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ORIGINAL ARTICLE

# Factors affecting energy-efficiency investment in the hotel industry: survey results from Spain

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**Abstract** Increasing energy efficiency is a major way of saving energy and thus reducing energy expenses. However, adoption of energy efficiency is generally low, as demonstrated by the energy efficiency gap. To understand that gap, this paper analyses the factors that affect how the energy efficiency attribute is rated in investment in heating, ventilation and air conditioning (HVAC) systems in the hotel industry in Spain. A survey conducted on two hundred owners of hotels, hostels and holiday cottages (referred to jointly here for the sake of convenience as "the hotel industry") shows that the value placed on energy efficiency is influenced not just by climate conditions, environmental concern and type of hotel but also by other attributes of the HVAC system such as brand reliability, price and performance. The hotel industry may also be identifying EE as a proxy for quality rather than savings. Designing the right energy-efficiency policy entails accounting for potential responses by agents, and this analysis helps identify those drivers to which they may or may not respond.

**Keywords** Hotel industry · Energy-efficiency HVAC system · Barriers · Environmental attitudes · Energy efficiency investments

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## Introduction

Buildings account for 40% of Europe's final energy consumption (COM 2019; ODYSEE-MURE 2018). Non-residential buildings[1] of different types, including hotels, account on average for 25% of energy consumption from the total European building stock, which makes them major contributors to overall $CO_2$ emissions (WBG 2020). Moreover, non-residential buildings are on average 40% more energy-intensive than residential buildings; they also require more electrical energy

[1] Non-residential buildings are more heterogeneous than residential ones. A BPIE (Buildings Performance Institute Europe) survey states that non-residential buildings in Europe can be divided into the following categories: wholesale and retail (28%), offices (23%), educational (17%), hotels and restaurants (11%), hospitals (7%), sport facilities (4%) and others (11%).

than residential buildings (286 kWh/m$^2$ compared to 185 kWh/m$^2$) (D'Agostino et al. 2017).

Energy consumption in buildings varies from one European Union (EU) country to another. Differences may be explained by climate conditions, by building characteristics (e.g. building envelope, insulation level) and by social and cultural factors (lifestyle, habits, etc.) among others. Energy demand in non-residential buildings may also be influenced by economic growth and employment growth (Bertoldi et al. 2018).

Energy efficiency (EE) provides an opportunity to substantially reduce energy consumption and consequently GHG emissions from the services sector (Hrovatin et al. 2016; Liang et al. 2019; Schleich 2009; Schlomann and Schleich 2015) and also to reduce energy-related running costs in that sector (Mavrotas et al. 2003; Patel and Guedes 2017; Sakshi et al. 2020). Several studies have analysed the potential energy savings, avoided $CO_2$ emissions and profitability of EE investments (Cattaneo 2019; Fleiter et al. 2012). However, despite its significant monetary benefits and environmental advantages, EE adoption levels are generally low, as shown by the EE gap (Jaffe and Stavins 1994; Linares and Labandeira 2010; Shama 1983). A better understanding of barriers regarding large investments such as HVAC systems is particularly important in addressing this EE gap and encouraging more efficient purchases. In fact, studies exploring what barriers are most relevant to EE in the hotel industry provide important information for the design of effective policies for the promotion of energy EE (Schleich 2009).

Spain provides a very interesting case study for this sector due to the importance of tourism in the country (INE 2019; UNWTO 2019) and its significant energy consumption. The wide range of climates and types of hotel industry establishment in the country also provide a chance to explore the connection of these factors with the adoption of energy-efficiency measures, thus providing insights for other countries where tourism is also a significant part of the economy.

In Spain, 73% of the energy demand from buildings in 2017 (including residential and non-residential buildings) came from heating (40.4%) and electrical equipment (32.5%). Hot water accounted for 12.5%, air conditioning for 9%, and cooking for 5.5% of consumption (ODYSEE-MURE 2020). Focusing on non-residential buildings, 7% of the country's final energy consumption was attributable to restaurants and accommodation establishments (IDAE 2017). Most of the energy used came from electricity (74%), followed by natural gas (17%) and petroleum products (7%), while renewables had a direct contribution of 2.4% (IDAE 2017). The National Integrated Energy and Climate Plan 2021-2030 (PNIEC) (MITECO 2020), which defines the priorities for the energy transition, proposes measures to promote renewable energies and EE in heating systems among other points.

In that context, this study sets out (i) to analyse barriers that influence the consideration of EE by hotels in Spain; and (ii) to explore the effect of several drivers on the valuation of EE. The data used were collected expressly for this study from 200 hotels throughout Spain. The survey seeks to (i) assess the importance attributed to EE achieved through HVAC installation; and (ii) identify the most common barriers that prevent tourist establishments from investing in energy-efficient HVAC systems. A binary response model is estimated to explore whether these barriers and a set of other factors influence the consideration of EE in the purchasing decision, i.e., the consideration of EE as a *very important* attribute in the purchase of HVAC systems. Note that these barriers are analysed in isolation and no trade-off is allowed between them. That is, the analysis is *ceteris paribus*, so that it provides and understanding of the impact of one attribute when the rest remain constant. The results provide insights for policy makers for effective incentives to encourage the adoption of energy-efficient HVAC systems so as to decarbonise energy consumed in heating and cooling at hotels.

The rest of paper is organised as follows: the "Barriers to energy efficiency" offers an analysis of the barriers to the wider use of efficient HVAC systems, with a particular focus on non-residential buildings. The "Methodology" section describes the survey and the econometric model. The "Results and discussion" section presents and discusses the results. Finally, the "Conclusion" section concludes and outlines policy implications.

## Barriers to energy efficiency

Barriers to the adoption of EE measures have been analysed previously in the relevant literature for both residential (Gerarden et al. 2017; Linares and Labandeira 2010; Solà et al. 2020) and non-residential buildings (Cagno et al. 2013; Sorrell et al. 2004). Some of the main findings are described below.

Studies analysing the empirical relevance of barriers for EE in residential buildings have identified cognitive limitations, a lack of financial resources, the principal-agent problem and imperfect information problems as the most important barriers (Ramos et al. 2015; Stieß and Dunkelberg 2013).

Given that the building sector is characterised by dualities in the use of buildings (residential vs. non-residential), some of the barriers for residential buildings also apply to non-residential ones. So, as proposed by Ramos et al. (2015), references to barriers for residential buildings are included in order to draw analogies and provide a more integrated view of barriers to achieving optimal EE levels in residential and non-residential buildings. Further research would be needed to find differences among how these, and other barriers may affect residential and non-residential consumers. The heterogeneity of the households that make investment (or purchase) decisions and of the managers making equivalent decisions suggests that a whole new direction of research would be needed to answer this question.

## Barriers to energy efficiency in non-residential buildings

Econometric assessments of barriers in non-residential buildings show that EE investment is driven not only by market and behavioural factors but also by the characteristics of firms, such as organisational factors, the products and services offered by a company, location and profitability. Specific sectors such as industry, commerce and services have been analysed previously (Fleiter et al. 2012; Schleich 2009, 2004; Schleich and Gruber 2008). Three categories of barriers to EE in organisations have been proposed in the literature: (i) market barriers; (ii) behavioural barriers; and (iii) organisational barriers (Cagno et al. 2013; Sorrell et al. 2004). A summary of these barriers is presented in Table 1. Nonetheless, some barriers may fall under more than one category (Sorrell et al. 2011). These barriers are linked below to variables included in this analysis.

Market barriers include two important groups: informational failures and other market failures. Informational failures are led by imperfect and asymmetric information. These terms refer to a lack of information on costs and energy saving equipment, unclear information by technology providers or poor-quality information as to the energy performances of different technologies. Hidden costs (low perceived profitability of EE investments, additional costs associated with energy-efficient technologies, etc.) and risk and uncertainty (uncertainty about future energy prices, technical risks, economic and technological uncertainties concerning the business, etc.) may also be part of the problem (Cagno et al. 2013). Other market failures are related to access to capital and the principal-agent problem.

Among behavioural barriers, consumers tend to use simple calculations because of bounded rationality (e.g. individuals and companies ignore changes in real energy prices and energy savings that can be made over the lifetime of a good) (Blasch et al. 2019; Cattaneo 2019; Gillingham and Palmer 2014). In addition, Blasch et al. (2018) indicate that consumers need not only specific energy-related and financial knowledge but also the cognitive skills to apply that knowledge, in what they call "energy-related financial literacy". Moreover, the characteristics of information (specific, simple, personalised, updated, credible or trustworthy) comprise another significant barrier to energy-efficiency investment (Cagno et al. 2013).

Among organisational barriers, power barriers comprise a lack of power and/or influence by those in charge of energy management (lack of energy experts and skills, lack of energy audits, conflicts of interest between individuals and departments with different ideas and values influencing decision-making, or time pressure leading to concentrate solely on core business) and culture barriers refer to a lack of organisational culture leading people to ignore energy issues (Cagno et al. 2013; Hrovatin et al. 2016; Palm 2009).

Fleiter et al. (2012) summarise the main findings of empirical studies addressing the role of barriers for non-residential buildings. They find that the most frequent barriers are lack of information about energy consumption patterns and about EE measures, lack of time to analyse potentials for EE, priority setting within organizations and the principal-agent problem (Schleich 2009; Schleich and Gruber 2008).

## Barriers to energy-efficient HVAC systems in the hotel industry

Although the barriers indicated in Table 1 appear to be the most significant at organisations, there are differences by sector and size (Olsthoorn et al. 2017). Most barriers are more pronounced in less energy-intensive firms and in smaller firms (Schleich 2004). The main barriers for small and medium enterprises (SMEs) are a lack of capital and the technical risk of halting production for energy-intensive SMEs. For less energy-intensive SMEs, they are a lack of information and a lack of staff time (Fleiter et al. 2012). Moreover, the

**Table 1** A summary of the major barriers in non-residential buildings

| Category | Barriers | Description/examples |
|---|---|---|
| Market | | |
| Informational failures | Imperfect and/or asymmetric information | Lack of information on costs and energy saving equipment.<br>Unclear information by technology providers.<br>Poor-quality information as to the energy performances of different technologies. |
| | Hidden costs | Low perceived profitability of EE investments.<br>Additional costs associated with energy-efficient technology. |
| | Risk and uncertainty | Uncertainty about future energy prices.<br>Technical risks.<br>Economic and technological uncertainties in the business. |
| Other market failures | Access to capital | EE investments are usually assigned lower priority than essential maintenance projects or strategic investments. |
| | Principal-agent problem | Managers who hold their posts for only a short time may have limited incentives to invest in energy-efficient projects. |
| Behavioural | | |
| | Bounded rationality | Making satisfactory decisions rather than searching for optimum decision, following imprecise routines and rules of thumb. Moreover, firms seem to focus on the core production process rather than on ways to save energy costs. |
| | Characteristics of information | Information should be specific, simple, personalised, updated, credible and trustworthy. |
| Organizational | | |
| | Power | Low status of energy management may lead to issues having a lower priority within organisations. |
| | Culture | Organisations may encourage EE investments by developing a culture characterised by environmental values. |

Source: Own work adapted from Cagno et al. (2013), Hrovatin et al. (2016) and Schleich (2009)

significance of these barriers varies from one type of EE measure and technology to another. For example, installing an HVAC system calls for higher investment costs and a greater degree of complexity and customisation than measures involving lighting. This in turn is associated with higher hidden costs (Olsthoorn et al. 2017; Trianni et al. 2014). Specifically, Olsthoorn et al. (2017) conclude that the main barriers for heating replacement are the principal-agent problem, hidden costs (such as financing costs and other investment priorities) and lack of capital. As a result, many firms fail to perceive that investing in energy-efficient appliances reduces operating costs in the future by lowering energy costs.

