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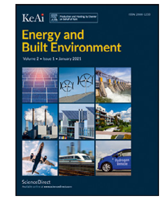

Drivers and barriers to energy-efficient technologies (EETs) in EU residential buildings

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A B S T R A C T

To achieve carbon targets, the European Union (EU) aims to promote nearly zero-energy buildings (nZEB). To enable the necessary transition, technical solutions need to converge with socio-economic factors, such values and awareness of stakeholders involved in the decision-making process. In this light, the aim of this paper is to characterise perceived drivers and barriers to nine energy-efficient technologies (EET), according to key decision-makers' and persuaders of the technology selection in the EU residential building context. Results are collected across eight EU countries, i.e. Belgium (BE), Germany (DE), Spain (ES), France (FR), Italy (IT), Netherlands (NL), Poland (PL), and United Kingdom (UK). The stakeholders' selected are architects, construction companies, engineers, installers and demand-side actors. Data from a multi-country survey is analysed to calculate the share of 15 drivers and 21 barriers (aggregated to 5 groups), being selected for each EET and country. The 5 groups considered to analyse drivers and barriers are environmental, technical, economic, social, legal. The perceived barriers and drivers were further studied for their association across the countries using the Pearson's Chi2 and a Cramer's V tests. The results demonstrate that across all EETs and countries, the technical and economic driver groups are perceived to have the highest potential to increase the implementation rate of EET. In terms of barriers, economic aspects are seen as the foremost reason that EET are not scaling faster. In both drivers and barriers legal aspects are the least often selected. In overall the barrier groups show significant variation across countries compared to driver groups. These findings provide an evidence-basis to better understand arguments in favour and against specific EETs and, in this way, support policy makers and other interested parties to increase the market share of the selected solutions.

1. Introduction

1.1. Motivation

In the European Union (EU), buildings are currently the single biggest contributor of GHG emissions, responsible for approximately 40% of energy consumption and 36% CO_2 emissions. Furthermore, about 35% of the building stock is over 50 years old and more than 75% is considered to be energy inefficient [1]. In view of these facts, the EU aims to promote nearly zero-energy buildings (nZEB) [2]. In line with requirements from the European Commission, EU countries had to develop and submit nearly zero-energy buildings national plans, describing how they intended to increase the number of nZEBs in their respective country to comply with the directive [3]. Although technology options to decrease building's energy demand to nZEB standards are readily available and, in many cases, economically viable [4–9], average annual construction and retrofit rates in the residential sector are still around 1% [10]. Of these, less than 5% are reaching these standards [11]. This implies that, despite their availability and economic viability, energy efficient technology solutions are not deployed at the required rate to meet EU's carbon reduction targets.

The discrepancy between the techno-economic potential and actual market behaviour has been coined as the 'energy efficiency gap' and implies that non-technical hurdles are preventing the large-scale diffusion of these solutions [12]. Any factor slowing the large-scale deployment of these technologies or limiting market success for cost-effective technology is referred to as a market barrier [13]. In this way, to foster the adoption of energy-efficient technologies, a pan-EU knowledge about the market-specific barriers and drivers is needed. This information can be particularly meaningful if it is based on evidence from the stakeholders involved in the technology selection, such as technology adopters, architects, engineers, constructors, and installers [14].

Against this background, the goal of the present study is to better understand what is impeding the large-scale deployment of these solutions. More specifically it focuses on gathering empirical evidence on the drivers and barriers for the available technology solutions allowing for differences across (1) stakeholders (potential adopters of the

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technologies, architects, engineers, constructors and installers), (2) EE technologies, and (3) EU countries. Findings can be used as evidence-basis to support policy makers further develop instruments and strategies, and companies or industry associations aiming to increase their market share of energy-efficient solutions.

1.2. Literature overview: drivers and barriers to energy efficient technologies in buildings

There is a broad literature on the drivers and barriers to energy efficiency in buildings. Several of these contributions discuss the situation in EU countries.

The reviewed scientific papers focus on empirical evidence on household's adoption of energy efficient systems, more particularly those which have collected the perception of key stakeholders involved in building projects within the last two decades (years 2000–2020). Most retrieved studies focus on a single country or stakeholder (Table 1). Persson and colleagues investigated the existence and significance of barriers and driving forces for the implementation of energy-efficient houses in Sweden, interviewing construction companies to gather this information. They concluded that there is a need to demonstrate to both construction companies and potential customers the viability of building passive houses and that future building regulations from the European Union are identified as a regulatory driver [15]. Cagno and colleagues conducted an exploratory investigation analyses to a set of Dutch manufacturing enterprises and other agencies to map the views of stakeholders in the decision-making cycle. Their findings lead them to conclude that much greater attention should be paid to issues, such as extending policies from industrial final users to all companies supplying enterprises with capital, technologies, services, information, and competences [16]. Likewise, the purpose of the paper developed by Beillan and colleagues was to analyse the weight of socio-economic factors in the decision-making process of multiple energy efficiency technologies across various European countries. For this they selected case studies in Germany, Switzerland, Italy, Spain and France. For each case on-site surveys were conducted, including qualitative interviews with the owners, the residents and the involved professionals. Results from their study showed that (1) people getting involved in projects of energy-efficient refurbishment aren't mainly and exclusively motivated by energy savings; (2) there's a lack of skilled work force able to meet the requirements of energy-efficient retrofitting; (3) public support schemes for retrofitting measures play a crucial role; (4) the local embedding of projects is important [17]. Cooke and colleagues reported on the results of a qualitative study about building project stakeholders in the UK—their experience of alternative energy technologies (AETs), the factors that influence assessments and their views on how to improve the chances of using AETs in future projects. Among other conclusions, they highlighted the lack of experience of installing AETs in buildings in the UK, and the understanding of these technologies is variables - in line with the results from Persson and colleagues. Also, that there were a number of drivers and barriers to the use of AETs in buildings at the time of the study, and that the relevance of each of these varied between projects, with time and with the technology [18]. Achtnicht and colleagues identified key drivers and barriers for the adoption of building energy retrofits in Germany by analysing data from a 2009 survey of more than 400 owner- occupiers of single-family detached, semidetached, and row houses. They found that private owners who are able to afford it financially, for whom it is profitable, and for whom there is a favourable opportunity were more likely to undertake energy retrofit activities [19]. Stieß and colleagues offered a comparison of homeowners applying low and zero carbon technologies versus those carrying out standard refurbishment measures. They concluded that the dissemination of information and transfer of knowledge played a key role in achieving energy-efficient refurbishment measures [20]. Likewise, Pelenur and colleagues link demographics with barriers to energy efficiency measures adoption in residential sector in the UK [21]. Michelsen

Table 1
Quota for drivers and barriers, per stakeholder group and countries.

