0.26 | 0 | 1 |
| Urban dweller | 8,450 | 0.60 | 0.49 | 0 | 1 |
| Residence type (house) | 8,450 | 0.56 | 0.50 | 0 | 1 |
| Residence type (other) | 8,450 | 0.03 | 0.18 | 0 | 1 |
| Access to outdoor space | 8,450 | 0.84 | 0.37 | 0 | 1 |
| Electricity for space heating | 8,450 | 0.62 | 0.49 | 0 | 1 |
| Electricity for water heating | 8,450 | 0.49 | 0.5 | 0 | 1 |
| Renewable electricity offered by provider | 8,450 | 0.29 | 0.45 | 0 | 1 |
| Smart meters offered by provider | 8,450 | 0.38 | 0.49 | 0 | 1 |
| Time-of-use tariffs offered by provider | 8,450 | 0.36 | 0.48 | 0 | 1 |
| Subjective energy poverty | 8,450 | 0.09 | 0.29 | 0 | 1 |
| Objective energy poverty | 8,450 | 0.04 | 0.19 | 0 | 1 |
| Environmental concern | 8,450 | 0.65 | 0.48 | 0 | 1 |
| Change unnecessary | 8,450 | 0.26 | 0.44 | 0 | 1 |
| Conflicting goals | 8,450 | 0.44 | 0.5 | 0 | 1 |
| Interpersonal issues | 8,450 | 0.11 | 0.31 | 0 | 1 |
| Knowledge | 8,450 | 0.27 | 0.44 | 0 | 1 |
| Environmental motivation | 8,450 | 0.49 | 0.13 | 0 | 1 |

Note: Sample size is reduced to missing observations from the following psychological barrier constructs: change unnecessary, conflicting goals; interpersonal, knowledge, as well as environmental motivation.

## *Full results*

### *Energy conservation*

## Table A.10. Determinants of energy conservation behaviours

Average marginal effects of independent variables on the probability of always engaging in energy conservation (s.e.)

| | Switching off lights | Washing full loads | Minimising space heating | Minimising hot water usage | Air drying laundry |
|---|---|---|---|---|---|
| Higher education | 0.019* | 0.018 | 0.045*** | 0.022** | 0.015 |
| (Base = no higher education) | (0.092) | (0.144) | (0) | (0.016) | (0.14) |
| Age (Base = 18-24) | | | | | |
| Age (25-34) | 0.056*** | 0.027 | -0.003 | -0.012 | 0.040** |
| | (0.008) | (0.207) | (0.865 | (0.351) | (0.023) |
| Age (35-44) | 0.038* | 0.055*** | 0.007 | 0.028* | 0.051*** |
| | (0.073) | (0.007) | (0.651) | (0.05) | (0.004) |
| Age (45-54) | 0.069*** | 0.080*** | 0.014 | 0.054*** | 0.059*** |
| | (0.001) | (0) | (0.362) | (0) | (0.001) |
| Age (55+) | 0.081*** | 0.092*** | 0.030** | 0.118*** | 0.025 |
| | (0) | (0) | (0.036) | (0) | (0.113) |
| Employed | 0.0123 | -0.009 | -0.004 | -0.011 | 0.033*** |