This paper analyses the factors that influence the adoption of energy-efficiency HVAC systems, focusing on the impacts of different barriers. A distinguishing feature of this study is its focus on behaviour regarding energy consumption at establishments and on investment in green and energy-efficient equipment[2]. All this contributes to a better understanding of the EE gap in the hotel industry.

As regards behavioural failures, Fadzli Haniff et al. (2013) conduct a detailed review of HVAC scheduling techniques for buildings, analysing energy and cost savings obtained by changing practices. They demonstrate that advanced scheduling techniques (e.g. a combination of “ON” and “OFF” statuses and precooling or preheating techniques) may be able to save up to 20% in energy and 20% in cost for HVAC systems used for heating and cooling buildings. Chedwal et al. (2015) estimate energy savings by applying advanced energy-efficiency HVAC systems in different categories of hotel buildings in India. They find that the payback period for replacing existing HVAC systems with grand source heat

[2] “Green and energy-efficient equipment” means energy-conservation equipment, i.e. types of equipment which permit energy-saving.

pumps (GSHP) is 5–7 years, and that such investments increase profits and make establishments more competitive in the tourism market (Cingoski and Petrevska 2018). Considering the current context of climate change, increases in extreme temperatures will have consequences for energy demand in this sector, not only for heating but also for cooling (Biardeau et al. 2020), thus making these practices even more important.

To explain the EE gap, it is also important to consider energy consumption behaviour at hotels. Owners believe that energy consumption depends not only on the EE of the HVAC system but also on the behaviour of customers. Liang et al. (2019) find that there are barriers to changing behaviour towards energy savings due to attitudes such as inattention and myopia among customers who do not pay the marginal cost of their energy consumption. To address these failures, Tiefenbeck et al. (2019) conduct a field experiment that provides information on energy and water consumption in every shower taken through a smart meter fitted to the hotel room shower unit. They show that real time feedback is a cost-efficient policy instrument for promoting resource conservation among hotel guests.

Related to this, several studies find no significant link between proenvironmental attitudes and investment in EE or energy-saving actions (Hornsey et al. 2016; Kollmuss and Agyeman 2002; Ramos et al. 2016; Schleich et al. 2016; van der Linden 2017), in other words that proenvironmental attitudes may not always translate into substantial proenvironmental action (Cattaneo 2019). Moreover, Nauges and Wheeler (2017) suggest that proenvironmental attitudes may have a negative effect on environmental concerns because agents who invest in energy mitigation behaviour may feel less concerned about climate change. Other behavioural explanations include lifestyle categories that capture the energy culture of a company (i.e. how energy is perceived and what habits and routines are in place). This allows for a deeper understanding of how and why companies improve EE (Palm 2009; Trianni et al. 2017). For the specific case of the hotel industry and investment in energy-efficient HVAC systems, Ramos et al. (2016) find that environmental concerns appear to be significantly less relevant for high-cost energy-efficient investments (such as HVAC systems), suggesting that there may be a trade-off between environmentally friendly behaviours and monetary costs.

## Methodology

### Survey deployment

Two hundred telephone interviews were conducted in December 2017 and January 2018 by CPS[3], a specialist polling company. Establishments were recruited so as to provide a representative sample of types of accommodation, climate areas, geographical locations and other characteristics such as star rating and number of rooms. Decision-makers from three types of accommodation—individual hotels, hostels and cottages—were interviewed to explore their attitudes to HVAC systems. A preliminary test of the survey questionnaire was conducted. It included the three types of accommodation indicated plus international hotel chains, but the latter were left out of the final version because their decisions about HVAC systems were found to be centralised at their main offices and often unrelated to their geographical locations. The respondents targeted were individuals in charge of purchasing and investment decisions at the establishments. Seventy percent of the respondents were building owners and the rest had lease agreements. The establishments included in the survey were drawn from five main climate regions in Spain (Mediterranean, Atlantic, Continental, Subtropical and Mountain) and two types of surroundings (coast and inland). They also represented different star ratings. Establishments were also drawn from municipalities of different sizes. For a more detailed explanation of the characteristics of the sample, see Appendix A, Table 4.

The final questionnaire was designed based on the results of eight in-depth interviews conducted with Spanish accommodation operators to identify the key factors in their purchasing decisions. The analysis of these in-depth interviews revealed that consumers do not focus solely on the energy intensity of goods but are influenced by many other factors (de Ayala et al. 2020). Consequently, the goal of this analysis is to explore the interactions of these factors with the consideration of EE in purchasing decisions and to test a large number of factors. A binary response model (probit model) is thus used to explore the effect of several drivers on the weight given to EE. This enables drivers or factors to be analysed in isolation, i.e. keeping the rest

[3] CPS is a market research and opinion polling company that collects market and consumer information in Spain (https://www.cps2000.com/)

of the factors unchanged (*ceteris paribus*). Several earlier studies have used probit models for this type of approach in the energy context (Hrovatin et al. 2016; Liang et al. 2019; Olsthoorn et al. 2017; Schlomann and Schleich 2015). Other approaches in the literature, such as discrete choice experiments, do not keep other factors constant in order to analyse possible trade-off between a number of factors (Fleiter et al. 2012; Michelsen and Madlener 2012; Schleich 2009; Schleich and Gruber 2008). Both types of approach are useful and complementary for shedding more light on the topic.

The questionnaire contains sections on (i) socio-demographic and economic characteristics; (ii) the characteristics of HVAC systems; (iii) the attributes of the decision whether to purchase HVAC systems; (iv) barriers to EE investment; (v) understanding and use of existing labels and simulated monetary labels and (vi) environmental behaviour, including energy-saving habits and investments in green and energy-efficient equipment. More detailed information on the questionnaire, including all the questions, is presented in Appendix B.

## Barriers considered in the survey

The survey conducted here captures most of the relevant barriers for non-residential buildings identified in 'Barriers to energy efficiency in non-residential buildings'. Specifically, survey participants were asked to indicate their attitudes and beliefs concerning different market, behavioural and organisational barriers to EE. Respondents were asked to answer using a 4-point Likert scale ranging from "strongly disagree" to "strongly agree". Table 2 provides an overview of the fourteen barriers addressed in the survey.

Regarding market barriers, "EE does not vary" and "More energy consumption" reflect the low perceived profitability of EE. "More EE goods are less reliable" and "Uncertainty as to energy prices hinders EE investment" are expected to capture the risk and uncertainty related to investing in energy-efficient heating systems. "Loan access limits my purchases" and "Cannot afford to upgrade" capture the importance of external access to capital due to high interest rates but also internal access to capital because EE investments are often classified as less urgent than essential maintenance projects or strategic investments. And "Effectiveness of energy consumption information" refers to measures to make guests aware of energy consumption, aligning the incentives for energy savings between managers and guests. Behavioural failures are measured using several barriers that account for bounded rationality in EE investment decisions. The survey also inquired about organisational barriers such as willingness to take a chance on new technologies and the comfort and environmental values of the establishments, thus capturing information on the scale of EE investments in the accommodation sector.

## Econometric model

A binary response model is built up using a probit model (Greene 2003; Wooldridge 2002). The dependent variable represents the probability of hotels rating EE as a *very important* attribute of their HVAC investment decision. Based on the literature review in the previous section, we use explanatory variables from seven different categories referring to (i) geoclimatic areas; (ii) socio-economic characteristics; (iii) technical characteristics of HVAC systems; (iv) specific attributes of HVAC systems such as price, brand reliability, performance and noise; (v) barriers to investing in energy-efficient HVAC systems; (vi) knowledge and perception of monetary information labels; (vii) environmental behaviour and (viii) habits for energy savings and investment in green equipment. The general specification of the probit model applied can be expressed as follows:

$$\begin{aligned}\Pr\left(Y=1 \mid X\right) = {} & \beta_1 + \beta_2 \text{GeoClimatic areas} \\ & + \beta_3 \text{Socioeconomic characteristics} \\ & + \beta_4 \text{HVAC technical characteristics} \\ & + \beta_5 \text{HVAC specific attributes} \\ & + \beta_6 \text{Barriers to EE} \\ & + \beta_7 \text{Monetary information label} \\ & + \beta_8 \text{Environmental behaviour} \\ & + \beta_9 \text{Habits\&Investment} + \varepsilon \end{aligned} \qquad (1)$$

where $Y$ is "Energy Efficiency is a *very important* attribute in the purchasing decision", $X$ contains explanatory variables and $\varepsilon \sim N(0, 1)$ is the error term. The elements of the vector of parameters $[\beta_1, \ldots, \beta_9]$ are reported as the marginal effects of the explanatory variables on the consideration of EE, with all other attributes remaining unchanged