		Quota																	
		BE		DE		ES		FR		IT		NL		PL		UK		TOTAL	
#	Stakeholder groups	Drivers	Barriers	Drivers	Barriers	Drivers	Barriers	Drivers	Barriers	Drivers	Barriers	Drivers	Barriers	Drivers	Barriers	Drivers	Barriers	Drivers	Barriers
1.1	Architect	11	13	13	14	29	30	28	27	23	23	19	19	24	22	8	8	**155**	**156**
1.2	Engineer	16	16	16	19	28	29	16	18	19	18	12	10	34	33	9	10	**150**	**153**
1.3.	Construction companies	14	16	20	19	26	26	16	15	37	37	28	27	28	26	70	70	**239**	**236**
1.4	Installers	19	19	20	19	26	26	25	23	31	32	22	19	6	5	6	4	**155**	**147**
1.5	Demand-side actors	31	34	66	75	114	121	67	71	110	127	85	86	88	93	66	66	**627**	**673**
TOTAL		**91**	**98**	**135**	**146**	**223**	**232**	**152**	**154**	**220**	**237**	**166**	**161**	**180**	**179**	**159**	**158**	**1326**	**1365**

and Madlener explored the multi-dimensionality of the homeowners' motivation to decide between competing residential heating systems in Germany, concluding that adoption motivations can be grouped around six dimensions: (1) cost aspects, (2) general attitude towards the technologies, (3) government grant, (4) reactions to external threats (i.e., environmental or energy supply security considerations), (5) comfort considerations, and (6) influence of peers [22]. In Germany too, Kesternich and colleagues derived factors that increase the willingness to pay (WTP) of homeowners for energy efficiency in the specific case of an upcoming move. Their estimation results suggested that the WTP is not determined by socioeconomic attributes like household income or formal education, but rather by environmental concerns and energy awareness [23]. Likewise, Caird and colleagues surveyed consumers' (i.e. technology adopters) to study the reasons behind adoption of energy efficiency measures and renewable energy systems, including drivers and barriers. The reasons for considering but rejecting these technologies include the familiar price barriers, as well as other obstacles that varied according to the technology concerned [24]. Finally, Heiskanen offered a literature review on renewable energy technology deployment in residential buildings, in which concluded that a research gap exists because building owners across Europe are quite diverse, and the European markets exhibit different stages of maturity [25].

This literature overview shows a body of knowledge covering household-level factors influencing the adoption of building-scale energy efficiency solutions. Yet, each study addresses a distinct country, technology solution(s) and stakeholder´s perspective. The only cross-country analysis of household adoption of energy efficient technologies and behavioural practices we are aware of is the OECD report "Assessing the Impacts of Climate Change" (2011) [26]. Results across the selected OECD countries included in the study were found to vary considerably with respect to appliance stock, investments in energy-savings equipment, energy savings behaviour, government support received for installations of energy- efficient technologies, environmental concerns and attitudes, or motivations to reduce energy consumption. For example, Dutch households are most likely to turn off their electronic appliances and devices. In comparison, households in Australia, the Czech Republic and South Korea are the least likely to switch off appliance in standby mode, while households in Sweden and Norway are the least likely to turn off lights when leaving a room. The June 2011 Eurobarometer survey also hints at differences across EU Members in terms of environmental concerns and actions [27]. For instance, in Luxembourg and Denmark 34% and 31% of the population, respectively, considers climate change to be the single most serious problem facing the world. In Portugal and Ireland, this share is only 7% and 13%, respectively. In the 6 months prior to the survey, about three quarters of Swedes, Slovenes and Luxembourgian report to have taken personal actions to fight climate change, but less than a third of Poles, Romanians or Estonians report the same. However, given the diversity of local and national contexts, studies from one country or specific technology cannot be readily generalized to other region or technology, even within the EU. Thus, comparing findings across studies and countries is not possible, as these differ in terms of technologies selected, behavioural practices, explanatory variables, and methods.

2. Materials and methods

This section describes the survey instrument used to retrieve the data as well as the analysis applied. The data collected from a large-scale multi-country survey are displayed and analysed for the percentage of respondents across the countries stating the relevance of various drivers and barriers for EETs. The perceived barriers and drivers were further studied for their association across the countries using the Pearson's Chi2 and a Cramer's V tests. The lower the p-value for Pearson's Chi2, the higher the level of association, i.e. how the preference towards a driver or barrier varies across the selected countries. Similarly, the higher value of Cramer's V (between 0 and 1), the higher the level of association.

2.1. Data collection: a multi country online survey

The empirical analysis is based on data collected from a multi-country online survey distributed in 2019 across 8 European countries: Belgium (BE), Germany (DE), Spain (ES), France (FR), Italy (IT), Netherlands (NL), Poland (PL), and United Kingdom (UK). To enable cross-country comparability of the results, all countries used a common survey instrument translated into the local language and jargon with the support of a market expert team and stakeholder representatives from each country. The overall sample contains 7231 responses [28–30]. Since the population of interest (i.e. residential building projects in the EU) is significantly large and heterogeneous, and there was a need to represent even small subgroups of the population (e.g. stakeholder groups, comprehensive refurbishment projects, etc.), a stratified sample approach was considered as the most appropriate. To characterise the population of interest, the sample was then divided into three stratification axes, as of the main elements building projects are composed of: (I) stakeholder group, (II) building typology, and (III) project type. Based on the stratified approach, there was no maximum number of responses stipulated but rather a minimum quota for the three axes of stratification (Annex II, Table A2). One stratification axis is controlled ex-ante (i.e. stakeholder group) and two are controlled for during the survey or ex-post (i.e. building typology and project type). A number of steps were followed to control the ex-ante axis in the survey distribution. The first step was to study the structure of the axis in each country, which was done in terms of number of companies and sizes (i.e. number of employees). This information was collected from Eurostat [31]. This source was chosen because it ensured the cross-comparability of the statistics. This information was then transferred to a market research institute, commissioned for the distribution of the survey across the selected countries. The market research institute was then responsible for collecting the contacts for the selected stakeholder groups according to the number of companies and sizes specified by the Eurostat database for each country. The contact directory for each stakeholder group and country was constructed from different sources, namely: yellow pages, online lists, purchase of list from different suppliers (e.g. green book) or even sometimes from random telephone selection [32].