| | | | | | |
|---|---|---|---|---|---|
| (Base = not employed) | (0.307) | (0.474) | (0.709) | (0.242) | (0.002) |
| Female | 0.052*** | 0.066*** | 0.043*** | 0.013 | 0.049*** |
| (Base = male) | (0) | (0) | (0) | (0.127) | (0) |
| High income | -0.007 | -0.003 | -0.044*** | -0.023** | -0.018* |
| (Base = income quintiles 1-4) | (0.559) | (0.81) | (0) | (0.021) | (0.099) |
| Number of adults | -0.004 | 0.016** | -0.011** | -0.002 | -0.003 |
| | (0.498) | (0.013) | (0.039) | (0.617) | (0.587) |
| Number of children | -0.022*** | -0.014*** | -0.003 | 0.007* | -0.010** |
| | (0) | (0.004) | (0.491) | (0.056) | (0.016) |
| Urban dweller | 0.006 | -0.028** | -0.001 | 0.008 | -0.004 |
| (Base = rural dweller) | (0.617) | (0.019) | (0.905) | (0.34) | (0.679) |
| Residence size<br>(Base = 24m2 or less) | | | | | |
| Residence size (25-50m2) | -0.065 | 0.125** | -0.012 | 0.001 | -0.063 |
| | (0.107) | (0.018) | (0.74) | (0.98) | (0.163) |
| Residence size (51-75m2) | -0.046 | 0.154*** | 0.026 | -0.012 | -0.063 |
| | (0.232) | (0.002) | (0.443) | (0.719) | (0.147) |
| Residence size (76-100m2) | -0.062 | 0.175*** | 0.025 | 0.014 | -0.077* |
| | (0.1) | (0) | (0.458) | (0.679) | (0.073) |
| Residence size (101-150m2) | -0.024 | 0.194*** | 0.021 | 0.016 | -0.062 |
| | (0.531) | (0) | (0.537) | (0.639) | (0.149) |
| Residence size (151-200m2) | -0.034 | 0.206*** | 0.014 | 0.005 | -0.082* |
| | (0.342) | (0) | (0.693) | (0.899) | (0.064) |
| Residence size (more than 200m2) | -0.050 | 0.219*** | 0.008 | 0.002 | -0.104** |
| | (0.23) | (0) | (0.831) | (0.964) | (0.021) |
| Residence size (don't know) | -0.069* | 0.132** | -0.004 | -0.037 | -0.084* |
| | (0.084) | (0.012) | (0.901) | (0.284) | (0.059) |
| Renewable electricity offered by provider | -0.027** | -0.021 | 0.026*** | 0.033*** | 0.031*** |
| (Base = not offered) | (0.031) | (0.113) | (0.01) | (0.001) | (0.005) |
| Smart meter offered by provider | -0.001 | 0.026** | 0.033*** | 0.033*** | 0.042*** |
| (Base = not offered) | (0.957) | (0.045) | (0.001) | (0) | (0) |
| Time-of-use tariffs offered by provider | 0.005 | 0.041*** | 0.005 | 0.019** | 0.009 |
| (Base = not offered) | (0.656) | (0.001) | (0.595) | (0.035) | (0.39) |
| Perceived energy poverty | -0.0251 | 0.034* | 0.123*** | 0.119*** | 0.085*** |
| | (0.14) | (0.076) | (0) | (0) | (0) |
| Objective energy poverty | 0.034 | 0.006 | 0.092*** | 0.104*** | 0.035 |
| | (0.239) | (0.844) | (0) | (0) | (0.136) |
| Environmental concern | 0.051*** | 0.059*** | 0.057*** | 0.083*** | 0.053*** |
| | (0) | (0) | (0) | (0) | (0) |
| Environmental motivation | 0.042 | -0.057 | 0.175*** | 0.194*** | 0.061 |
| | (0.317) | (0.211) | (0) | (0) | (0.117) |
| Perceived vulnerability | 0.0813*** | 0.093*** | 0.056*** | 0.004 | -0.026* |
| | (0) | (0) | (0) | -0.748 | -0.053 |
| Change unnecessary | -0.049*** | -0.073*** | -0.083*** | -0.077*** | -0.040*** |
| | (0) | (0) | (0) | (0) | (0) |
| Conflicting goals | -0.090*** | -0.091*** | -0.090*** | -0.112*** | -0.060*** |
| | (0) | (0) | (0) | (0) | (0) |
| Interpersonal issues | -0.063*** | -0.045*** | -0.027** | -0.035*** | -0.040*** |
| | (0) | (0.007) | (0.031) | (0.004) | (0.004) |
| Knowledge | 0.042*** | 0.031** | 0.010 | -0.011 | -0.014 |
| | (0.001) | (0.016) | (0.314) | (0.228) | (0.19) |
| Country fixed effects | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| (Base = Belgium) | | | | | |
| Canada | -0.045* | -0.124*** | -0.076*** | -0.102*** | -0.252*** |
| | (0.053) | (0) | (0) | (0) | (0) |
| Israel | -0.072*** | -0.028 | -0.128*** | -0.085*** | 0.090*** |
| | (0.003) | (0.28) | (0) | (0) | (0.001) |
| France | 0.034 | -0.051** | -0.043** | -0.058*** | 0.196*** |
| | (0.124) | (0.049) | (0.041) | (0.004) | (0) |
| Netherlands | -0.076*** | -0.060** | -0.085*** | -0.059*** | -0.0324 |
| | (0.002) | (0.027) | (0) | (0.004) | (0.192) |
| Sweden | -0.301*** | -0.124*** | -0.211*** | -0.124*** | -0.067*** |
| | (0) | (0) | (0) | (0) | -0.005 |
| Switzerland | -0.030 | 0.012 | -0.098*** | -0.066*** | -0.009 |
| | (0.221) | (0.65) | (0) | (0.001) | (0.719) |
| United Kingdom | -0.074*** | 0.006 | 0.080*** | 0.051** | 0.118*** |
| | (0.002) | (0.793) | (0.001) | (0.026) | (0) |
| United States | -0.052** | -0.059** | -0.074*** | -0.073*** | -0.300*** |
| | (0.01) | (0.01) | (0) | (0) | (0) |
| Electricity for space heating | | | -0.004 | | |
| (Base = not electric) | | | (0.673) | | |
| Electricity for water heating | | | | 0.021*** | |
| (Base = not electric) | | | | (0.009) | |
| Residence type (house) | | | | | 0.016 |
| (Base = apartment) | | | | | (0.193) |
| Residence type (other) | | | | | -0.024 |
| (Base = apartment) | | | | | (0.417) |
| N | 8450 | 8450 | 8450 | 8450 | 8450 |
| Chi square | 664.05 | 533.61 | 935.32 | 961.99 | 1605.13 |
| Log Pseudo Likelihood | -6524.0872 | -8736.0161 | -10449.512 | -10651.73 | -10351.118 |

Note: Ordered logit estimation, robust standard errors in parentheses. Post-stratification weights used in the estimation. The baseline level for energy poverty measures, environmental concerns, perceived vulnerability, and the dragons of inactions is "No". The variables "number of adults", "number of children" as well as "environmental motivation" are not categorical variables, hence the displayed effect is the marginal effect of increasing the variable level by 1 unit. As regards to environmental motivation, which ranges between 0 and 1, the marginal effect translates a change from no environmental motivation to full environmental motivation.