**Table 2** Overview of the barriers addressed in the survey ($N = 191$)

| Category | Variable | Mean | SD | Description |
|---|---|---|---|---|
| Market | | | | |
| Hidden costs | EE does not vary | 3.32 | 0.68 | Low perceived profitability of EE, considering that all new HVAC systems have similar EE levels. |
| | More energy consumption | 2.24 | 0.72 | The saving in EE would enable the services offered by the establishment to be expanded and more electrical appliances to be fitted, producing a rebound effect. |
| Risk and uncertainty | More EE goods are less reliable | 2.07 | 0.56 | More energy-efficient HVAC systems are less reliable. |
| | Uncertainty as to energy prices hinders EE investment | 3.28 | 0.67 | Uncertainty as to energy prices discourages investment in EE. |
| Access to capital | Loan access limits my purchases | 2.89 | 0.89 | Lack of access to loans (excluding loans from friends and family) prevents more energy-efficient choices from being made. |
| | Cannot afford to upgrade | 3.18 | 0.76 | The establishment cannot afford to upgrade the EE of its HVAC system. |
| Principal-agent problem | Effectiveness of energy consumption information | 3.11 | 0.76 | The establishment has effective measures to make guests aware of energy consumption. |
| Behavioural | | | | |
| Bounded rationality | Understand energy consumption | 2.37 | 0.67 | Good understanding of the energy consumption of the HVAC system at the establishment. |
| | Understand money saved | 2.55 | 0.77 | Good understanding of how much money would be saved if the establishment bought a more energy-efficient HVAC system. |
| | Aware energy price | 2.22 | 0.79 | Awareness of energy prices, i.e. the prices of the energy sources (gas, heating oil, electricity) that the establishment uses. |
| | Would buy if peers do so | 2.94 | 0.77 | The establishment would be more likely to buy an energy efficient HVAC system if other establishments did likewise. |
| Organizational | | | | |
| Power | Willingness to take a chance on new technologies | 2.74 | 0.78 | The establishment is willing to take a chance on new technologies to reduce its energy consumption. |
| Culture | EE upgrade improves comfort | 2.70 | 0.76 | EE upgrades increase the value of the establishment. |
| | Reduce environmental impact | 3.10 | 0.74 | Buying a more energy efficient HVAC system would reduce the establishment's environmental impact. |

(*ceteris paribus*). With binary independent variables, marginal effects measure a discrete change, i.e. how predicted probabilities change as the binary independent variable changes from 0 to 1. For a continuous independent variable, it measures the amount of change in the probability of considering EE produced by a 1-unit change of the independent variable as *very important*.

The explanatory variable "Barriers to EE" includes the market, behavioural and organisational barriers described above in 'Barriers considered in the survey'. All the barriers described in Table 2 were tested and the selection of the final model presented in Table 3 is based on the Akaike Information Criterion.

## Results and discussion

### Descriptive statistics

Descriptive statistics are used to describe and discuss the findings for the full sample in more detail regarding energy-efficiency considerations for the purchase of

**Table 3** Marginal effects of the EE attribute for hotels and similar establishments in Spain

| | Marginal effects | Standard error | $P > \|z\|$ |
|---|---|---|---|
| Geoclimatic areas | | | |
| Mediterranean (inland and coast) | -Reference | | |
| Atlantic (inland and coast) | 0.0485 | 0.142 | 0.733 |
| Continental (inland) | 0.283** | 0.102 | 0.005 |
| Subtropical (inland and coast) | 0.105 | 0.149 | 0.484 |
| Mountain (inland) | 0.00263 | 0.159 | 0.987 |
| Socioeconomic characteristics | | | |
| Hotel | -Reference- | | |
| Hostel (=1 yes) | 0.204** | 0.082 | 0.013 |
| Cottage (=1 yes) | 0.0884 | 0.126 | 0.482 |
| Owners of the building (=1 if yes) | − 0.0722 | 0.133 | 0.588 |
| Number of years in operation | 0.00278 | 0.002 | 0.265 |
| Occupancy rate in high season (range 0-100) | 0.00561** | 0.002 | 0.009 |
| HVAC technical characteristics | | | |
| HVAC system with natural gas (=1 yes) | − 0.103 | 0.153 | 0.502 |
| HVAC system with propane (=1 yes) | 0.380** | 0.141 | 0.007 |
| HVAC system with heating oil (=1 yes) | 0.0577 | 0.113 | 0.610 |
| HVAC system with electricity (=1 yes) | − 0.243** | 0.100 | 0.015 |
| Heating system with biomass (=1 yes) | − 0.0838 | 0.103 | 0.418 |
| HVAC system with geothermal (=1 yes) | − 0.164 | 0.245 | 0.504 |
| Heating-only system (=1 yes) | 0.0825 | 0.106 | 0.435 |
| HVAC-specific attributes | | | |
| Price (=1 if very important) | 0.192** | 0.088 | 0.029 |
| Brand reliability (=1 if very important) | 0.243*** | 0.078 | 0.002 |
| Performance (=1 if very important) | 0.269** | 0.088 | 0.002 |
| Noise (=1 if very important) | 0.138 | 0.088 | 0.117 |
| Barriers to energy-efficient HVAC systems | | | |
| Market barriers | | | |
| Loan access limits my purchases (=1 if strongly agree) | − 0.0788 | 0.097 | 0.419 |
| Effectiveness of energy consumption information (=1 if strongly agree) | 0.141 | 0.130 | 0.280 |
| Behavioural barriers | | | |
| Understand energy consumption (=1 if strongly agree) | − 0.0961 | 0.091 | 0.290 |
| Organisational barriers | | | |
| Willingness to take a chance on new technologies (=1 if strongly agree) | 0.171* | 0.094 | 0.069 |
| Monetary information label | | | |
| Understandable (=1 if strongly and slightly agree) | − 0.0658 | 0.121 | 0.588 |
| Trustworthy (=1 if strongly and slightly agree) | − 0.0886 | 0.108 | 0.411 |
| Influence on purchasing decision (=1 if strongly and slightly agree) | 0.0397 | 0.120 | 0.740 |
| Helpful to understand how much energy is consumed by HVAC (=1 if strongly and slightly agree) | 0.259** | 0.123 | 0.035 |
| Environmental behaviour | | | |
| Concern for the environment (=1 if extremely concerned) | 0.154* | 0.082 | 0.061 |
| Habits for energy savings | | | |
| HVAC automatic control (=1 if always) | 0.176* | 0.076 | 0.020 |

**Table 3** (continued)

| | Marginal effects | Standard error | $P > \|z\|$ |
|---|---|---|---|
| Information (=1 if always) | − 0.0666 | 0.090 | 0.457 |
| Investments in green and energy-efficient equipment | | | |
| EE appliances (=1 if yes) | − 0.0661 | 0.075 | 0.379 |
| EE windows (=1 if yes) | − 0.164 | 0.086 | 0.056 |
| Wall and roof insulation (=1 if yes) | − 0.186* | 0.082 | 0.023 |
| Light sensors (=1 if yes) | 0.0813 | 0.075 | 0.280 |
| Solar panels (=1 if yes) | 0.0706 | 0.082 | 0.389 |
| Observations | 191 | | |
| LR $chi^2(16)$ | 112.18 | | |
| Prob > $chi^2$ | 0.0000 | | |
| Pseudo $R^2$ | 0.4919 | | |
| Log likelihood | − 61.53 | | |

***, ** and * indicate significance at 1%, 5% and 10% level. Robust standard errors are used in the probit model

HVAC systems and to explain their socio-demographic background.

### *Socio-demographic and economic characteristics of establishments*

The socio-demographic and economic characteristics of an establishment may influence the adoption of EE HVAC. The establishments surveyed have been running on average for 17 years, with a range from 1 to 86 years. The average number of rooms is 26, but the range is wide: from 1 to 434. The average occupancy rate of rooms is 80% during the high season and 40% during the low season. In 2017, most establishments considered that their businesses were financially sound, and they did not envisage or anticipate financial problems in the future[4]. On a scale from 1 ("I am having major financial difficulties") to 10 ("My financial situation is very comfortable"), the average score is 6 for the present situation and 7 for expectations for the following 5 years (Table 5 in Appendix).

### *Technical characteristics and specific attributes of HVAC*

The HVAC systems used vary from one establishment to another, with more than one type of system in some cases (e.g. cottages with reverse cycle air conditioning system and fireplaces or wood stoves). 27% of establishments have combined HVAC systems, 72% have separate heating systems and 18% also have separate cooling systems. The energy sources used for separate heating systems are heating oil (39%), electricity (18%), biomass (17%), natural gas (13%), propane (9%) and renewable energies such as photovoltaic and geothermal energy (4%). Combined systems and separate cooling systems use electricity. On average, HVAC systems were installed 10 years ago, with a range from 1 to 65 years.

HVAC systems are not a recent innovation in the Spanish hotel industry and the willingness to upgrade the EE of systems is low. Only 6% of respondents reported that they had upgraded to a more energy-efficient HVAC system in the last 5 years and 94% reported that they did not plan to upgrade their HVAC systems in the next 5 years. They stated that their current HVAC was working properly and assigned less importance to other reasons (e.g. building infrastructure problems, limits on access to loans, the current HVAC covers the needs of the establishment). This may be considered as a limitation in the analysis.

Energy efficiency is the attribute most frequently rated as important in choosing an HVAC system (Fig. 1). 67% of respondents rate it as a *very important* attribute. Other attributes less highly rated than energy efficiency[5] are also classed as important in purchasing

[4] Note that the survey was conducted well before the COVID-19 crisis.

[5] Student's *t* tests report significant heterogeneity in the rating of attributes according to a test on the variance and indicate that the average rating of energy efficiency differs from that of brand reliability and performance with a 95% confidence level and from that of price and noise with a 90% confidence level.

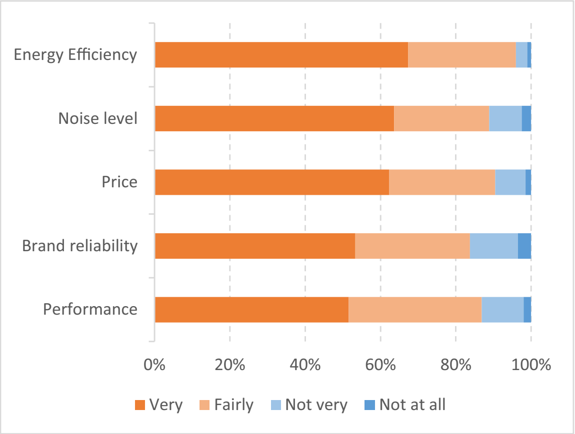


**Fig. 1** Importance of the attributes of HVAC systems in purchasing decisions for establishments in Spain

decisions: noise level (decibels) is ranked second (64% rate it as *very important*), followed by price (62%). Brand reliability (i.e. durability and technical and maintenance support) and performance (such as automatic control, temperatures adjustable according to outside temperature and humidity level, heat recovery and integrated heating and cooling functions) are also rated as *very important* by at least 50% of respondents.

### *Barriers to energy-efficient HVAC systems*

The three families of barriers identified in the literature were investigated in the survey and in the preliminary in-depth interviews (see Fig. 2) using fourteen statements.