The original survey contained responses from seven stakeholder groups: (1) Conceiving, planning, and consulting services; (2) Material and technology supply; (3) Construction & installation; (4) Enabling services; (5) Operation and maintenance services; (6) Institutional demand side, and (7) Private demand side. However, the present study focuses on collecting the perspective of key decision-makers in the technology selection. Therefore, some stakeholder groups had to be excluded from the analysis. To select what stakeholder groups were included in the analysis, a literature review was performed. In this, several sources identified demand-side actors, (e.g. institutional and private demand side) are key decision-makers in the technology selection [33,34]. Nevertheless, recent findings demonstrate that in the technology selection process in EU residential buildings, many other stakeholders are involved and interconnected in these decisions, some of which can have the same or even more power and communication than the demand-side actors, namely architects, engineers, construction companies and installers [14]. These findings substantiate some earlier results from Beillan and colleagues, which had identified that architects played a key role for orienting homeowners towards comprehensive energy-efficient retrofitting. [17]. This supports the investigations from Heiskanen that indicated that installers are often the main source of information for building owners, and their recommendations have significant weight in the choice of several building systems or components [23]. On this basis, the barriers and drivers are based on the following perspective: architects (1.1), engineers (1.2), construction companies (1.3), installers (1.4), and demand-side actors, including institutional demand side, such as housing compa-

Table A2
Minimum quota defined in the survey. Breakdown per stratification axis.

Stakeholder		Project type						Sub-total		Grand-total
		New built		Deep refurbishment		All other measures (including maintenance, refurbishment)				
Group	**Sub-groups**	**SDB**	**MDB**	**SDB**	**MDB**	**SDB**	**MDB**	**SDB**	**MDB**	**SDB + MDB**
1. Conceiving, planning, and consulting services	*Architects and engineers*	9	9	9	9	9	9	27	27	**54**
2. Material and technology supply	*Material or technology manufacturer or retailer*	9	9	9	9	9	9	27	27	**54**
3. Construction & installation	*Construction companies and installers*	10	10	10	10	10	10	30	30	**60**
4. Enabling services	*Local authorities, banks and other financial services*	9	9	9	9	9	9	27	27	**54**
5. Operation and maintenance services	*Energy supply/utility and ESCO, facility managers: commercial, administrative, technical, maintenance, etc.*	10	10	10	10	10	10	30	30	**60**
6. Institutional demand side	*Investors, developers, housing companies for profit, public/part Governmental/non-profit*	15	15	15	15	15	15	15	45	**60**
7. Private demand side	*Private house owners, flats rented out or self-owned*	26	26	26	26	26	26	78	78	**156**
Total	**88**	**88**	**88**	**88**	**88**	**88**	**234**	**264**	**498**	

nies (for profit), housing company or housing association, cooperative (public/part governmental/non-profit) and private demand side, including: private owner (1.5).

In order to collect the information to identify the respondent's role in the building value chain, the respondents were asked: "Are you working professionally in one of the following companies or organisation types?" followed by a list of 21 options, including "Other company or organisation type in the building or construction sector" and "No, I do not work professionally in any company or organisation type related to the building and construction sector". To encompass all demand-side actors including private owners, for those interviewees who had indicated not to be working professionally in an organization from the building sector, there was the follow-up question "Do you privately own one or more residential home(s) or flat(s)?"

Since the analysis focused on a specific stakeholder groups (i.e. architects, engineers, construction companies, installers and demand-side actors), a subset of the complete database was used. Subsequently, the final sample used for this study consists of 1782 responses, with the following distribution across countries: BE = 115, DE = 181, ES = 317, FR = 209, IT = 329, NL = 216, PL = 204, UK = 211. The subset obtained for the above-mentioned stakeholder groups are further divided into two parts, one each for drivers and barriers. Based on the contact collection approach, it is reasonable to assume that these subsets are randomly collected. Because the scope of this study is limited to provide a basic analysis on the choice of drivers and barriers by country, stakeholder and technology separately. The inclusion of sample weights would be appropriate for performing an aggregated analysis where all three strata (country, stakeholders, and building typology) are studied together. In this way, the response to the above questions on drivers and barriers was another dimension defining the sample size. The parts are based on the valid responses to analyse the driver or barrier groups (i.e. at least one of the answer options in the question checked). This division is necessary as the respondents were given the freedom to answer either barriers or drivers or both based on their level of experience and knowledge. The complete list of stakeholders and their respective quotas in the final dataset with valid observations for driver and barrier groups are described in Table 1. The datasets for driver and barrier groups have 1326 and 1365 responses respectively. Among the stakeholders, nearly 50% quota belongs to the demand-side actors (1.5), followed by the construction companies (1.3). The architects (1.1), engineers (1.2), installers (1.4) have almost equal quota. Among the countries, the highest quota belongs to the IT and lowest is for the BE. The lower sample size for the architects (1.1), engineers (1.2), and installers (1.4) in the UK, also for the installers (1.4) in the PL, does not affect the analysis, as all these stakeholders are treated as a single entity. The combined sample size matters in case of estimating the shares for drivers and barriers for various EETs. The fact that the number of responses is not exactly matching is because the respondents could answer either of the driver or barrier or both. The selection of drivers and barriers as well as the main categories were extracted from the literature study [22,35,36]. The questions related to drivers and barriers can be found in the Appendix I. For the entire questionnaire refer to [32].

To collect the information on the drivers for the EETs, interviewees were asked "What should happen to scale%tech% in%country%?" for a randomly selected technology. They were offered 15 answer options, grouped into the same 5 categories: environmental, technical, economic, social and legal. Again, they also had the option to select "*Other*" and "*I don't know*". We also included the option *"I don't want this technology to be scaled"*. The valid observations shown in Table 1 exclude the respondents who answered, "*I don't know*" and *"I don't want this technology to be scaled"* for the drivers. The complete list of drivers and driver groups are shown in Table 2.

As a follow-up question, to identify perceived barriers, they were asked: "What are the key barriers for %tech% in the current%country% market?" for the same technology and were provided with 21 answer options, clustered into the same 5 categories as the drivers: environmental, technical, economic, social and legal. Along with the choice "Other" and "I don't know". The complete list of barriers and barrier groups are shown in Table 3. The valid observations shown in Table 1 exclude the respondents who answered, "I don't know" for barriers.