### *Investment in low-emissions energy technologies*

## Table A.11. Determinants of investment in highly energy-efficient appliances, energy-efficient windows and thermal insulation

Average marginal effects

| | | Energy-efficient Appliances | Energy-efficient windows | Thermal insulation |
|---|---|---|---|---|
| Age | 25-34 | 0.002 | 0.007 | -0.064*** |
| | | (0.920) | (0.756) | (0.005) |
| | 35-44 | -0.003 | 0.008 | -0.095*** |
| | | (0.891) | (0.740) | (0) |
| | 45-54 | 0.011 | 0.066*** | -0.086*** |
| | | (0.626) | (0.003) | (0) |
| | 55+ | 0.0567*** | 0.157*** | -0.018 |
| | | (0) | (0) | (0.377) |
| Higher education | Yes | 0.039*** | 0.049*** | 0.053*** |
| | | (0.001) | (0) | (0) |

| | | | | |
|---|---|---|---|---|
| Employed | Yes | -0.009 | 0.003 | -0.022 |
| | | (0.501) | (0.839) | (0.15) |
| Female | Yes | 0.016 | -0.005 | -0.050** |
| | | (0.16) | (0.699) | (0) |
| High income | Yes | 0.035** | 0.032** | 0.056*** |
| | | (0.013) | (0.028) | (0.001) |
| Number of adults | // | 0.021*** | 0.006 | 0.009 |
| | | (0.003) | (0.378) | (0.239) |
| Number of children | // | 0.018*** | 0.012** | 0.022*** |
| | | (0.002) | (0.015) | (0) |
| Urban dweller | Yes | -0.004 | -0.006 | -0.029** |
| | | (0.686) | (0.663) | (0.05) |
| Home ownership | Yes | 0.039*** | 0.013 | 0.057*** |
| | | (0.002) | (0.403) | (0.001) |
| Renewable electricity offered by provider | Yes | 0.036*** | 0.035** | 0.079*** |
| | | (0.01) | (0.014) | (0) |
| Smart meter offered by provider | Yes | 0.055*** | 0.045*** | 0.037** |
| | | (0) | (0.001) | (0.015) |
| Time-of-use tariffs offered by provider | Yes | 0.056*** | 0.043*** | 0.056*** |
| | | (0) | (0.001) | (0) |
| Environmental concern | Yes | 0.058*** | 0.063*** | 0.028* |
| | | (0) | (0) | -0.053 |
| Environmental motivation | // | 0.126*** | 0.033 | 0.117** |
| | | (0.006) | (0.487) | (0.033) |
| Perceived vulnerability | // | 0.091*** | 0.025 | -0.004 |
| | | (0) | (0.139) | (0.843) |
| Country fixed effects (benchmark = Belgium) | US | 0.029 | -0.243*** | -0.199*** |
| | | (0.201) | (0) | (0) |
| | UK | -0.024 | 0.014 | -0.007 |
| | | (0.383) | (0.574) | (0.817) |
| | FR | -0.122*** | -0.081*** | -0.044 |
| | | (0) | (0.001) | (0.133) |
| | NL | 0.050* | 0.023 | -0.032 |
| | | (0.058) | (0.362) | (0.295) |
| | SE | 0.001 | -0.092*** | -0.153*** |
| | | (0.978) | (0.001) | (0) |
| | CH | 0.081*** | 0.009 | -0.03 |
| | | (0.005) | (0.733) | (0.377) |
| | IL | 0.138*** | -0.424*** | -0.359*** |
| | | (0) | (0) | (0) |
| | CA | 0.037 | -0.169*** | -0.158*** |
| | | (0.156) | (0) | (0) |
| Residence type | House | | -0.021 | -0.022 |
| | | | (0.195) | (0.231) |
| | Other | | -0.041 | -0.100** |
| | | | (0.22) | (0.019) |
| Residence size | 25-50m2 | | 0.024 | 0.006 |
| | | | (0.681) | (0.923) |
| | 51-75m2 | | 0.051 | -0.023 |
| | | | (0.357) | (0.707) |
| | 76-100m2 | | 0.025 | 0.015 |
| | | | (0.658) | (0.808) |
| | 101-150m2 | | 0.080 | 0.038 |

| | | | | |
|---|---|---|---|---|
| | | | (0.151) | (0.529) |
| | 151-200m2 | | 0.096* | 0.077 |
| | | | (0.094) | (0.215) |
| | More than 200m2 | | 0.108* | 0.129** |
| | | | (0.064) | (0.041) |
| | Don't know | | -0.014 | -0.022 |
| | | | (0.814) | (0.728) |
| N | | 7005 | 6702 | 5924 |
| Wald Chi square | | 368.03 | 795.57 | 619.81 |
| Log pseudo likelihood | | -3850.0868 | -3648.6089 | -3583.4285 |

Note: Binary logit estimation, robust standard errors in parentheses. Post-stratification weights used in the estimation.