Regarding market barriers, the vast majority of respondents were found to believe in the reliability of energy-efficient equipment: about 83% disagreed or strongly disagreed with the idea that more energy-efficient HVAC systems were less reliable. This is supported by Peruzzi et al. (2014), who reveal the importance of reliability for HVAC systems, especially for those systems that must guarantee uninterrupted service. 67% of respondents answered that lack of access to loans was an important barrier limiting their energy-efficient HVAC purchases. It is also important to consider that about 61% of respondents strongly or slightly believed that specific measures could make customers more aware of and more responsible regarding their energy consumption. As for behavioural barriers, 38% of respondents knew how much energy their equipment consumed, and 34% were aware of energy prices, but only 7.5% strongly agreed that they understand how much money they would save if they bought a more energy-efficient HVAC system. Concerning organisational barriers, about 39% of respondents strongly agreed that they were willing to take a chance on new technology to reduce their energy consumption and only 30% of respondents stated that they could not afford to buy a new, energy-efficient HVAC system. It is also important to highlight that about 43% of respondents strongly agreed that buying a HVAC system with more energy-efficient properties would reduce their environmental impact.

### *The role of energy efficiency labels*

Several studies highlight the importance of labelling schemes in preventing informational failures and consequently addressing the EE gap (Carroll et al. 2016; Lucas and Galarraga 2015). We therefore also analyse the role of ecodesign[6] and energy labelling[7] regulations used in HVAC systems. According to Figs. 3 and 4, in the case of both heating and cooling systems only half the respondents (i.e. 100 respondents) acknowledged the existence of the energy label and/or technical specifications label. 70% of those respondents who were aware of the ecodesign and energy labelling of heating systems stated that these labels had influenced past purchasing decisions for heating systems (see Fig. 3), and 74% of those aware of ecodesign and energy labelling of cooling systems stated that these labels had influenced past purchasing decisions for such systems (see Fig. 4). In addition, 97% of the respondents agreed with the statement that their company considered energy efficiency labels when purchasing heating and cooling systems. That is, their answers to this question were not directly linked to past purchasing decisions being conditioned by the label. In fact, they may be reflecting future preferences too.

[6] The first ecodesign regulation was implemented in 1992 for new hot-water boilers fired with liquid or gaseous fuels (92/42/EEC) and later extended to energy-using products (2005/32/EC). The latest ecodesign regulation, published in 2016 (2016/2281/EU) implementing Directive 2009/125/EC, summarises the most relevant information on energy performance, EE and the emission of nitrogen oxides from air heating and cooling products, high temperature process chillers and fan coil units.

[7] Most heating and cooling products are also covered by energy labelling regulations and use technical labels which include information on the energy rating of their cooling and heating functions and indications of their hourly or annual energy consumption and their noise levels. The information on the label and its design vary depending on product regulations: 2002/31/EC for air conditioners, repealed by 626/2011/EU; 811/2013/EU for space heaters and combination heaters; 2015/1186/EU for local space heaters, 2015/1187/EU for solid fuel boilers; all of them supplementing Directive 2010/30/EU.

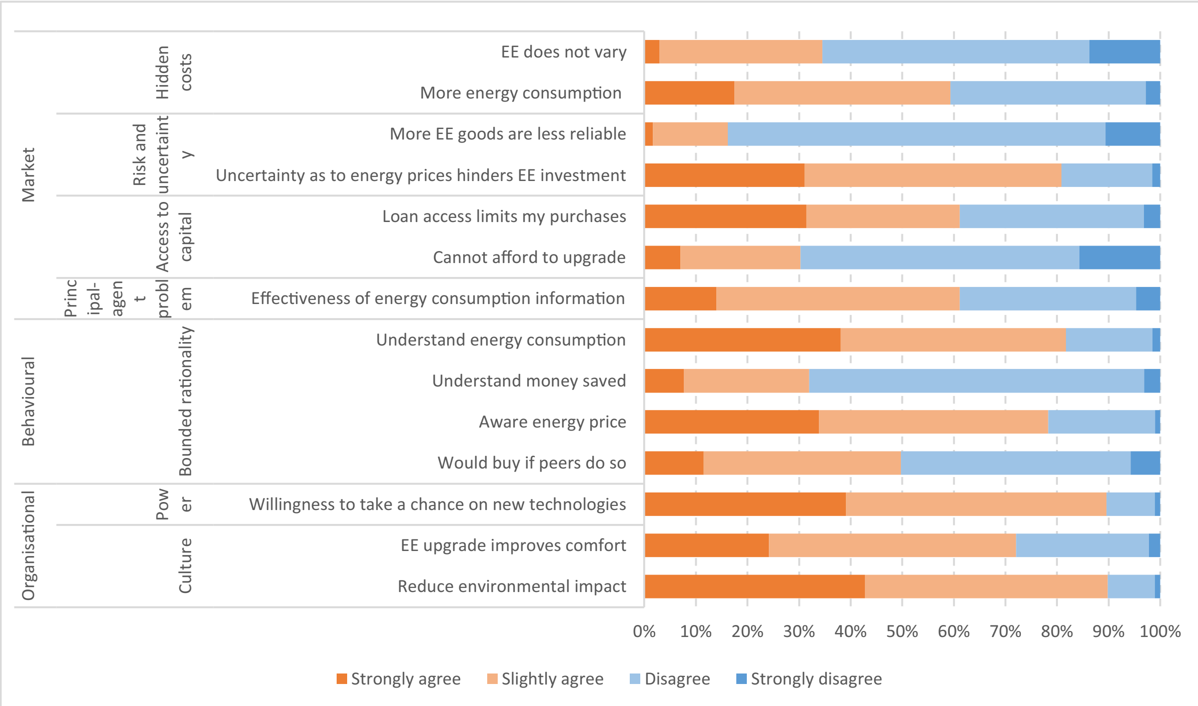


**Fig. 2** Agreement with drivers and barriers for energy-efficient HVAC systems for hotel establishments in Spain. Note: The respondents indicated their agreement to several statements on a scale with the four ordered response categories "strongly agree", "slightly agree", "disagree" and "strongly disagree"

Several studies of the effectiveness of energy labelling suggest different ways of improving such labels, so it is important to understand how consumers use the information on the labels in their purchasing decisions (Heinzle and Wüstenhagen 2012; Stadelmann and Schubert 2018). In this regard, the responses in the study reported here indicate a high level of agreement about understanding of and trust in existing energy-efficiency labels.

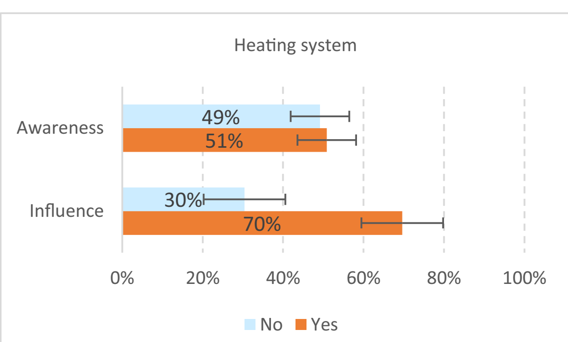


**Fig. 3** Awareness and influence of ecodesign and energy labelling regulations with 95% confidence intervals. "Influence" data refers to those respondents who are aware of both types of regulation

This study also analyses the role of labels in HVAC systems with energy-cost information and incorporate those statements into the survey presented in 'Barriers considered in the survey'. Ninety percent of hotel owners think that labels with additional monetary information are more understandable and trustworthy (85%) than existing EE labels, and 92% of respondents said that these labels would influence their purchasing decisions. In fact, most

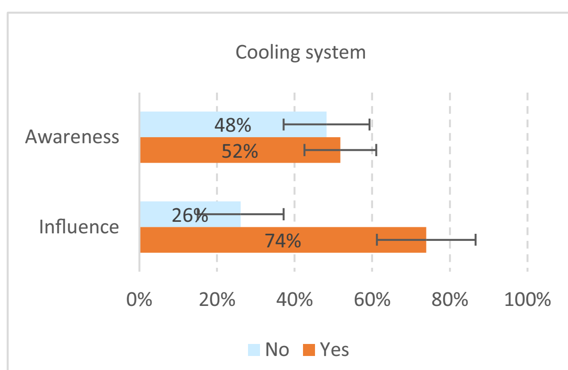


**Fig. 4** Awareness and influence of ecodesign and energy labelling regulations with 95% confidence intervals. "Influence" data refers to those respondents who are aware of both types of regulation

respondents believed that a label with additional monetary information would be more helpful in understanding how much energy was consumed by an HVAC system (89%) and calculating how much it cost to run (88%). Finally, 30% of respondents believed that there was a risk of labels potentially being manipulated by manufacturers.

### *Hotel owners' attitudes towards the environment*

Lastly, this study includes attitudes and beliefs about environmental issues. Eighty-six percent of respondents stated that they were concerned or extremely concerned about the environment. Habits for energy savings and investments in green and energy-efficient equipment were measured using a survey question validated by the OECD (2011). Regarding energy saving behaviour, we analyse how often establishments implement the following practices in their business: automatic control of HVAC systems or regular information to promote responsible consumption of energy and water by workers. Answers were classified into the following categories: "Never", "Occasionally", "Often" and "Always". The responses indicate a high level of recognition of these practices. Specifically, 37.5% of respondents stated that they always automatically controlled the use of HVAC systems in rooms (e.g. by using smart key cards, smart thermostats or on/off programming). Seventy-one percent also answered that they always provided information on energy consumption to promote responsible energy consumption among workers.

In regard to other energy-efficiency investments, this study analyses whether establishments have invested or not in green and energy-efficient equipment, with the following response categories: "Yes", "No", "Already equipped, more than 10 years ago", and "Not possible/feasible in my establishment". It is important to note that 66% of respondents have energy-efficient appliances (e.g. minibars or TVs) installed. All respondents except one were also found to have invested in LED lighting. Seventy percent of establishments stated that they had invested in energy-efficient windows and thermal insulation of walls and roofs. Sixty percent said that they had sensors for controlling lights and temperature in common areas. Finally, respondents were asked to indicate whether they had invested in solar panels for electricity generation or for heating water. Such investments were found to be much less common, with only 23.5% of establishments equipped with this technology. According to Caird et al. (2008), this may be explained by barriers such as uncertainty as to the performance and reliability of the technology.

### Factors influencing the importance assigned to EE as an attribute

The factors influencing the rating of EE as a *very important* attribute were explored in a probit model. The results are presented in Table 3. All categories of factors have an influence on the probability of the value EE very importantly.