The final sample sizes for drivers was (1326) and (1365) for barriers respectively. The fact that the numbers of responses are not exactly matching is since the respondents could answer either of the driver or barrier or both. The selection of drivers and barriers as well as the main categories were extracted from the literature study [22,35,36]. The questions above can be found in the Appendix I. For the entire questionnaire refer to [32].

The format of the survey allowed participants to choose more than one answer option out of 15 drivers and 21 barriers displayed in Tables 2 and 3. Based on this, Table 4 shows the number of observations making 1 or more number of choices in both drivers and barriers. For example, in IT and for building automation, 7 observations choose

Table 2
Breakdown of drivers and groups.

Driver Group	Driver	Definition
Environmental	1	Improvement of the technology's environmental performance (e.g. less energy consumption or carbon emissions)
	2	Energy input such as electricity, district heat, gas, oil should be produced more from renewable energy sources
Technical	3	Improvement of the reliability and functionality
	4	Easier installation process
	5	Improved user-friendly
	6	Better design
	7	Improving Advertising / Technical Information Technology
Economic	8	Price decrease and shorter payback time
	9	Energy cost saving and low running costs
Social	10	Better marketing of technology
	11	Improved consideration of demands by tenants and building owners
	12	Improved communication in project teams
Legal	13	Enforcement of building codes or by other legal requirements
	14	Promotion of energy-efficiency, low-carbon or sustainability labels for buildings
	15	Information campaign of authorities

Table 3
Breakdown of barriers and groups.

Barrier Group	#	Definition
Environmental	1	Lack of ambitious and clear political environmental targets
	2	Lack of environmental awareness
Technical	3	Lack of reliable technologies
	4	Lack of high-performance technologies
	5	Lack of simple production process
	6	Lack of comprehensive information about alternatives and advantages/disadvantages
Economic	7	Lack of affordable products
	8	Low energy prices
	9	Lack of subsidies
	10	Lack of tax incentives
	11	Lack of trust / awareness of lower life cycle / running costs
	12	Lack of comprehensive financing models
	13	Lack of qualified organizations / employees (e.g. for installation, construction)
Social	14	Lack of trust / awareness in higher acoustic comfort
	15	Lack of trust / awareness in heat comfort
	16	Lack of interest in attractive design
	17	Lack of short or easy installation or maintenance
	18	Lack of education
Legal	19	Lack of a comprehensive legal framework
	20	Lack of a comprehensive building standards
	21	Lack of implementation of legal standards

just one driver, and 6 observations choose just one barrier. The data shows that there is nearly an equal number of respondents making 1 to 5 choices in both drivers and barriers, in each EET. The distribution also varies among technologies and countries. For instance, in Building automation & smart metering IT, NL and UK have a higher number of responses between 1 and 2 choices than BE, DE, ES and FR, where the highest number of responses have selected between 3 and 5 drivers or barriers. Based on the numbers from Table 4, the authors decided to carry out the analysis at the level of group of driver and barriers, due to two major reasons. One of the reasons is, there are too many options for both drivers and barriers to make a cogent analysis. Also, most of the arguments can be correlated. For instance, a respondent may select "lack of affordable products" an argument which can be linked to "lack of subsidies". In such cases, calculating the shares (probabilities) at the individual driver or barrier level to estimate the aggregate share for the groups will lead to an underestimation of the shares. Thus, the shares estimated at the group level does not include the number of drivers or barriers selected in that group. For instance, any respondent choosing at least one of the barriers from 3 to 6 in Table 3 is considered as an observation selecting the Technical barrier group.

2.2. Data analysis: overview of methodology

The data analysis is comprised of two parts. The first part estimates the probability of selecting each driver and barrier group for each EET and country combination. As shown in Eq. (1), the probabilities are the ratio between the number of respondents thought a driver/barrier is significant (r_i) and the total number of respondents that answered the survey (N_i). These P_i are presented as percentages of respondents selecting the drivers and barriers in Sections 3.1 and 3.2.

$$P_i = \frac{r_i}{N_i} \tag{1}$$

In the second part, the level of two-way association between these probabilities and the eight countries is estimated using the Pearson's Chi2 and Cramer's V test. These statistics measure the two-way dependency between the probabilities of drivers/barriers among the countries. The Pearson's Chi2 is estimated from the number of observations in the matrix (n_{ij}) as shown in the Eq. (2) below where, i is country (rows), and j is if a driver/barrier is selected or not selected (columns) for an EET and country [37]. Hence, there are eight rows ($i = 1, 2, 3 \ldots, 8$) representing the countries and two columns ($j = 0,1$) where $j = 1$ if a driver or barrier is selected for a given EET, and $j = 0$ if not selected.

$$Chi2 = \sum_i \sum_j \frac{\left(n_{ij} - m_{ij}\right)^2}{m_{ij}}; \text{ where } m_{ij} = \frac{\left(\sum_i n_{ij}\right)\left(\sum_j n_{ij}\right)}{\sum_i \sum_j n_{ij}} \tag{2}$$

Since there are eight countries and two options (a driver/barrier selected or not selected), the Chi2 obtained above has a total degree of freedom equal to seven i.e., (8–1) *(2–1). The Cramer's V is defined as given in Eq. (3) below where, n is the sample size and t is the minimum of number rows minus and number of columns minus one, $t = 1$ in current paper as the number of rows equal to eight (countries) and the

Table 4
Number of choices per EET, across selected countries for drivers and barriers.