## Table A.12. Determinants of investment in solar PV, solar water heating, battery storage and heat pumps

Average marginal effects

| | | Solar PV | Solar water heater | Battery storage | Heat pump |
|---|---|---|---|---|---|
| Age | 25-34 | -0.041** | -0.021 | -0.086*** | -0.093*** |
| | | (0.027) | (0.201) | (0) | (0) |
| | 35-44 | -0.090*** | -0.073*** | -0.123*** | -0.163** |
| | | (0) | (0) | (0) | (0) |
| | 45-54 | -0.131*** | -0.103*** | -0.164*** | -0.179*** |
| | | (0) | (0) | (0) | (0) |
| | 55+ | -0.122*** | -0.098*** | -0.175*** | -0.176*** |
| | | (0) | (0) | (0) | (0) |
| Higher education | Yes | 0.015 | 0.043*** | 0.028** | 0.036*** |
| | | (0.223) | (0) | (0.015) | (0.004) |
| Employed | Yes | 0.012 | 0.034*** | 0.036*** | 0.002 |
| | | (0.359) | (0.003) | (0.003) | (0.865) |
| Female | Yes | -0.054*** | -0.038*** | -0.023** | -0.058*** |
| | | (0) | (0) | (0.022) | (0) |
| High income | Yes | 0.032** | 0.001 | 0.001 | 0.006 |
| | | (0.013) | (0.936) | (0.947) | (0.651) |
| Number of adults | // | 0.007 | -0.003 | 0.003 | -0.006 |
| | | (0.324) | (0.557) | (0.619) | (0.351) |
| Number of children | // | 0.0172*** | 0.0174*** | 0.0140*** | 0.0279*** |
| | | (0) | (0) | (0) | (0) |
| Urban dweller | Yes | -0.005 | 0.024** | 0.018 | -0.013 |
| | | (0.693) | (0.021) | (0.149) | (0.289) |
| Home ownership | Yes | 0.018 | -0.009 | 0.004 | -0.003 |
| | | (0.268) | (0.488) | (0.773) | (0.872) |
| Renewable electricity offered by provider | Yes | 0.188*** | 0.095*** | 0.091*** | 0.113*** |
| | | (0) | (0) | (0) | (0) |
| Smart meter offered by provider | Yes | 0.042*** | 0.055*** | 0.070*** | 0.048*** |
| | | (0.001) | (0) | (0) | (0) |
| Time-of-use tariffs offered by provider | Yes | 0.028** | 0.039*** | 0.062*** | 0.046*** |
| | | (0.022) | (0) | (0) | (0) |
| Environmental concern | Yes | 0.023* | 0.027** | 0.025** | 0.009 |

| | | | | | |
|---|---|---|---|---|---|
| | | (0.062) | (0.01) | (0.027) | (0.48) |
| Environmental motivation | // | 0.137*** | 0.074* | 0.215*** | 0.141*** |
| | | (0.003) | (0.072) | (0) | (0.003) |
| Perceived vulnerability | // | -0.057*** | -0.055*** | -0.063*** | -0.080*** |
| | | (0.001) | (0) | (0) | (0) |
| Country fixed effects (benchmark = Belgium) | US | -0.173*** | -0.033* | 0.058*** | 0.069*** |
| | | (0) | (0.097) | (0.004) | (0.003) |
| | UK | -0.177*** | -0.038* | 0.009 | -0.027 |
| | | (0) | (0.086) | (0.685) | (0.268) |
| | FR | -0.205*** | -0.045* | -0.045** | 0.027 |
| | | (0) | (0.051) | (0.039) | (0.3) |
| | NL | 0.059* | -0.052** | -0.007 | -0.029 |
| | | (0.06) | (0.02) | (0.745) | (0.244) |
| | SE | -0.176*** | 0.030 | 0.069*** | 0.289*** |
| | | (0) | (0.238) | (0.006) | (0) |
| | CH | -0.105*** | 0.0749*** | -0.004 | 0.191*** |
| | | (0.001) | (0.007) | (0.857) | (0) |
| | IL | -0.152*** | 0.734*** | 0.132*** | -0.032 |
| | | (0) | (0) | (0) | (0.229) |
| | CA | -0.260*** | -0.066*** | 0.0142 | 0.010 |
| | | (0) | (0.003) | (0.53) | (0.693) |
| Residence type | House | -0.044*** | -0.034*** | -0.071*** | -0.026* |
| | | (0.007) | (0.006) | (0) | (0.1) |
| | Other | -0.067* | -0.018 | -0.061* | -0.031 |
| | | (0.073) | (0.623) | (0.06) | (0.388) |
| Residence size | 25-50m2 | -0.061 | -0.047 | 0.038 | 0.044 |
| | | (0.343) | (0.209) | (0.436) | (0.34) |
| | 51-75m2 | -0.066 | 0.002 | 0.021 | 0.021 |
| | | (0.29) | (0.965) | (0.646) | (0.629) |
| | 76-100m2 | -0.080 | -0.020 | 0.040 | 0.051 |
| | | (0.205) | (0.566) | (0.389) | (0.235) |
| | 101-150m2 | -0.057 | -0.006 | 0.034 | 0.095** |
| | | (0.368) | (0.86) | (0.471) | (0.028) |
| | 151-200m2 | -0.0526 | 0.0124 | 0.0442 | 0.105** |
| | | (0.415) | (0.737) | (0.354) | (0.021) |
| | More than 200m2 | -0.052 | -0.040 | 0.007 | 0.106** |
| | | (0.428) | (0.3) | (0.885) | (0.023) |
| | Don't know | -0.113* | -0.078** | -0.022 | -0.016 |
| | | (0.077) | (0.042) | (0.647) | (0.717) |
| Access to outdoor space | Yes | 0.107*** | 0.056*** | 0.026 | 0.078*** |
| | | (0) | (0.001) | (0.136) | (0.001) |
| N | | 5473 | 5528 | 5682 | 5498 |
| Wald-Chi square | | 843.32 | 1015.84 | 697.35 | 745.32 |
| Log pseudo likelihood | | -2363.6234 | -1762.7571 | -2125.3117 | -2409.3109 |

Note: Binary logit estimation, robust standard errors in parentheses. Post-stratification weights used in the estimation.