Establishments in areas with a continental climate are 28% more likely to value EE as a *very important* attribute than those located in a Mediterranean climate. Managers of establishments in areas characterised by hot summers and cold winters are more interested in EE as it might reduce energy-related running costs of air conditioning and heating. The type of establishment also plays a significant role: hostels are 20% more likely to value EE as a *very important* attribute than hotels. This may be because small establishments are more concerned about energy bills, given that they have lower personnel costs and higher energy costs than larger hotels. Another reason may be that the level of insulation in hostels is lower. Financial soundness was found to be significantly correlated with occupancy rates during the high season. The latter variable was used to avoid collinearity in the regression to capture the income situation. Establishments with higher occupancy rates and thus higher energy consumption are more likely to value EE as a *very important* attribute. For example, those with an 80% occupancy rate[8] are 45% more likely to do so. The possible reason is that higher occupancy establishments may have higher energy costs and so they may recoup EE investments more rapidly. We find no evidence of barriers to access to capital in the rating of EE.

Some technical characteristics of HVAC systems have a significant impact on ratings. Establishments with HVAC systems that run on propane are 38% more likely to value EE as a *very important* attribute. In terms of energy price, a comparison of the energy sources considered in this study reveals that propane costs more than natural gas but less than heating oil and electricity for heating (EIA 2020). The higher price of propane may lead owners to use energy-efficient equipment so as to reduce their HVAC bills. Nevertheless, buildings in Spain are less likely to have propane-fired HVAC

[8] This corresponds to the average and median rates of occupancy.

systems than buildings in other countries (e.g. the USA) (EIA 2011), which suggests that effects involving this technology should be interpreted with caution. On the other hand, establishments that use electricity are 24% less likely to rate EE as a *very important* attribute. This may be for two reasons: one is that establishments which use electricity are relatively unconcerned about EE and the other is that energy consumption in these establishments is lower than energy consumption in other establishments.

Attributes of HVAC systems such as price, brand reliability and performance are also important determinants of the decisions made by establishments. Specifically, respondents who consider price as a *very important* attribute are 19% more likely to value EE as a *very important* attribute. One interpretation of this positive relationship concerns the budget constraints of consumers. Consumers with a binding budget constraint rate price (namely low prices) and EE as important in reducing running costs. Energy-efficient goods are more expensive, so these consumers are less likely to buy such goods. This budget constraint explains EE campaigns with financial incentives to buy energy-efficient goods. Other studies show that energy-efficient equipment is more price-elastic than regular equipment (Coad et al. 2009; Galarraga et al. 2011). Other attributes, such as brand reliability and performance, also significantly affect the rating of EE, to a similar extent to prices[9]. Indeed, respondents who rate the brand reliability and performance of HVAC systems as a *very important* attribute are 24% and 27% more likely, respectively, to rate EE as a *very important* attribute. Brand reliability and performance are thus as important as price is in the rating of EE. These findings provide evidence that consumers prefer energy-efficient HVAC systems which also have good performance and good brand reliability. This could indicate that they may be considering EE as a proxy for quality, i.e. considering the ability of HVAC systems to fulfil a specific requirement.

The attitude towards specific barriers as regards EE also helps to explain why EE is rated as *very important*. Respondents who strongly agree with taking a chance on new technologies to reduce their energy consumption are 17% more likely to rate EE as a *very important* attribute. This result, combined with the intention to upgrade HVAC systems, however, seems to indicate a gap between beliefs and purchasing decisions due to the barriers to EE adoption reviewed above. Indeed, 40% of respondents indicated that they were willing to take a chance on new technologies to reduce their energy consumption, but only 6% reported that they planned to change their HVAC systems. Similar results are observed in household energy-efficiency choices. Damigos et al. (2020) find no evidence that this same belief increases the purchase of energy-efficient refrigerators.

In regard to the role of monetary information labels, we find that hotel owners who state that a label with additional monetary information would be more helpful than the current label are 26% more likely to rate EE as a *very important* attribute.

Environmental concerns are also a factor in explaining EE in the hotel industry. On average, owners more concerned about the environment are 15% more likely to rate EE as a *very important* attribute. This finding is consistent with those of other studies such as Damigos et al. (2020) and Shen (2008), who show that the importance of EE is positively affected by the proenvironmental behaviour of the respondents. Energy-saving habits positively influence the probability of rating EE as a *very important* attribute, as expected from other studies (Palm 2009). Indeed, establishments that always control the use of HVAC systems in rooms automatically (e.g. using smart key cards or on/off programming) are 18% more likely to rate EE as a *very important* attribute. This result supplements the existing literature on EE measures in the service sector, which finds that factors affecting the adoption of high-cost technologies such as HVAC systems also affect the adoption of low-cost measures (e.g. switching off lights whenever possible or managing and controlling energy use) (Schlomann and Schleich 2015).

Interestingly, we find that establishments with thermal insulation in walls and roofs are 19% less likely to rate EE as a *very important* attribute. This seems to indicate a negative feedback from nonHVAC-related EE investment in the rating of EE. Establishments which invest in insulation have lower heating and cooling consumption, so their need for energy-efficient HVAC systems, or the savings brought by them, is lower. This may lead them to underrate the EE attribute. Moreover, it would make sense for owners to scale down the importance of this attribute for the future once major action towards it has been taken. Another potential explanation is that establishments which undertake substantial environmental actions such as investing in insulation and energy-efficient windows feel less motivated

[9] A test of equality of marginal effects for brand, performance and price fails to reject it.

to adopt further proenvironmental measures. They believe that their investment in thermal insulation of walls and roofs has already helped to mitigate climate change. This result supports previous findings on environmental concerns and energy mitigation behaviour (Nauges and Wheeler 2017; van der Linden 2017). For example, Nauges and Wheeler (2017) find that adoption of mitigation behaviour may have a negative effect on a household's climate change concerns.

## Conclusions

HVAC systems are major consumers of energy in the hotel industry, and reducing and decarbonising energy consumption on heating and cooling is crucial for the energy transition. EE provides an important pathway for reducing energy consumption, generating energy savings and reducing energy expenses. However, it is often observed that investments in EE are lower than they should be. The analysis reported here, based on a survey of the hotel industry, identifies factors that influence the EE choices of Spanish accommodation owners and contributes to the literature exploring the barriers to EE investment in that industry.

The main results of this study are that hotel accommodation owners rate EE highly in their purchasing decisions but that several barriers limit the importance attributed to EE and thus their investment in EE. Those factors are related to the market and to individual behavioural and organisational factors.

There is evidence of lack of information and bounded rationality, because only a third of all respondents know how much energy their equipment consumes and what the price of energy is. Results also show that the decision of whether to purchase HVAC seems to be affected by existing energy labels, and establishments believe that a label with additional monetary information would be more understandable and helpful in understanding how much energy is consumed by HVAC systems and in calculating how much HVAC would cost to run.

The market price of goods also influences how highly EE is rated by owners. Lower prices would help to increase the importance attributed to EE, and other attributes reflecting the quality of goods, such as brand reliability and performance in terms of services provided, also positively influence EE.

Organisational factors such as the importance attributed to new technologies and environmental concerns are also a factor in explaining EE in the hotel industry, although there is a gap between beliefs and purchasing decisions.

Climate considerations, information and the technical characteristics of establishments affect how highly the energy-efficiency attribute is rated. A negative feedback effect is detected from investment in other EE goods but not in HVAC-related equipment. Establishments with thermal insulation in walls and roofs are less likely to rate EE as a *very important* attribute. However, those that always control the use of HVAC systems in rooms automatically (e.g. by using smart key cards or on/off programming) are more likely to rate EE as a *very important* attribute.

This research has several policy implications. To design the right EE policy, one must account for the potential responses by agents, and the analysis reported here helps identify the drivers to which they may or may not respond. This is consistent with the findings of Blasch et al. (2018), who analyse the concept of "energy-related financial literacy" (which measures the level of energy-related knowledge and cognitive abilities that consumers need in order to take decisions with respect to investment for the production of energy services and their consumption). One of the points brought to light by our survey is the lack of knowledge among owners of hotel establishments about the energy and monetary savings provided by more energy-efficient equipment. This clearly indicates that it is of interest to use information-based policy instruments such as labels, energy audits and feedback on bills. This is reinforced by the fact that many owners do value the information provided by labels, and would like that information to be included.

This analysis also shows that different responses may be obtained in different climates: policies could be directed first at those areas, such as continental climates, where agents are more responsive to EE concerns. Also, in terms of directing policies, interaction with building retrofitting also needs to be accounted for, given that interest in EE HVACs decreases when buildings have been thermally insulated.

Energy taxes help reduce free-riding and rebound effects, and may also help accentuate pro-energy-efficiency attitudes among current owners of HVAC systems based on fossil fuels. Energy demand measured trough the occupancy rate is found to influence the rating of EE positively. A higher associated cost for energy would therefore reinforce the importance given to EE help owners reconsider their currently low willingness to upgrade HVAC systems, though subsidies may also be required to help overcome the bounded rationality problem. Subsidies may also help overcome the gap between beliefs and purchasing decisions.

Finally, the fact that EE is strongly linked with price, brand reliability and performance means that those who invest in cheaper, low-quality equipment seem less likely to rate EE highly. Here, the introduction of stricter, mandatory EE standards across the board would ensure that energy is saved even in such cases.

However, it is worth remarking once again that our study addresses potential barriers to the adoption of EE but is not able to measure how they translate into underinvestment in EE, given the low replacement rate in the sample. This would be of course a very welcome element for improving policies, and to determine the real consequences of these barriers. Further research is ongoing in this area.