		1. Building automation & smart metering								2. District heating								3. Electric storage							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**>7**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**>7**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**>7**
BE	**Drivers**	1	1	3	0	1	1	0	2	0	4	4	1	2	0	2	1	1	0	2	1	2	1	0	1
	Barriers	0	1	3	0	2	0	0	3	0	2	5	3	2	0	1	3	2	1	3	1	1	0	0	2
DE	**Drivers**	1	2	0	2	4	2	1	1	2	2	0	3	5	0	0	0	4	3	2	0	2	0	0	2
	Barriers	1	1	2	2	3	2	2	0	4	3	2	2	4	0	1	0	4	4	2	0	2	0	1	1
ES	**Drivers**	0	4	4	6	2	3	1	0	2	1	5	4	3	6	2	1	2	6	6	5	6	3	1	2
	Barriers	1	4	4	5	5	2	2	0	2	7	2	5	8	1	3	1	2	2	6	4	5	5	1	3
FR	**Drivers**	0	2	7	3	3	0	1	3	2	1	1	3	3	1	2	2	2	3	1	1	7	2	1	0
	Barriers	0	3	4	3	3	2	0	2	0	5	2	1	2	2	1	3	1	1	2	3	4	1	1	3
IT	**Drivers**	7	3	7	3	2	1	0	0	6	6	5	3	1	2	0	1	4	10	5	2	0	1	0	0
	Barriers	6	7	4	3	5	0	0	1	6	11	7	1	2	0	0	1	8	10	5	1	0	0	0	0
NL	**Drivers**	5	1	7	2	2	2	1	0	1	7	6	2	4	0	0	0	8	1	2	1	2	0	0	0
	Barriers	6	3	3	0	4	0	2	1	0	7	6	1	3	1	1	0	8	3	0	0	3	0	0	0
PL	**Drivers**	1	0	1	4	4	2	2	4	3	2	1	0	6	4	1	1	2	5	3	3	5	1	0	0
	Barriers	1	0	1	2	7	1	2	4	1	2	2	1	4	3	3	1	1	3	4	1	4	2	1	2
UK	**Drivers**	4	6	0	2	5	1	1	3	5	0	1	2	4	1	0	2	3	3	3	1	3	1	1	0
	Barriers	4	4	2	2	5	1	0	3	3	2	4	2	1	0	0	4	4	2	3	0	5	0	0	1
Total	**Drivers**	**19**	**19**	**29**	**22**	**23**	**12**	**7**	**13**	**21**	**23**	**23**	**18**	**28**	**14**	**7**	**8**	**26**	**31**	**24**	**14**	**27**	**9**	**3**	**5**
	Barriers	**19**	**23**	**23**	**17**	**34**	**8**	**8**	**14**	**16**	**39**	**30**	**16**	**26**	**7**	**10**	**13**	**30**	**26**	**25**	**10**	**24**	**8**	**4**	**12**

		4. Heat Pumps								5. High-performance windows								6. Insulation							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**>7**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**>7**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**>7**
BE	**Drivers**	2	1	3	1	0	0	0	2	1	3	3	2	1	0	0	1	1	3	6	2	0	0	0	0
	Barriers	2	0	3	1	0	2	0	2	1	4	3	1	0	2	0	1	1	4	6	1	1	0	0	0
DE	**Drivers**	3	2	0	2	4	1	1	1	1	6	2	2	3	0	0	0	2	1	2	0	2	1	1	1
	Barriers	4	2	0	1	5	2	0	2	4	1	3	1	4	0	1	0	2	2	1	1	1	0	0	4
ES	**Drivers**	3	3	7	2	2	5	0	2	4	1	7	7	2	1	1	0	5	5	10	5	0	3	0	0
	Barriers	0	6	6	3	5	2	1	1	1	2	6	4	4	3	3	0	4	4	6	4	8	3	0	1
FR	**Drivers**	2	6	0	1	4	1	2	1	5	3	3	2	5	0	1	2	0	1	5	0	5	1	2	0
	Barriers	3	2	1	2	2	0	0	4	3	4	2	4	6	1	0	3	2	1	3	0	4	2	2	2
IT	**Drivers**	12	9	3	3	1	0	0	1	10	7	2	5	1	0	0	0	8	6	3	3	1	1	0	1
	Barriers	11	4	8	3	1	0	0	1	11	6	4	1	3	0	0	0	8	7	2	3	1	2	0	0
NL	**Drivers**	10	6	3	0	1	0	0	0	1	3	3	3	3	0	1	0	4	6	2	1	3	0	0	0
	Barriers	2	6	3	1	3	0	0	1	2	1	1	4	3	1	0	0	10	0	2	1	2	0	0	0
PL	**Drivers**	7	1	3	4	2	1	0	0	2	3	4	2	6	3	3	2	2	3	2	3	6	3	1	5
	Barriers	4	0	4	4	3	1	0	2	0	3	3	1	7	1	3	6	2	1	1	4	6	2	2	7
UK	**Drivers**	2	3	1	1	3	1	1	2	2	2	4	2	2	2	2	2	4	4	4	5	3	1	0	3
	Barriers	1	2	4	1	3	1	0	2	2	3	3	2	1	1	3	2	5	3	5	1	8	1	1	1
Total	**Drivers**	**41**	**31**	**20**	**14**	**17**	**9**	**4**	**9**	**26**	**28**	**28**	**25**	**23**	**6**	**8**	**7**	**26**	**29**	**34**	**19**	**20**	**10**	**4**	**10**
	Barriers	**27**	**22**	**29**	**16**	**22**	**8**	**1**	**15**	**24**	**24**	**25**	**18**	**28**	**9**	**10**	**12**	**34**	**22**	**26**	**15**	**31**	**10**	**5**	**15**