## Supplementary material for Section 5

### *Discrete choice experiment design*

Choice sets were developed from the full factorial design matrix containing all possible combinations of attribute levels. Choice sets with dominated alternatives are removed, leaving nine feasible choice sets. To reduce cognitive burden, choice sets are blocked into three groups (see 'block' in Table 2), such that each respondent is asked to make a choice for three different choice sets. Respondents were randomly assigned to one of the three blocks. Table 4 summarises the number of respondents in each block by country.

### Table A.13. Choice sets for the discrete choice experiment

| Block | Question | Alternative 1 Cost | Alternative 1 Emissions | Alternative 2 Cost | Alternative 2 Emissions |
|---|---|---|---|---|---|
| 1 | C51 | 5% increase | 10% decrease | 10% increase | 30% decrease |
| 1 | C52 | 20% increase | 50% decrease | 5% increase | 10% decrease |
| 1 | C53 | 10% increase | 10% decrease | 20% increase | 30% decrease |
| 2 | C54 | 10% increase | 50% decrease | 5% increase | 10% decrease |
| 2 | C55 | 10% increase | 50% decrease | 5% increase | 30% decrease |
| 2 | C56 | 10% increase | 10% decrease | 20% increase | 50% decrease |
| 3 | C57 | 5% increase | 10% decrease | 20% increase | 30% decrease |
| 3 | C58 | 20% increase | 50% decrease | 5% increase | 30% decrease |
| 3 | C59 | 20% increase | 50% decrease | 10% increase | 30% decrease |

### Table A.14. Number of respondents by country

| | Belgium | Canada | France | Ireland | Netherlands | Sweden | Switzerland | United Kingdom | United States |
|---|---|---|---|---|---|---|---|---|---|
| Block 1 | 292 | 286 | 281 | 286 | 288 | 287 | 291 | 296 | 530 |
| Block 2 | 287 | 291 | 289 | 286 | 288 | 289 | 293 | 296 | 530 |
| Block 3 | 291 | 290 | 297 | 289 | 284 | 286 | 291 | 292 | 531 |
| Total | 870 | 867 | 867 | 861 | 860 | 862 | 875 | 884 | 1,591 |

### *Example discrete choice experiment for the United Kingdom*

Please imagine that you have the opportunity to select a new electricity provider for your household if you wish. Below you will be presented with three scenarios in which you can choose to switch to a new provider or to stay with your current provider. Please assume that, apart from the differences shown, the providers do not differ in any other way (e.g. regarding the reliability of the electricity supply).

Your current provider costs GBP 0.17/kWh and emits 250 g CO2e/kWh, which are average for the United Kingdom. The average amount of greenhouse gas emissions emitted per kWh of electricity across all OECD countries is 345 g CO2e/kWh.

Given the different options available in each of the following scenarios, please indicate which provider you would choose:

| | Provider 1 | Provider 2 | Current provider |
|---|---|---|---|
| **Change in price per kWh** | GBP 0.21 / kWh (20% increase relative to your current provider) | GBP 0.18 / kWh (5% increase relative to your current provider) | GBP 0.17 / kWh (No change) |
| **Change in amount of greenhouse gas emissions per kWh** | 125 g CO2e/kWh (50% decrease relative to your current provider) | 225 g CO2e/kWh (10% decrease relative to your current provider) | 250 g CO2e/kWh /kWh (No change) |

Which provider would you choose?

1. Provider 1
2. Provider 2
3. Current provider

### *Econometric model*

A conditional logit model is used for estimating preferences towards attributes. Respondents were asked to choose their preferred option from a set of three hypothetical alternatives. This was repeated three times, enabling an estimation of the utility functions. According to random utility theory (McFadden, 1973[151]), respondent *n* (*n*= 1,…, *N*) ) is considered to obtain utility for choosing provider *i* (*i* = 1, … , 3) as shown in Eq. (1).

$$U_{ni} = V_{ni} + \varepsilon_{ni} \quad (1)$$

Indirect utility $V_{ni}$ consists of the observable utility of the price and GHG emissions attributes, $V_{ni}$, and the stochastic component of utility, $\varepsilon_{ni}$, which is identically and independently distributed and follows a Type-I extreme value distribution. The ASC denotes an alternative-specific constant representing the status quo option. The probability that alternative (provider) $i$ is chosen by respondent $n$ can be expressed as in Eq. (2):

$$P_{ni}\left(U_{ni} > U_{nj}, \forall j \in C, i \neq j\right) = \frac{exp(\mu V_{ni})}{\sum_{j \in C} exp(\mu V_{nj})}, \quad (2)$$

where $\mu$ is a scale parameter. We assume a linear model for $V_{ni}$ as in Eq. (3).