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**Declarations**

**Conflict of interest** The authors declare that they have no conflict of interest.

## Appendix A Descriptive statistics for dependent and explanatory variables (*N* = 191)

**Table 4.** Detailed information on hotel industry establishments

| Geoclimatic areas | Mediterranean | | | Atlantic | | Continental | Subtropical | | Mountain |
|---|---|---|---|---|---|---|---|---|---|
| | Coast | Inland | | Coast | Inland | Inland | Coast | Inland | Inland |
| | 8% | 13% | | 7% | 14% | 21.5% | 6.5% | 8.5% | 21.5% |
| Type of accommodation | Hotel | | | Hostel | | | Cottage | | |
| | 33.5% | | | 33.5% | | | 33% | | |
| Star-rating | Five Gold Star<br>1.49%<br>Four Gold Star<br>25.37%<br>Three Gold Star<br>29.85%<br>Two Gold Star<br>23.88%<br>One Gold Star<br>19.40% | | | Three Silver Star<br>1.49%<br>Two Silver Star<br>50.75%<br>One Silver Star<br>47.76% | | | Five "Wheat ears"<br>1.52%<br>Four "Wheat ears"<br>4.55%<br>Three "Wheat ears"<br>16.67%<br>Two "Wheat ears"<br>15.15%<br>One "Wheat ears"<br>15.15%<br>Not defined<br>46.97% | | |
| Number of rooms | From < 10 to > 150 | | | From < 5 to > 25 | | | From < 3 to > 7 | | |
| | Mean | Min | Max | Mean | Min | Max | Mean | Min | Max |
| | 58.42 | 6 | 434 | 15.15 | 3 | 42 | 15.15 | 3 | 28 |

**Table 5** Descriptive statistics for the dependent and explanatory variables included in the econometric analysis

| Variable | Unit | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| Type of accommodation | Number<br>1= Hotel<br>2= Hostel<br>3= Cottage | 1.99 | 0.82 | 1 | 3 |
| Climate | Number<br>1=Mediterranean (coast & inland)<br>2=Atlantic (coast & inland)<br>3=Continental (coast & inland)<br>4=Subtropical (coast & inland)<br>5=Mountain (inland) | 2.95 | 1.44 | 1 | 5 |
| Owners of the building (=1 if yes) | 0/1 dummy | 0.88 | 0.33 | 0 | 1 |
| Number of years in operation | Number | 16.72 | 15.27 | 1 | 86 |
| Occupancy rate in high season | % | 79.99 | 17.84 | 10 | 100 |
| Current financial situation | Number | 6.40 | 1.62 | 2 | 10 |
| Future financial situation | Number | 7.22 | 1.58 | 2 | 10 |
| EE as a very important attribute | 0/1 dummy | 0.67 | 0.47 | 0 | 1 |
| HVAC system with natural gas | 0/1 dummy | 0.13 | 0.33 | 0 | 1 |
| HVAC system with propane | 0/1 dummy | 0.10 | 0.30 | 0 | 1 |
| HVAC system with heating oil | 0/1 dummy | 0.36 | 0.47 | 0 | 1 |
| HVAC system with electricity | 0/1 dummy | 0.58 | 0.50 | 0 | 1 |
| Heating system with biomass | 0/1 dummy | 0.15 | 0.36 | 0 | 1 |
| HVAC system with geothermal | 0/1 dummy | 0.01 | 0.10 | 0 | 1 |
| Heating-only system | 0/1 dummy | 0.72 | 0.45 | 0 | 1 |
| Price (=1 if very important) | 0/1 dummy | 0.62 | 0.49 | 0 | 1 |
| Brand reliability (=1 if very important) | 0/1 dummy | 0.53 | 0.50 | 0 | 1 |
| Performance (=1 if very important) | 0/1 dummy | 0.51 | 0.50 | 0 | 1 |
| Noise (=1 if very important) | 0/1 dummy | 0.63 | 0.48 | 0 | 1 |
| Access to loans limits my purchases (=1 if strongly agree) | 0/1 dummy | 0.30 | 0.46 | 0 | 1 |
| Understand the energy consumption (=1 if strongly agree) | 0/1 dummy | 0.38 | 0.49 | 0 | 1 |
| Take a chance on new technologies (=1 if strongly agree) | 0/1 dummy | 0.38 | 0.49 | 0 | 1 |
| Effectiveness of energy consumption information (=1 if strongly agree) | 0/1 dummy | 0.14 | 0.34 | 0 | 1 |
| Understandable (=1 if strongly and slightly agree) | 0/1 dummy | 0.85 | 0.36 | 0 | 1 |
| Trustworthy (=1 if strongly and slightly agree) | 0/1 dummy | 0.79 | 0.41 | 0 | 1 |
| Influence on purchasing decision (=1 if strongly and slightly agree) | 0/1 dummy | 0.87 | 0.34 | 0 | 1 |
| Helpful to understand how much energy is consumed by HVAC (=1 if strongly and slightly agree) | 0/1 dummy | 0.83 | 0.38 | 0 | 1 |
| Concern for the environment (=1 if extremely concerned) | 0/1 dummy | 0.43 | 0.50 | 0 | 1 |
| Automatic control (=1 if always) | 0/1 dummy | 0.38 | 0.49 | 0 | 1 |
| Regular information to promote responsible consumption of energy and water (=1 if always) | 0/1 dummy | 0.71 | 0.45 | 0 | 1 |
| EE Appliances (=1 if yes) | 0/1 dummy | 0.58 | 0.50 | 0 | 1 |
| EE windows (=1 if yes) | 0/1 dummy | 0.60 | 0.49 | 0 | 1 |
| Wall and roof insulation (=1 if yes) | 0/1 dummy | 0.56 | 0.50 | 0 | 1 |
| Sensors (=1 if yes) | 0/1 dummy | 0.59 | 0.49 | 0 | 1 |
| Solar panels (=1 if yes) | 0/1 dummy | 0.24 | 0.43 | 0 | 1 |

## Appendix B

**Table 6.** Full questionnaire for hotel industry establishments in Spain

| Screening | Category of answer/coding |
|---|---|
| Type of accommodation | 1 (Hotel); 3 (Hostel); 4 (Cottage) |
| Climate zones | 1 (Mediterranean-Coast); 2 (Mediterranean-Inland); 3 (Atlantic-Coast); 4 (Atlantic-Inland); 5 (Continental-Coast); 6 (Continental-Inland); 7 (Subtropical-Inland); 8 (Mountain-Inland) |
| Do you own the building or does your establishment operate in the building under a lease agreement? | 1 (Owner); 2 (lease agreement) |
| Are you the person in charge of making the decision whether to purchase HVAC systems? | 1 (Yes); 0 (No) |
| HVAC Technical characteristics | |
| Please indicate the type of HVAC system at your establishment | |
| Reverse cycle air conditioning system (cold and hot air) | 0 (No); 1 (Yes) |
| Heating-only system (wall radiator, portable radiator, fireplace or wood stove, underfloor heating) | 0 (No); 1 (Yes) |
| Cooling-only system (fixed or portable) | 0 (No); 1 (Yes) |
| Ceiling fan | 0 (No); 1 (Yes) |
| Other | [Open text] |
| Energy source used for HVAC system: | |
| Natural gas | 0 (No); 1 (Yes) |
| Propane | 0 (No); 1 (Yes) |
| Heating oil | 0 (No); 1 (Yes) |
| Electricity | 0 (No); 1 (Yes) |
| Biomass | 0 (No); 1 (Yes) |
| Solar energy | 0 (No); 1 (Yes) |
| Geothermal energy | 0 (No); 1 (Yes) |
| Other | [Open text] |
| How old is your HVAC system? | |
| Reverse cycle air conditioning system (cold and hot air) | [Open text] |
| Heating-only system, wall radiator | [Open text] |
| Heating-only system, portable radiator | [Open text] |
| Heating-only system, fireplace or wood stove | [Open text] |
| Heating-only system, underfloor heating | [Open text] |
| Cooling-only system, fixed | [Open text] |
| Cooling-only system, portable | [Open text] |
| Ceiling fan | [Open text] |
| Other systems | [Open text] |
| Attributes of the purchasing decision | |
| Has your establishment changed its HVAC system in the last 5 years? | 0 (No); 1 (Yes); -999 (Don't know /No answer) |
| [if Q5=NO] Why? | |
| Our HVAC system works properly | 0 (No); 1 (Yes); -999 (Don't know / No answer) |
| Because the infrastructure of the building makes it difficult | 0 (No); 1 (Yes); -999 (Don't know / No answer) |
| Lack of access to finance | 0 (No); 1 (Yes); -999 (Don't know / No answer) |

**Table 6.** (continued)

| | |
|---|---|
| I consider that the current HVAC system is the most efficient | 0 (No); 1 (Yes); -999 (Don't know / No answer) |
| The current HVAC system was installed recently | 0 (No); 1 (Yes); -999 (Don't know / No answer) |
| I have other refurbishments planned and cannot afford also to change the establishment's HVAC systems | 0 (No); 1 (Yes); -999 (Don't know / No answer) |
| Because the current HVAC system covers the needs of our establishment | 0 (No); 1 (Yes); -999 (Don't know / No answer) |
| Other | [Open text] |
| [if Q5=1] For what purpose? | |
| To modernize the HVAC system | 0 (No); 1 (Yes); -999 (Don't know / No answer) |
| To switch to a more efficient HVAC system | 0 (No); 1 (Yes); -999 (Don't know / No answer) |
| To install a reversible system (heating, hot water and air conditioning) | 0 (No); 1 (Yes); -999 (Don't know / No answer) |
| To change the energy source used by the HVAC system | 0 (No); 1 (Yes); -999 (Don't know / No answer) |
| Other | [Open text] |
| Do you intend to change the current HVAC system at your establishment in the *next 5 years*? | 0 (No); 1 (Yes); -999 (Don't know / No answer) |
| Please rate the importance of each of the following characteristics when buying an HVAC system | |
| Price | 1 (not at all important); 2 (not very important); 3 (fairly important); 4 (very important); -999 (Don't know/ No answer) |
| Energy efficiency/energy consumption | 1 (not at all important); 2 (not very important); 3 (fairly important); 4 (very important); -999 (Don't know/ No answer) |
| Brand reliability (durability, technical and maintenance support, etc.) | 1 (not at all important); 2 (not very important); 3 (fairly important); 4 (very important); -999 (Don't know/ No answer) |
| Performance (hot and cool air, remote control, etc.) | 1 (not at all important); 2 (not very important); 3 (fairly important); 4 (very important); -999 (Don't know/ No answer) |
| Noise | 1 (not at all important); 2 (not very important); 3 (fairly important); 4 (very important); -999 (Don't know/ No answer) |
| Attitudes towards EE (exploring costs and benefits) | |
| Please state whether you disagree or agree with the following statements in relation to energy efficiency: | |
| Buying a more energy efficient HVAC system would reduce my establishment's environmental impact | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| All new HVAC systems have similar EE levels | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| More energy-efficient HVAC systems are less reliable | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| I am willing to take a chance on new technologies to reduce my establishment's energy consumption | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/No answer) |
| Lack of access to loans (excluding loans from friends and family) prevents us from making more energy-efficient choices | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| I have a good understanding of the energy consumption of the HVAC system at the establishment | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| I am aware of energy prices, i.e. the price of the energy sources (gas, heating oil, electricity) that our establishment uses | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| I understand how much money I would save if my establishment bought a more energy-efficient HVAC system | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| My establishment would be more likely to buy an energy-efficient HVAC system if other establishments also do so | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| My establishment cannot afford to upgrade the EE of our HVAC system | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| EE upgrades increase the value of the establishment | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree);-999 (Don't know/ No answer) |
| The saving in EE would enable us to expand the services offered by our establishment and fit more electrical appliances | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree);-999 (Don't know/ No answer) |
| The establishment has effective measures to make the customer aware of energy consumption | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree);-999 (Don't know/ No answer) |