		7. Photovoltaic systems								8. Solar thermal systems								9. Ventilation (with heat recovery)							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**>7**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**>7**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**>7**
BE	**Drivers**	0	5	4	1	1	1	0	1	2	0	1	1	1	0	0	2	0	1	5	1	0	1	0	0
	Barriers	1	1	5	2	1	1	1	1	0	1	2	2	0	0	1	1	0	3	2	0	2	0	0	1
DE	**Drivers**	2	2	4	3	4	2	1	3	3	6	0	2	6	6	0	1	2	0	1	2	5	2	0	2
	Barriers	2	2	2	5	4	6	1	1	6	3	5	0	4	3	0	3	2	0	1	2	6	2	0	2
ES	**Drivers**	4	3	5	4	5	3	0	0	6	4	3	4	7	1	0	2	2	5	5	4	4	0	1	1
	Barriers	4	5	3	5	4	1	2	1	3	4	6	7	3	2	1	0	4	6	2	4	1	5	0	2
FR	**Drivers**	0	0	4	2	3	4	2	2	2	4	1	2	4	2	0	1	4	2	3	1	2	4	0	0
	Barriers	0	2	4	3	2	0	1	6	2	2	3	3	3	3	0	2	4	2	0	2	5	1	0	2
IT	**Drivers**	3	7	5	7	3	0	0	0	4	13	3	2	2	0	1	0	7	8	2	4	3	0	0	0
	Barriers	7	7	4	1	5	1	1	0	6	7	7	6	1	1	0	0	4	14	5	3	2	0	1	0
NL	**Drivers**	9	4	4	2	3	1	1	1	3	5	5	1	3	2	0	0	6	6	2	1	1	1	1	0
	Barriers	10	5	4	1	2	0	0	3	5	3	4	3	4	2	0	1	8	5	0	2	1	2	0	1
PL	**Drivers**	2	5	5	1	3	0	2	3	1	1	3	3	5	2	2	2	1	0	1	1	6	0	2	6
	Barriers	3	1	5	1	7	2	2	1	1	0	2	1	9	2	2	2	0	0	1	2	5	1	1	8
UK	**Drivers**	2	4	2	2	6	1	2	1	0	3	6	0	5	1	0	1	3	1	6	2	1	1	0	1
	Barriers	5		3	0	3	3	0	3	1	2	5	1	2	0	0	2	0	5	5	1	3	0	1	1
Total	**Drivers**	**22**	**30**	**33**	**22**	**28**	**12**	**8**	**11**	**21**	**36**	**22**	**15**	**33**	**14**	**3**	**9**	**25**	**23**	**25**	**16**	**22**	**9**	**4**	**10**
	Barriers	**32**	**23**	**30**	**18**	**28**	**14**	**8**	**16**	**24**	**22**	**34**	**23**	**26**	**13**	**4**	**11**	**22**	**35**	**16**	**16**	**25**	**11**	**3**	**17**

number columns is equal to two (if a driver or barrier selected or not). The value of Cramer's V varies between zero and one, one showing the high correlation [38].

$$Cramer's\ V = \sqrt{\frac{Chi2}{nt}} \tag{3}$$

The Pearson's Chi2 and Cramer's V test evaluates the following hypotheses (H_0, H_A):

- *Null Hypothesis (H_0): There is no change in the influence of a driver or barrier for an EET (j) across the countries (i).*
- *Alternative Hypothesis (H_A): There is a change in the influence a driver or barrier for an EET (j) across the countries (i).*

The test statistic for Pearson's Chi2 estimated in Eq. (2) is compared with the Chi2 distribution with degrees of freedom seven and the significance level 5% (i.e., absolute value of Pr in Table 5 is less than or equal to 0.05). If the test statistic is significant the H_0 could be rejected,

Table 5
Pearsons Chi2 and Cramers V, across selected EET for drivers and barriers.

EET	Category	Drivers				Barriers			
		Obs.	Pearson Chi2	Pr	Cramér's V	Obs.	Pearson Chi2	Pr	Cramér's V
1. Building automation and smart metering	**Environmental**	144	13.01	0.07	0.30	146	10.63	0.16	0.27
	Technical* **		**16.56**	**0.02**	**0.34**		17.28	0.02	0.34
	Economic* **		**10.91**	**0.14**	**0.28**		14.28	0.05	0.31
	Social		12.51	0.09	0.30		12.24	0.09	0.29
	Legal **		18.13	0.01	0.36		**10.08**	**0.18**	**0.26**
2. District heating	**Environmental*** **	142	**12.01**	**0.10**	**0.29**	157	20.59	0.00	0.36
	Technical* **		**9.88**	**0.20**	**0.26**		15.44	0.03	0.31
	Economic **		14.58	0.04	0.32		**3.16**	**0.87**	**0.14**
	Social		11.72	0.11	0.29		12.55	0.08	0.28
	Legal*		**23.48**	**0.00**	**0.41**		**19.32**	**0.01**	**0.35**
3. Electric storage	**Environmental**	139	8.21	0.32	0.24	139	12.03	0.10	0.29
	Technical*		**25.35**	**0.00**	**0.43**		**27.89**	**0.00**	**0.45**
	Economic* **		**7.90**	**0.34**	**0.24**		20.77	0.00	0.39
	Social		9.02	0.25	0.26		13.23	0.07	0.31
	Legal*		**24.42**	**0.00**	**0.42**		**21.81**	**0.00**	**0.40**
4. Heat pumps	**Environmental** **	145	23.12	0.00	0.40	140	**7.81**	**0.35**	**0.24**
	Technical* **		**9.18**	**0.24**	**0.25**		16.13	0.02	0.34
	Economic		8.88	0.26	0.25		7.52	0.38	0.23
	Social		12.43	0.09	0.29		11.61	0.11	0.29
	Legal **		37.16	0.00	0.51		12.47	0.09	0.30
5. High-performance windows	**Environmental*** **	151	**5.36**	**0.62**	**0.19**	150	21.72	0.00	0.38
	Technical* **		11.41	0.12	0.28		19.54	0.01	0.36
	Economic*		**22.45**	**0.00**	**0.39**		**17.76**	**0.01**	**0.34**
	Social *		**25.04**	**0.00**	**0.41**		**26.60**	**0.00**	**0.42**
	Legal*		**19.93**	**0.01**	**0.36**		**15.56**	**0.03**	**0.32**
6. Insulation	**Environmental*** **	152	**13.97**	**0.05**	**0.30**	158	16.09	0.02	0.32
	Technical* **		**8.28**	**0.31**	**0.23**		17.25	0.02	0.33
	Economic **		17.13	0.02	0.34		**13.25**	**0.07**	**0.29**
	Social*		**30.85**	**0.00**	**0.45**		**16.72**	**0.02**	**0.33**
	Legal*		**24.37**	**0.00**	**0.40**		**25.51**	**0.00**	**0.40**
7. Photovoltaic systems	**Environmental**	166	13.08	0.07	0.28	173	10.92	0.14	0.25
	Technical*		**22.44**	**0.00**	**0.37**		**21.88**	**0.00**	**0.36**
	Economic		6.69	0.46	0.20		12.78	0.08	0.27
	Social **		17.25	0.02	0.32		**7.32**	**0.40**	**0.21**
	Legal* **		**11.70**	**0.11**	**0.27**		21.87	0.00	0.36
8. Solar-thermal systems	**Environmental**	153	7.46	0.38	0.22	157	10.01	0.19	0.25
	Technical* **		**10.28**	**0.17**	**0.26**		19.33	0.01	0.35
	Economic		11.68	0.11	0.28		5.10	0.65	0.18
	Social*		**15.77**	**0.03**	**0.32**		**15.08**	**0.04**	**0.31**
	Legal*		**32.81**	**0.00**	**0.46**		**14.80**	**0.04**	**0.31**
9. Ventilation (with heat recovery)	**Environmental*** **	134	**12.56**	**0.08**	**0.31**	145	19.75	0.01	0.37
	Technical*		**21.30**	**0.00**	**0.40**		**20.68**	**0.00**	**0.38**
	Economic*		**21.43**	**0.00**	**0.40**		**14.36**	**0.05**	**0.32**
	Social*		**16.61**	**0.02**	**0.35**		**24.24**	**0.00**	**0.41**
	Legal*		**28.97**	**0.00**	**0.47**		**38.91**	**0.00**	**0.52**

Note: Significant at 5% level: 1. Drivers (***), 2. Barriers (**), and 3. Both drivers and barriers (*).

proving a significant change in the influence a driver or barrier across countries.