Two expanded model are developed that include interaction terms with the ASC and with the attributes to explore to what extent the characteristics of respondents may affect preferences.[57] Previous studies find that socioeconomic variables affect energy-related behaviours (Huebner et al., 2016[152]; Jones and Lomas, 2015[153]; Longhi, 2015[154]) and choice of energy options (e.g., (Ruokamo et al., 2019[114])). Therefore, household income, age, sex, educational background, and resident status are therefore considered in interaction terms with the ASC and choice attributes. The dummy variable representing high-income equals one if a respondent earns highest category of household income question. Dummy variables for old, female, university, and living alone are equal to one if a respondent is older than 55 years old, female, completed a bachelor's degree or higher, or live by themselves, respectively. Finally, the high electricity fee dummy variable is equal to one if a respondent reports pays the highest category of electricity fee.

Respondents' views on climate change and other environmental issues are also considered. The environmental concern variable is equal to one if a respondent reports that climate change or other

[57] Socioeconomic characteristics can only enter the model only via their interaction with alternative-specific variables, i.e. the attributes or ASC.

environmental issues are either important or very important to them personally. Finally, we also examine the possible impact of country differences on the preferences of attributes. In Expanded Model 1, the ASC is interacted with socioeconomic characteristics variables, environmental concern, and country dummies as indicated in Eq. (3).

$$U_{ni} = ASC + \beta_1 Price_{ni} + \beta_2 GHG\ Emission_{ni} + ASC * \boldsymbol{Socioeconomic}_{ni} + ASC * Environmental\ concern_{ni} + ASC * \boldsymbol{Country}_{ni} + \varepsilon_{ni} \quad (3)$$

Expanded Model 2 includes four interaction terms: ASC times socioeconomic characteristics, ASC times environmental concern, price times country dummy variables, and GHG emission times country dummy variables (see Eq. (4)).

$$U_{ni} = ASC + \beta_1 Price_{ni} + \beta_2 GHG\ Emission_{ni} + ASC * \boldsymbol{Socioeconomics}_{ni} + ASC * Environmental\ concern_{ni} + Price * \boldsymbol{Country}_{ni} + GHG\ Emission * \boldsymbol{Country}_{ni} + \varepsilon_{ni} \quad (4)$$

Marginal willingness-to-pay (MWTP) for emission reductions which can be estimated as follows:

$$MWTP = -\left(\frac{\beta_{GHG\ emission}}{\beta_{price}}\right) \quad (5)$$

where $\beta_{GHG\ emission}$ and $\beta_{price}$ are the estimated coefficient for percent change in GHG emissions per kWh and percent change in electricity price per kWh, respectively. MWTP is typically interpreted in nominal terms (e.g. price per unit of GHG emissions). As the experiment was implemented using different currencies for respondents across countries, estimated coefficients are measured in percent terms. As a result, MWTP can be considered to be a measure of elasticity (i.e. the percent change in price that a respondent is willing to pay for a 1% change in GHG emissions intensity).

### *Full results*

In light of evidence that socioeconomic variables affect energy-related behaviours (Huebner et al., 2016[152]; Jones and Lomas, 2015[153]; Longhi, 2015[154]) and energy choices (e.g., (Ruokamo et al., 2019[114])), an Expanded Model 1 includes interaction terms of socioeconomic characteristics with the alternative-specific constant (ASC), which represents the status quo. Income, age, sex and level of electricity fee are controlled for in the model using dummy variables. In an Expanded Model 2, the price and GHG emissions attributes are interacted with country fixed effects to allow for cross country variation in preferences for price and emissions intensity, as well as in marginal willingness-to-pay for reductions in emissions intensity.

In the Basic Model (Table A.15), the estimated parameters for price and GHG emission attributes are negative and statistically significant, indicating that, all else equal, respondents prefer electricity that is supplied at a lower cost and has lower emissions intensity, in line with previous studies (Boeri and Longo, 2017[155]; Morita and Managi, 2015[102]; Murakami et al., 2015[156]); Byun and Lee, 2017; Komarek et al., 2011).

Expanded Model 1 includes main effects for the two main attributes (i.e. price and GHG emissions), as well as interaction terms between the ASC and socioeconomic and household characteristics. The parameter estimate for the ASC is positive and significant. In contrast to one previous study (Ruokamo et al., 2019[114]), this finding indicates that remaining with the current provider increases a households' utility. If all of the characteristics of the options are assumed to be observed, this result can be considered a status-quo bias, and has been evidenced in other work (e.g. Brown and Krishna (2004[157]), Pichert and Katsikopoulos (2008[158])). The transaction costs associating with switching providers, such as the required administrative processes and potential disruption, can serve as deterrents to switching. High income earners, as well as those with a higher education, are less likely to select the status quo option, i.e. more willing to switch to the new provider, than their counterparts, a finding that is in line with previous work (Ruokamo et al., 2019[114]). Other interaction terms indicate that women, those over 55, those living by themselves, as well as those paying the most for electricity exhibit a tendency to remain with the current provider.

Expanded Model 2 indicates that preferences regarding energy providers differ across countries. Households in Switzerland, Israel, the United States and Canada appear to be most sensitive to price, as well as emissions intensity of the electricity provided. Because Belgium serves as the reference country, the interaction term of GHG emission times country dummy is the relative preference for GHG emissions of the respective country compared to households in Belgium.