**Table 6.** (continued)

| | |
|---|---|
| Uncertainty as to the price of energy discourages investment in energy efficiency | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree);-999 (Don't know/ No answer) |
| Understanding and use of existing labels and simulated monetary labels | |
| Are you aware of the Energy Label and Data Sheet for HVAC systems? | 0 (No); 1 (Yes) |
| Did the Energy Label and/or Data Sheet affect your choice of an HVAC system? | 0 (No); 1 (Yes); -998 (Not applicable); -999 (Don't know) |
| Please state whether you disagree or agree with the following statements in relation to the information provided in the Energy Efficiency label and Data Sheets for HVAC systems: | |
| It is understandable | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| It is trustworthy | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| It is manipulated by sellers | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| It influences my choice of an HVAC system | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| It helps me to understand how much energy an HVAC system consumes | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| It helps me calculate how much an HVAC system will cost to run | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| Imagine an energy label with energy cost information for HVAC systems, e.g. "It is estimated that the lifetime energy cost of an HVAC system that consumes 4,000 kWh (10 years) is €5,000". In relation to this new information, please state whether you disagree or agree with the following statements: | |
| It would be understandable | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| It would be trustworthy | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| It would be manipulated by sellers | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| It would influence my choice of an HVAC system | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| It would help me to understand how much energy an HVAC system consumes | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| It would help me calculate how much an HVAC system will cost to run | 1 (strongly disagree); 2 (slightly disagree); 3 (slightly agree); 4 (strongly agree); -999 (Don't know/ No answer) |
| Environmental concerns | |
| Please rate how concerned your establishment is about the environment (for example, pollution, global warming and climate change) | 1 (not concerned); 2 (slightly concerned); 3 (concerned); 4 (extremely concerned); -999 (Don't know/ No answer) |
| Habits for energy savings | |
| How often does your establishment perform the following in your day to day operations? | |
| Automatic control of HVAC systems in rooms, for example, smart key cards, programming the power button to turn on and off, smart thermostats, etc. | 1 (never); 2 (occasionally); 3 (often); 4 (always); -999 (Don't know/ No answer) |
| Periodic information to promote responsible consumption of water and energy among workers | 1 (never); 2 (occasionally); 3 (often); 4 (always); -999 (Don't know/ No answer) |
| Investments in green and energy-efficient equipment | |
| Has your business installed any of the following items for energy savings in the last 10 years? | |

**Table 6.** (continued)

| | |
|---|---|
| Top-rated energy-efficient electronic devices (e.g. TVs, computers) | 1 (yes); 2 (no); 3 (already equipped, more than 10 years ago); 4 (not possible / feasible in my building) |
| Low-energy light bulbs (compact fluorescent, LED) | 1 (yes); 2 (no); 3 (already equipped, more than 10 years ago); 4 (not possible / feasible in my building) |
| Energy-efficient windows (e.g. double or triple glazed windows) | 1 (yes); 2 (no); 3 (already equipped, more than 10 years ago); 4 (not possible / feasible in my building) |
| Thermal insulation of walls/roof | 1 (yes); 2 (no); 3 (already equipped; more than 10 years ago); 4 (not possible / feasible in my building) |
| Sensors for controlling the switching on and off of lights in common areas | 1 (yes); 2 (no); 3 (already equipped; more than 10 years ago); 4 (not possible / feasible in my building) |
| Solar panels | 1 (yes); 2 (no); 3 (already equipped, more than 10 years ago); 4 (not possible / feasible in my building) |
| Socioeconomic characteristics | |
| How would you describe your current income on a scale from 1 to 10, where 1 means that your establishment is having financial difficulties and 10 means that it is financially very sound | 1 (The lodging has financial difficulties); 2; 3; 4; 5; 6; 7; 8; 9; 10 (The lodging has a very good financial situation); -999 (Don't know / No answer) |
| How would you describe your incomes during the next five years on a scale from 1 to 10, where 1 means that your establishment is expected to have financial difficulties and 10 means that it is expected to be financially very sound | 1 (The lodging will have financial difficulties); 2; 3; 4; 5; 6; 7; 8; 9; 10 (The lodging will have a very good financial situation); -999 (Don't know / No answer) |
| Hotel star rating | 1 (Five gold stars); 2 (Four gold stars); 3 (Three gold stars); 4 (Two gold stars); 5 (One gold star) -998 (Not applicable) |
| Hostel star rating | 6 (Three silver stars); 7 (Two silver stars); 8 (One silver star); -998 (Not applicable) |
| Cottage star rating | 9 (One wheat ear); 10 (Two wheat ears); 11 (Three wheat ears); 12 (Four wheat ears); 13 (Five wheat ears); 14 (Not specified); -998 (Not applicable) |
| Years in business | [open text] |
| Number of rooms | [open text] |
| Months of high season and low season: January, February, March, April, May, June, July, August, September, October, November, December | 0 (No); 1 (Yes) |
| What is the average occupancy rate in high and low season? (%) | [open text] |

## References


Bertoldi, P., López-Lorente, J., Labanca, N., 2018. Energy consumption and energy efficiency trends in the EU-28 2000-2015 [WWW Document]. EU Science Hub - European Commission. URL https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/energy-consumption-and-energy-efficiency-trends-eu-28-2000-2015 ().

Biardeau, L. T., Davis, L. W., Gertler, P., & Wolfram, C. (2020). Heat exposure and global air conditioning. *Nat Sustain, 3*, 25–28. https://doi.org/10.1038/s41893-019-0441-9.

Blasch, J., Boogen, N., Daminato, C., & Filippini, M. (2018). *Empower the consumer! Energy-related financial literacy and its socioeconomic determinants (SSRN Scholarly Paper No. ID 3175874)*. Rochester: Social Science Research Network. https://doi.org/10.2139/ssrn.3175874.

Blasch, J., Filippini, M., & Kumar, N. (2019). Boundedly rational consumers, energy and investment literacy, and the display of information on household appliances. *Resour Energy Econ, 56*, 39–58. https://doi.org/10.1016/j.reseneeco.2017.06.001.

Cagno, E., Worrell, E., Trianni, A., & Pugliese, G. (2013). A novel approach for barriers to industrial energy efficiency. *Renew Sust Energ Rev, 19*, 290–308. https://doi.org/10.1016/j.rser.2012.11.007.

Caird, S., Roy, R. E., & Herring, H. (2008). *Improving the energy performance of UK households: Results from surveys of consumer adoption and use of low- and zero-carbon technologies*. https://doi.org/10.1007/s12053-008-9013-y.

Carroll, J., Denny, E., & Lyons, S. (2016). The effects of energy cost labelling on appliance purchasing decisions: trial results from Ireland. *J Consum Policy, 39*, 23–40. https://doi.org/10.1007/s10603-015-9306-4.

Cattaneo, C. (2019). Internal and external barriers to energy efficiency: which role for policy interventions? *Energy Efficiency, 12*, 1293–1311. https://doi.org/10.1007/s12053-019-09775-1.

Chedwal, R., Mathur, J., Agarwal, G. D., & Dhaka, S. (2015). Energy saving potential through Energy Conservation

Building Code and advance energy efficiency measures in hotel buildings of Jaipur City, India. *Energy Build, 92*, 282–295. https://doi.org/10.1016/j.enbuild.2015.01.066.

Cingoski, V., & Petrevska, B. (2018). Making hotels more energy efficient: the managerial perception. *Econ Res-Ekonomska Istraživanja, 31*, 87–101. https://doi.org/10.1080/1331677X.2017.1421994.

Coad, A., de Haan, P., & Woersdorfer, J. S. (2009). Consumer support for environmental policies: an application to purchases of green cars. *Ecol Econ, 68*, 2078–2086. https://doi.org/10.1016/j.ecolecon.2009.01.015.

COM, 2019. Communication on The European Green Deal [WWW Document]. European Commission - European Commission. URL https://ec.europa.eu/info/publications/communication-european-green-deal_en ().

D'Agostino, D., Cuniberti, B., & Bertoldi, P. (2017). Energy consumption and efficiency technology measures in European non-residential buildings. *Energy Build, 153*, 72–86. https://doi.org/10.1016/j.enbuild.2017.07.062.

Damigos, D., Kontogianni, A., Tourkolias, C., & Skourtos, M. (2020). Behind the scenes: Why are energy efficient home appliances such a hard sell? *Resour Conserv Recycl, 158*, 104761. https://doi.org/10.1016/j.resconrec.2020.104761.

de Ayala, A., Foudi, S., del Solà, M., López-Bernabé, E., & Galarraga, I. (2020). Consumers' preferences regarding energy efficiency: a qualitative analysis based on the household and services sectors in Spain. *Energy Efficiency, 14*, 3. https://doi.org/10.1007/s12053-020-09921-0.

EIA, 2020. U.S. Energy Information Administration - EIA - Independent Statistics and Analysis [WWW Document]. URL https://www.eia.gov/outlooks/aeo/data/browser/#/?id=3-AEO2020&region=1-0&cases=ref2020&start=2019&end=2020&f=A&linechart=ref2020-d112119a.3-3-AEO2020.1-0&map=ref2020-d112119a.4-3-AEO2020.1-0&sourcekey=0 ().

EIA, 2011. Beyond natural gas and electricity; more than 10% of U.S. homes use heating oil or propane - Today in Energy - U.S. Energy Information Administration (EIA) [WWW Document]. URL https://www.eia.gov/todayinenergy/detail.php?id=4070 ().

Fadzli Haniff, M., Selamat, H., Yusof, R., Buyamin, S., & Sham Ismail, F. (2013). Review of HVAC scheduling techniques for buildings towards energy-efficient and cost-effective operations. *Renew Sust Energ Rev, 27*, 94–103. https://doi.org/10.1016/j.rser.2013.06.041.

Fleiter, T., Schleich, J., & Ravivanpong, P. (2012). Adoption of energy-efficiency measures in SMEs - an empirical analysis based on energy audit data from Germany. *Energy Policy, 51*, 863–875.