3. Results

3.1. Drivers for EET adoption

Key drivers vary across EET as well as across countries. Across all of the selected EETs, the technical and economic drivers have the highest share, except for IT and NL, where technical arguments are not so predominant. In the case of BE, another key group is the social. The technical driver group has a major share in the UK across all EETs with 100% in electric storage. The social driver is less selected in countries like ES across all technologies, being technical and environmental conditions the strongest motives. The least often selected driver across all countries are legal related matters. In BE, main arguments in favour of EETs vary substantially across the solutions. For instance, for building automation and smart metering, as well as for electric storage, social and/or environmental arguments are the most common. Whereas in district heating, heat pumps, insulation and solar thermal, it is related to technical concerns. It is noteworthy that across all technologies except photovoltaic systems, economic drivers are among the least often selected. In DE, the most often selected driver across all EETs is technical-related matters, except for district heating which is led by environmental concerns. Again, across all technologies, the least often selected argument are legal ones. This is quite the opposite picture to ES, where legal-related arguments are the most often selected ones across all EETs, except photovoltaic systems where economic aspects are identified to lead their uptake. In FR, driver groups vary substantially across the various EETs. In building automation and smart metering, district heating, photovoltaic and solar thermal systems, and ventilation (with heat recovery) technical drivers are the first or second most selected driver. Whereas for electric storage, heat pumps, high-performance windows and, insulation it is economic parameters. These results can also be seen in IT, where techno-economic arguments are the most predominant across all technology solutions, except electric storage and ventilation (with heat recovery), where the technical aspects are among the least relevant. In NL, across all technologies except ventilation (with heat recovery), the most often selected drivers are the economic-related ones. Whereas the least often selected ones are on environmental and legal matters. In PL, techno-economic matters are always among the most predominant, except in photovoltaic systems and solar thermal systems where the technical aspects are not so relevant. Finally, in the UK, driver groups vary across EETs. For instance, for building automation and smart metering, district heating, electric storage, and ventilation with heat recovery technical and environmental aspects are the most relevant. While for heat pumps and high-performance windows it is the techno-economic related ones. It should also be noted that given the respondent was able to cross more than one driver, it could be that in some countries, the percentages for some groups are high. This does not necessarily mean that it is much more relevant than others, but simply that they could select more than one options in that same group.

3.2. Barriers for EET adoption

As in the case of the drivers, barriers to EET vary across the sampled solution and countries and the economic barrier group has the highest share (except electric storage EET in the DE). Economic arguments are followed mainly by technical aspects. As in the case of the drivers, legal arguments have the least number of responses across countries and technologies. When looking at each of the examined countries it can be depicted that in BE, main arguments impeding the large-scale deployment of the selected technologies are economic-related. These are followed by social-related barriers. When it comes to the least often identified arguments in BE across all EETs, it is legal and environmental matters. In DE, technical and economic aspects are the most often selected. Against legal matters which are the least often. In ES, economic aspects are also identified across all EETs as the most important, whereas, as in the other cases, legal aspects are the least relevant. Once again, in FR economic aspects are of most relevance, followed by technological impediments. The results for IT are quite similar to the ones portrayed in ES, where economic-related arguments are perceived as crucial in the drawback of their implementation in residential building projects, closely followed by technical and social. In the case of the NL, economic matters are clearly the most relevant hurdle impeding the uptake of all of the selected EETs, whereas legal matters play a minor role in their restriction. In the case of high-performing windows, social aspects are also identified as quite relevant in their limitation. In PL, key impediments are related to technical or economic aspects, with the only exception of high-performance windows and insulation, where the environmental are much more predominant than technical. In the case of ventilation (with heat recovery), economic and social have the same crucial weight in their blockage. Finally, in the UK, across all technologies technical and/or economic related matters are of utmost importance when it comes to barriers to EETs. In this way, in overall, BE and PL show the most distinct results of all countries. Again, given the respondent was able to cross more than one choice, it could be that in some countries, the percentages for some groups are high. This does not necessarily mean that it is much more relevant than others, but simply that they could select more than one options in that same group.

3.3. Pearsons Chi2 and Cramers V test

Table 5 shows the Pearson's Chi2 and Cramer's V test statistics between various EETs and driver or barrier groups. There are 45 combinations (number of rows in Table 5), 9 EETs and 5 groups for each driver and barrier groups. Overall, out of these 45 combinations, the Chi2 are significant at 5% level for 15 EET and driver or barrier group combinations (*), 6 for EET and driver group combinations (**); and 13 for EET and barrier group combinations (***). Table 5 also highlights the groups for which the Chi2 is not significant at 5% for both driver and barrier groups. It is worthy to note that the choice of legal driver and barrier groups in seven out of nine EETs is found to vary significantly at 5% level across the countries, except the building automation and heat pumps (which is significant in driver groups but not in barrier groups). This shows that the legal aspects vary from country to country considerably. Also, Cramer's V for legal driver and barrier group vary between 0.3–0.5, proving the strong association between the stakeholder choices and country.

Comparing Table 5 with the above Figs. 3.1.1–3.1.9 for drivers, and Figs. 3.2.1–3.2.9 for barriers, the ventilation EET and legal group has the highest significance, at 1% level for Chi2 with Cramer's V close to 0.5 in both driver (25% in IT to 94% in PL) and barrier (10% in IT to 73% in DE). In case of driver groups, the legal drivers for heat pumps show the most significant variation across countries i.e., the choice having highest association with countries (10% NL to 78% in BE). In case of barrier groups, environmental barriers for ventilation show the most significant variation (38% in FR to 87% in DE) (Figs. 3.2.1–3.2.9).