## Table A.15. Preference parameter estimates of basic and expanded models

Regression coefficients and average marginal effects (AMEs)

| | Basic Model | | Expanded Model 1 | | Expanded Model 2 | |
|---|---|---|---|---|---|---|
| | Coef. (s.e.) | AME (s.e.) | Coef. (s.e.) | AME (s.e.) | Coef. (s.e.) | AME (s.e.) |
| **Main effects** | | | | | | |
| Price | -3.562*** (0.216) | -0.037*** (0.008) | -3.555*** (0.217) | -0.041*** (0.009) | -4.229*** (0.231) | -0.047*** (0.011) |
| GHG emissions | -1.223*** (0.083) | -0.013*** (0.003) | -1.210*** (0.083) | -0.014*** (0.003) | -0.384*** (0.130) | -0.004*** (0.001) |
| ASC | 0.643*** (0.026) | 0.007*** (0.002) | 1.161*** (0.054) | 0.013*** (0.004) | 0.917*** (0.039) | 0.010*** (0.003) |
| **Interaction terms: Socioeconomics** | | | | | | |
| ASC × Female | | | 0.136*** | 0.002*** | 0.134*** | 0.001*** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | (0.027) | (0.001) | (0.027) | (0.001) |
| ASC × Above 55 years old | | | 0.606*** (0.029) | 0.007*** (0.002) | 0.606*** (0.028) | 0.007*** (0.002) |
| ASC × High income | | | -0.098*** (0.034) | -0.001** (0.000) | -0.078** (0.034) | -0.001* (0.000) |
| ASC × Living alone | | | 0.178*** (0.032) | 0.002*** (0.001) | 0.202*** (0.032) | 0.002*** (0.001) |
| ASC × Higher education | | | -0.302*** (0.029) | -0.003*** (0.001) | -0.320*** (0.028) | -0.004*** (0.001) |
| ASC × High electricity cost | | | 0.180*** (0.058) | 0.002** (0.001) | 0.159*** (0.058) | 0.002** (0.001) |
| ASC × Environmentally concerned | | | -0.817 *** (0.028) | -0.009*** (0.003) | -0.814*** (0.028) | -0.009*** (0.003) |
| **Interaction terms: Countries** | | | | | | |
| ASC × Canada | | | -0.289*** (0.057) | -0.003*** (0.001) | | |
| ASC × Israel | | | -0.483*** (0.059) | -0.006*** (0.002) | | |
| ASC × France | | | -0.013 (0.057) | -0.000 (0.001) | | |
| ASC × Netherlands | | | 0.036 (0.057) | 0.000 (0.001) | | |
| ASC × Sweden | | | -0.030 (0.057) | -0.000 (0.001) | | |
| ASC × Switzerland | | | -0.609*** (0.058) | -0.007*** (0.002) | | |
| ASC × United Kingdom | | | -0.188*** (0.058) | -0.002** (0.001) | | |
| ASC × United States | | | -0.413*** (0.053) | -0.005** (0.001) | | |
| Price × Canada | | | | | 0.774*** (0.113) | 0.009*** (0.003) |
| Price × Israel | | | | | 1.140*** (0.112) | 0.013*** (0.004) |
| Price × France | | | | | 0.350*** (0.115) | 0.004** (0.002) |
| Price × Netherlands | | | | | 0.236** (0.116) | 0.003* (0.001) |
| Price × Sweden | | | | | 0.124 (0.117) | 0.001 (0.001) |
| Price × Switzerland | | | | | 1.540*** (0.111) | 0.017*** (0.005) |
| Price × United Kingdom | | | | | 0.372*** (0.114) | 0.004** (0.002) |
| Price × United States | | | | | 0.943*** (0.101) | 0.010*** (0.003) |
| GHG Emissions × Canada | | | | | -0.969*** (0.145) | -0.011*** (0.003) |
| GHG Emissions × France | | | | | -0.425*** (0.146) | -0.005** (0.002) |
| GHG Emissions × Israel | | | | | -1.439*** (0.145) | -0.016*** (0.005) |
| GHG Emissions × Netherlands | | | | | -0.283* (0.148) | -0.003* (0.002) |
| GHG Emissions × Sweden | | | | | -0.184 (0.148) | -0.002 (0.002) |

| | | | | | | |
|---|---|---|---|---|---|---|
| GHG Emissions × Switzerland | | | | | -2.024*** (0.143) | -0.023*** (0.006) |
| GHG Emissions × United Kingdom | | | | | -0.414*** (0.146) | -0.005** (0.002) |
| GHG Emissions × United States | | | | | -1.199*** (0.128) | -0.013*** (0.004) |
| Log-likelihood function | -44,820.158 | | -43,866.482 | | -4,3812.68 | |
| AIC | 89,646.32 | | 87,768.96 | | 87,677.36 | |
| BIC | 89,674.06 | | 87,935.45 | | 87,917.84 | |
| Observations (Respondents) | 76,833 (8,537) | | 76,833 (8,537) | | 76,833 (8,537) | |

Note: Average marginal measure the change in the likelihood of choosing a provider given a one unit increase in the independent variable. In the Basic Model, a 1% increase in the price per kWh reduces the probability of choosing a provider by 3.7 percentage points. * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

### *Carbon tax scenario analysis*

The carbon tax scenario assumes a tax of $\tau$ that ranges between 0 and 250 $\frac{USD}{ton\ CO2}$. This carbon tax is converted into a country-specific increase in electricity price by multiplying $\tau$ by the country-specific carbon intensity of the electricity mix $\kappa_C$ (expressed in $\frac{ton\ CO2}{kWh}$). Calculating $x_C(\tau) = \tau \times \kappa_C$ (now expressed in $\frac{USD}{kWh}$). $x_C(\tau)$ indicates that the country-specific electricity tax depends on the carbon tax level $\tau$. Next, $x_C(\tau)$ is added to the country-specific price of electricity from the status-quo provider, $p_C$. The total electricity price in the presence of a carbon tax $\tau$ is then: $P_C(\tau) = p_C + x_C(\tau)$. The choice probability of the status-quo alternative (one line for each country) is plotted for $0 < \tau < 250$, fixing $\mathbf{x}$ (i.e. the individual-specific explanatory variables, gender, income, age, ... etc) to the country average, $\overline{\mathbf{x}_c}$. The probability that the average respondent in country $c$ (of characteristics $\overline{\mathbf{x}_c}$) chooses the status-quo alternative in country $c$ is: $\mathrm{Prob}_{\mathrm{SQ}}(\tau|\overline{\mathbf{x}_c})$.