Galarraga, I., González-Eguino, M., & Markandya, A. (2011). Willingness to pay and price elasticities of demand for energy-efficient appliances: combining the hedonic approach and demand systems. *Energy Econ, 33*(Supplement 1), S66–S74. https://doi.org/10.1016/j.eneco.2011.07.028.

Gerarden, T. D., Newell, R. G., & Stavins, R. N. (2017). Assessing the Energy-Efficiency Gap. *J Econ Lit, 55*, 1486–1525. https://doi.org/10.1257/jel.20161360.

Gillingham, K., & Palmer, K. (2014). Bridging the Energy Efficiency Gap: Policy Insights from Economic Theory and Empirical Evidence. *Rev Environ Econ Policy, 8*, 18–38. https://doi.org/10.1093/reep/ret021.

Greene, W.H., 2003. Econometric Analysis, 8th Edition [WWW Document]. URL /content/one-dot-com/one-dot-com/us/en/higher-education/program.html ().

Heinzle, S. L., & Wüstenhagen, R. (2012). Dynamic Adjustment of Eco-labeling Schemes and Consumer Choice – the Revision of the EU Energy Label as a Missed Opportunity? *Bus Strateg Environ, 21*, 60–70. https://doi.org/10.1002/bse.722.

Hornsey, M. J., Harris, E. A., Bain, P. G., & Fielding, K. S. (2016). Meta-analyses of the determinants and outcomes of belief in climate change. *Nat Clim Chang, 6*, 622–626. https://doi.org/10.1038/nclimate2943.

Hrovatin, N., Dolšak, N., & Zorić, J. (2016). Factors impacting investments in energy efficiency and clean technologies: empirical evidence from Slovenian manufacturing firms. *J Clean Prod, 127*, 475–486. https://doi.org/10.1016/j.jclepro.2016.04.039.

IDAE, 2017. Estudios, informes y estadísticas | IDAE [WWW Document]. URL http://www.idae.es/estudios-informes-y-estadisticas ().

INE, 2019. INEbase / Servicios /Hostelería y turismo /Cuenta satélite del turismo de España / Resultados [WWW Document]. INE. URL https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736169169&menu=resultados&idp=1254735576863 ().

Jaffe, A. B., & Stavins, R. N. (1994). The energy-efficiency gap what does it mean? *Energy Policy, 22*, 804–810. https://doi.org/10.1016/0301-4215(94)90138-4.

Kollmuss, A., & Agyeman, J. (2002). *Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior?* https://doi.org/10.1080/13504620220145401.

Liang, J., Qiu, Y., & Hu, M. (2019). Mind the energy performance gap: evidence from green commercial buildings. *Resour Conserv Recycl, 141*, 364–377. https://doi.org/10.1016/j.resconrec.2018.10.021.

Linares, P., & Labandeira, X. (2010). Energy efficiency: economics and policy. *J Econ Surv, 24*, 573–592. https://doi.org/10.1111/j.1467-6419.2009.00609.x.

Lucas, J., & Galarraga, I. (2015). Green Energy Labelling. In A. Ansuategi, J. Delgado, & I. Galarraga (Eds.), *Green energy and efficiency: an economic perspective, green energy and technology* (pp. 133–164). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-03632-8_6.

Mavrotas, G., Demertzis, H., Meintani, A., & Diakoulaki, D. (2003). Energy planning in buildings under uncertainty in fuel costs: the case of a hotel unit in Greece. *Energy Convers Manag, 44*, 1303–1321. https://doi.org/10.1016/S0196-8904(02)00119-X.

Michelsen, C. C., & Madlener, R. (2012). Homeowners' preferences for adopting innovative residential heating systems: a discrete choice analysis for Germany. *Energy Econ, 34*, 1271–1283. https://doi.org/10.1016/j.eneco.2012.06.009.

MITECO, 2020. Plan Nacional Integrado de Energía y Clima (PNIEC) 2021-2030 [WWW Document]. URL https://www.miteco.gob.es/es/prensa/pniec.aspx ().

Nauges, C., & Wheeler, S. A. (2017). The complex relationship between households' climate change concerns and their water and energy mitigation behaviour. *Ecol Econ, 141*, 87–94. https://doi.org/10.1016/j.ecolecon.2017.05.026.

ODYSEE-MURE, 2020. Spain energy efficiency & Trends policies | Spain profile | ODYSSEE-MURE [WWW Document]. URL https://www.odyssee-mure.eu/publications/efficiency-trends-policies-profiles/spain.html ().

ODYSEE-MURE, 2018. Energy efficiency trends in buildings [WWW Document]. URL https://www.odyssee-mure.eu/publications/br/energy-efficiency-in-buildings.html ().

OECD, 2011. Greening household behaviour: overview from the 2011 survey - OECD [WWW Document]. URL https://www.oecd.org/env/consumption-innovation/greening-household-behaviour-2014.htm ().

Olsthoorn, M., Schleich, J., & Hirzel, S. (2017). Adoption of energy efficiency measures for non-residential buildings: technological and organizational heterogeneity in the trade, commerce and services sector. *Ecol Econ, 136*, 240–254. https://doi.org/10.1016/j.ecolecon.2017.02.022.

Palm, J. (2009). Placing barriers to industrial energy efficiency in a social context: a discussion of lifestyle categorisation. *Energy Efficiency, 2*, 263–270. https://doi.org/10.1007/s12053-009-9042-1.

Patel, P. C., & Guedes, M. J. (2017). Surviving the recession with efficiency improvements: the case of hospitality firms in Portugal. *Int J Tour Res, 19*, 594–604. https://doi.org/10.1002/jtr.2132.

Peruzzi, L., Salata, F., de Lieto Vollaro, A., & de Lieto Vollaro, R. (2014). The reliability of technological systems with high energy efficiency in residential buildings. *Energy Build, 68*, 19–24. https://doi.org/10.1016/j.enbuild.2013.09.027.

Ramos, A., Gago, A., Labandeira, X., & Linares, P. (2015). The role of information for energy efficiency in the residential sector. *Energy Econ, 52*, S17–S29. https://doi.org/10.1016/j.eneco.2015.08.022.

Ramos, A., Labandeira, X., & Löschel, A. (2016). Pro-environmental households and energy efficiency in Spain. *Environ Resour Econ, 63*, 367–393. https://doi.org/10.1007/s10640-015-9899-8.

Sakshi, S., Cerchione, R., & Bansal, H. (2020). Measuring the impact of sustainability policy and practices in tourism and hospitality industry. *Bus Strateg Environ, 29*, 1109–1126. https://doi.org/10.1002/bse.2420.

Schleich, J. (2009). Barriers to energy efficiency: a comparison across the German commercial and services sector. *Ecol Econ, 68*, 2150–2159. https://doi.org/10.1016/j.ecolecon.2009.02.008.

Schleich, J. (2004). Do energy audits help reduce barriers to energy efficiency? An empirical analysis for Germany. *Int J Energy Technol Policy, 2*, 226–239.

Schleich, J., Gassmann, X., Faure, C., & Meissner, T. (2016). Making the implicit explicit: a look inside the implicit discount rate. *Energy Policy, 97*, 321–331. https://doi.org/10.1016/j.enpol.2016.07.044.

Schleich, J., & Gruber, E. (2008). Beyond case studies: barriers to energy efficiency in commerce and the services sector. *Energy Econ, 30*, 449–464.

Schlomann, B., & Schleich, J. (2015). Adoption of low-cost energy efficiency measures in the tertiary sector—an empirical analysis based on energy survey data. *Renew Sust Energ Rev, 43*, 1127–1133. https://doi.org/10.1016/j.rser.2014.11.089.

Shama, A. (1983). Energy conservation in US buildings: solving the high potential/low adoption paradox from a behavioural perspective. *Energy Policy, 11*, 148–167. https://doi.org/10.1016/0301-4215(83)90027-7.

Shen, J., 2008. Understanding the determinants of consumers f willingness to pay for eco-labeled products: an empirical analysis of the China Environmental Label (No. 08E001), OSIPP Discussion Paper, OSIPP Discussion Paper. Osaka School of International Public Policy, Osaka University.

Solà, M. d. M., de Ayala, A., Galarraga, I. & Escapa M (2020). Promoting energy efficiency at household level: a literature review. *Energy Effic, 14,* 6. https://doi.org/10.1007/s12053-020-09918-9.

Sorrell, S., Mallett, A., Nye, S., 2011. Barriers to industrial energy efficiency: a literature review.

Sorrell, S., O'Malley, E., Schleich, J., & Scott, S. (2004). *The economics of energy efficiency: barriers to cost-effective investment*. Edward Elgar Publishing.

Stadelmann, M., & Schubert, R. (2018). How do different designs of energy labels influence purchases of household appliances? A field study in Switzerland. *Ecol Econ, 144*, 112–123. https://doi.org/10.1016/j.ecolecon.2017.07.031.

Stieß, I., & Dunkelberg, E. (2013). Objectives, barriers and occasions for energy efficient refurbishment by private homeowners. *J Clean Prod, 48*, 250–259. https://doi.org/10.1016/j.jclepro.2012.09.041.

Tiefenbeck, V., Wörner, A., Schöb, S., Fleisch, E., & Staake, T. (2019). Real-time feedback promotes energy conservation in the absence of volunteer selection bias and monetary incentives. *Nat Energy, 4*, 35–41. https://doi.org/10.1038/s41560-018-0282-1.

Trianni, A., Cagno, E., & De Donatis, A. (2014). A framework to characterize energy efficiency measures. *Appl Energy, 118*, 207–220. https://doi.org/10.1016/j.apenergy.2013.12.042.

Trianni, A., Cagno, E., Marchesani, F., & Spallina, G. (2017). Classification of drivers for industrial energy efficiency and their effect on the barriers affecting the investment decision-making process. *Energy Efficiency, 10*, 199–215. https://doi.org/10.1007/s12053-016-9455-6.

UNWTO (Ed.). (2019). *International tourism highlights* (2019th ed.). Madrid: World Tourism Organization (UNWTO). https://doi.org/10.18111/9789284421152.

van der Linden, S. (2017). *Determinants and measurement of climate change risk perception, worry, and concern (SSRN Scholarly Paper No. ID 2953631)*. Rochester, NY: Social Science Research Network.

WBG, 2020. CO2 emissions from electricity and heat production, total (% of total fuel combustion) | Data [WWW Document]. URL https://data.worldbank.org/indicator/EN.CO2.ETOT.ZS ().

Wooldridge, J.M., 2002. Econometric Analysis of Cross Section and Panel Data | The MIT Press [WWW Document]. URL https://mitpress.mit.edu/books/econometric-analysis-cross-section-and-panel-data ().