4. Discussion and conclusions

The goal of this study was to characterise perceived drivers and barriers to EETs adoption according to key decision-makers and persuaders in the technology selection. The selected solutions were building automation and smart metering, district heating, electric storage, heat pumps, high-performance windows, insulation, photovoltaic systems, solar thermal systems, and ventilation (with heat recovery). To this end, results from a multi-country survey were collected and assessed in order to better understand the market similarities and differences across these countries.

Findings show that drivers and barriers to EETs adoption differ depending on the specific solution and country. Yet, some general conclusions can be extracted. When it comes to potential drivers for the implementation of EETs, key decision-makers and persuaders identified economic and technical aspects as being the most relevant, especially among district heating, heat pumps, photovoltaic, solar thermal, and ventilation (with heat recovery). When it comes to barriers impeding the selection of these technologies, it is economic-related arguments, such as "Lack of trust / awareness of lower life cycle / running costs", the most often selected ones.

This outcome indicates that the assumed economic viability of these solutions is not sufficiently acknowledged or appealing to foster their large-scale deployment in the selected countries. This coincides with some of the findings from previous studies [39], which try to monetize other impacts of the energy efficiency measures in order to make these actions more appealing to the decision-makers [39,40]. In turn, it strengthens the results of the study by Stieß and colleagues, highlighting the critical role that the dissemination of information and transfer of knowledge play in achieving energy-efficient refurbishment measures. Likewise, the fact that environmental aspects are not the most often selected ones, also suports the findings from Beillan and colleagues indicating that people getting involved in projects of energy-efficient refurbishment aren't mainly and exclusively motivated by energy savings. Results of this study further compliment the findings from Michelsen and colleagues, concluding that adoption motivations for can be grouped around the various dimensions [22]. This study also suggest that inasmuch these various dimensions exist, they do not entail the same weight across technologies and countries. Finally, the results from this paper shed light to the findings from Caird and colleagues, which identified that obstacles for energy efficiency that varied according to the technology concerned [24], by providing an overview on how these barriers (and drivers) might vary across solutions and geographies. In terms of geographies, is worth noting that within this study, results vary across countries even within the same EU climatic zone (e.g. IT and ES). This emphasises the presence of values and awareness in the adoption of EET technologies at a national level, along with the importance of developing policy measures that address this matter at a country-scale.

Future research should focus on extending the findings of this study to the remaining EU countries, as well as non-residential buildings. Likewise, advancing the understanding on how the various arguments vary across the specific stakeholder groups. Findings from this study could be used to develop evidence-base policy instruments (national and pan-

Figs. 3.1.1–3.1.9. The percentage of respondents choosing a driver group across the selected EETs and countries.

Figs. 3.2.1–3.2.9. The percentage of respondents choosing a barrier group across the selected EETs and countries.

EU) aiming to foster the large-scale diffusion of energy-efficient technologies. In particular, findings from this paper could support the identification of key barriers and drivers per technology solutions, as well as the linkage of these to the particular stakeholder groups.

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Appendix A. Survey Questions

Are you working professionally in one of the following company or organisation types?

Please tick the most relevant (work more than 30% of your working hours).

MATERIAL AND TECHNOLOGY SUPPLIER

- Raw resource provider
- Technology or component manufacturer (e.g. HVAC, PV)
- Material or technology trader

SERVICE PROVIDER AND ENABLER

- Architect office
- Engineer office
- Consulting company
- Installer company
- Construction company
- Public authority
- Bank / other financial service company
- Facility management office - administrative
- Facility management office - technical
- Energy supply/utility or Energy service company (ESCO)
- Research institute
- Non-governmental organisation (NGO)
- Business association, agency
- Media company

DEMAND-SIDE ACTOR (demanding materials, technologies and services)

- Investment or development company
- Housing company (for profit)
- Housing company or housing association, cooperative (public/ part governmental/ non-profit)

OTHER company or organisation type in the building or construction sector:

Please insert text

- No, I do not work professionally in any company or organisation type related to the building and construction sector

Do you privately own one or more residential home(s) or flat(s)?

- Yes
- No

What are the key barriers for%tech% in the current%countryadj% market?

The technology is randomly selected and assigned to you.

- Environmental
  - ○ Lack of ambitious and clear political environmental targets
  - ○ Lack of environmental awareness
- Technical
  - ○ Lack of reliable technologies
  - ○ Lack of high-performance technologies
  - ○ Lack of simple production process
  - ○ Lack of comprehensive information about alternatives and advantages/disadvantages
- Economic
  - ○ Lack of affordable products
  - ○ Low energy prices
  - ○ Lack of subsidies
  - ○ Lack of tax incentives
  - ○ Lack of trust / awareness of lower life cycle / running costs
  - ○ Lack of comprehensive financing models
  - ○ Lack of qualified organizations/ employees (e.g. for installation, construction)
- Social
  - ○ Lack of trust / awareness in higher acoustic comfort
  - ○ Lack of trust / awareness in heat comfort
  - ○ Lack of interest in attractive design
  - ○ Lack of short or easy installation or maintenance
  - ○ Lack of education
- Legal
  - ○ Lack of a comprehensive legal framework
  - ○ Lack of a comprehensive building standards
  - ○ Lack of implementation of legal standards
- Other: Please describe
- I do not know

What should happen to scale%tech% in%country%?

The technology is randomly selected and assigned to you.

- Environmental
  - ○ Improvement of the technology's environmental performance (e.g. less energy consumption or carbon emissions)
  - ○ Energy input such as electricity, district heat, gas, oil should be produced more from renewable energy sources
- Technical
  - ○ Improvement of the reliability and functionality
  - ○ Easier installation process
  - ○ Improved user-friendliness
  - ○ Better design
- Economic
  - ○ Price decrease and shorter payback time
  - ○ Energy cost saving and low running costs
- Social
  - ○ Better marketing of technology
  - ○ Improved consideration of demands by tenants and building owners
  - ○ Improved communication in project teams
- Legal, standards and labels
  - ○ Enforcement of building codes or by other legal requirements
  - ○ Promotion of energy-efficiency, low-carbon or sustainability labels for buildings
  - ○ Information campaign of authorities
- Other: Please describe
- I do not think this technology should scale up
- I do not know

The complete questionnaire can be accessed through the link: https://chalmersuniversity.box.com/v/SurveyQuestionnaire.

Appendix B.Survey minimum quota

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