The scenario analysis is based on GHG emissions intensities in 2022. Table A A.16 reports the sources of GHG emissions intensity used in the scenario analysis.

## Table A A.16. Average prices and GHG emissions intensity in 2022

| Country | Average GHG emissions intensity (g $CO_2$e/kWh) | Source |
|---|---|---|
| Belgium | 145 | EEA (2023[106]) |
| Canada | 110 | Environment and Climate Change Canada (2023[159]) |
| France | 68 | EEA (2023[106]) |
| Israel | 542 | Electricity Maps (2024[107]). |
| Netherlands | 321 | EEA (2023[106]) |
| Sweden | 7 | EEA (2023[106]) |
| Switzerland | 150 | Electricity Maps (2024[107]). |
| United Kingdom | 264 | UK Department for Energy Security and Net Zero (2023[160]) |
| United States | 375 | US Environmental Protection Agency (2024[161]) |

Table A A.17 reports the percent change in the probability of choosing the brown electricity provider for different levels of the carbon tax ($\tau$ = 50, 100, 150, 200, 250). In other words, for a carbon tax $\tau$ = 50: $\Omega(\tau = 50) = \frac{\text{Prob}_{\text{SQ}}(\tau = 50|\overline{\mathbf{x}_c}) - \text{Prob}_{\text{SQ}}(\tau = 0|\overline{\mathbf{x}_c})}{\text{Prob}_{\text{SQ}}(\tau = 0|\overline{\mathbf{x}_c})}$. Table A A.18 presents the numerical results for the predicted probability of choosing the status quo option at varying price levels.

## Table A A.17. Predicted probability of choosing the status quo option at varying carbon tax levels

| Tau | Belgium | Canada | France | Israel | Netherlands | Sweden | Switzerland | United Kingdom | United States |
|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.33 | 0.50 | 0.42 | 0.42 | 0.45 | 0.52 | 0.39 | 0.39 | 0.45 |
| 0.05 | 0.32 | 0.49 | 0.41 | 0.39 | 0.44 | 0.52 | 0.39 | 0.37 | 0.43 |
| 0.10 | 0.32 | 0.48 | 0.41 | 0.37 | 0.42 | 0.52 | 0.38 | 0.36 | 0.41 |
| 0.15 | 0.31 | 0.48 | 0.41 | 0.34 | 0.40 | 0.52 | 0.37 | 0.35 | 0.39 |
| 0.20 | 0.30 | 0.47 | 0.40 | 0.31 | 0.39 | 0.51 | 0.36 | 0.33 | 0.38 |
| 0.25 | 0.30 | 0.47 | 0.40 | 0.29 | 0.37 | 0.51 | 0.36 | 0.32 | 0.36 |

Note: Tau ($\tau$) reflects the carbon tax level and is expressed in $\frac{USD}{g\ CO_2}$. A $\tau$ of 0.25$\frac{USD}{g\ CO_2}$ is therefore equivalent to a carbon tax of 250 $\frac{USD}{tonne\ CO_2}$. Kappa ($\kappa$) reflects the carbon intensity of electricity generation in a given country in $\frac{g\ CO_2}{kWh}$. The impact of a carbon tax on choice probabilities here captures the effect of both carbon intensity and price sensitivity combined.

## Table A A.18. Predicted probability of choosing the status quo option at varying price levels

| | Belgium | Canada | France | Israel | Netherlands | Sweden | Switzerland | United Kingdom | United States |
|---|---|---|---|---|---|---|---|---|---|
| Price 1 | 0.3555 | 0.574482 | 0.44714 | 0.755538 | 0.578034 | 0.521652 | 0.585125 | 0.470548 | 0.647933 |
| Price 2 | 0.286566 | 0.553244 | 0.399828 | 0.733515 | 0.541149 | 0.483188 | 0.552159 | 0.422921 | 0.628973 |
| Price 3 | 0.226304 | 0.53181 | 0.354314 | 0.71027 | 0.503808 | 0.444921 | 0.518729 | 0.376684 | 0.609608 |
| Price 4 | 0.175596 | 0.510258 | 0.311293 | 0.685865 | 0.466425 | 0.407297 | 0.485129 | 0.33259 | 0.589891 |
| Price 5 | 0.134278 | 0.488667 | 0.271301 | 0.660387 | 0.429414 | 0.37073 | 0.451664 | 0.291245 | 0.569881 |

Note: Price 1, 2, 3, 4, and 5 are equivalent to 20, 40, 60, 80, and 100% increases relative to the baseline price, i.e. the average price of electricity in 2020 according to IEA (2021[105]).