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Extending the unified theory of acceptance and use of technology for sustainable technologies context

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ABSTRACT

Following the United Nations' Sustainable Development Goals (SDG) recommendations, sustainable technologies are increasingly being introduced as a step toward more sustainable behaviors and efforts against environmental problems. However, a holistic investigation of the main factors influencing its adoption and use is necessary. To this end, this work aims to explain the determinants of sustainable technologies used by consumers. Specifically, we develop a contextualized model that extends the unified theory of acceptance and use of technology 2 (UTAUT2) by leveraging a mixed-methods approach and, therefore, conducting three studies. The so-developed contextualized model of consumer adoption of sustainable technology is tested using 2003 observations from five European countries. Such a sample also provides the opportunity for a cross-country comparison. We found that habit, environmental knowledge, information provision, and innovativeness were significant predictors of sustainable technology use. Additionally, the cross-country comparison revealed that although conclusions are generally consistent across the countries, they differ in some effects, like social influence and price value. Taken together, we thus provide insights into the consumers' motivations to adopt and use sustainable technologies.

1. Introduction

Sustainable technologies have increased interest from researchers and practitioners (Paddison & Choi, 2023). Due to environmental problems, technologies that are sustainable or help promote sustainable behaviors are the basis of many strategies for the mitigation of climate change. Sustainable technologies have become one of the ways to monitor and control resource consumption and increase individual awareness of sustainability (Whittaker et al., 2021). Therefore, the prominence of this type of technology in meeting the United Nations' Sustainable Development Goals (SDG) reinforces the relevance of studying its adoption. However, a holistic investigation of the determinants of its adoption and use is lacking. To this end, we seek to integrate prior research with a mixed-methods approach to develop a comprehensive model to understand consumer adoption of sustainable technologies.

Prior research on the adoption of sustainable technologies has used theories such as the theory of planned behavior (TPB) or the technology acceptance model (TAM) and then extended it with some other variables related to motivations or environmental concerns (Broman Toft et al., 2014; Perri et al., 2020). Some others try to combine different factors instead of drawing on any well-known theory (Hmielowski et al., 2019; Will & Schuller, 2016). Given this, as noted above, the literature lacks a holistic and comprehensive understanding of sustainable technology adoption and use determinants. Only recently have few studies on intelligent meter technology used quantitative and qualitative approaches to address this topic in a more complete and contextualized way. Based on this, two research objectives were established for this study. The first research objective is to complement prior work and provide a richer and more contextualized perspective of the phenomenon to develop a model to understand the determinants of sustainable technology adoption. To accomplish this objective, we draw on the unified theory of acceptance and use of technology 2 (UTAUT2) and extend it with insights from a qualitative study. We use a mixed-methods design in a way that provides more robust conclusions and better understands the phenomenon as a whole (Venkatesh et al., 2016). The second research objective is to provide a cross-country analysis, investigating the robustness of the achieved conclusions and/or understanding of cross-country differences. To accomplish this objective, we conducted our empirical examination in five European countries – Italy,

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Germany, Greece, Portugal, and the United Kingdom, rather than being limited by a single country investigation whose results may be affected by their different values (Wunderlich et al., 2019). Such cross-country investigations can reveal important insights into contextual boundaries of theories (Hong et al., 2014; Venkatesh et al., 2016; Venkatesh et al., 2010).

We make several contributions. First, integrating UTAUT2 and qualitative data contributes to a comprehensive understanding of sustainable technology adoption, thus addressing a critical gap in our current understanding. Second, by analyzing data from five different countries, this work provides insights into how sustainable technology adoption behavior varies across countries. Finally, our findings will help NGOs and practitioners to understand the determinants that influence the adoption of this critical type of technology and, in this way, better approach consumers and better formulate strategies for the achievement of sustainable development goals (SDGs).

2. Theoretical background

2.1. Sustainable technology

Given the environmental problems, mitigation efforts, from adopting renewable energy and energy-efficient appliances to adopting new habits and regulations to control energy behaviors, should be implemented (Paddison & Choi, 2023) and are being studied by researchers and policymakers (Pan et al., 2022). Sustainable technologies are technologies that resort to sustainable resources or reduce natural resource use (Crosno & Cui, 2014) that by themselves are more sustainable and efficient (Dadzie et al., 2018) or can also help consumers change their behavior towards sustainability through more active actions based on metering technologies (Barreto et al., 2014). Sustainable technologies can be considered a different type of technology, which is characterized by is a technological element but distinguished from other technologies for the same purpose by being innovative, sometimes requiring some knowledge, and many of them also able to invade the user's privacy and collect data (Wunderlich et al., 2019).

2.2. Prior research

Most studies on sustainable technologies used the theory of planned behavior (TPB) or the technology acceptance model (TAM) as a foundation. Indeed, a meta and weight analysis on sustainable technologies adoption (Neves et al., 2022) using TPB as the focal theory was later extended with some other variables/perspectives. Table 1 summarizes the most important theories and constructs used in prior research. For example, Bhutto et al. (2021), Kranz & Picot (2011), and Perri et al. (2020) used TPB. They extended it with environmental concerns and personal and social norms. They found the significance of all these variables in predicting intention to adopt smart energy and efficient technologies/appliances. These variables are aligned with the identified characteristics of sustainable technologies – they are considered pro-environmental behaviors. Additionally, most studies tend to include moral norms and environmental concerns in their research models. For example, Bhutto et al. (2021) and Tan et al. (2017) include both moral and social norms to explain the adoption of efficient technologies, concluding their relevance to the adoption. Some others investigated this adoption using TAM (Shin et al., 2018). For example, Broman Toft et al. (2014) concluded that adding personal norms to the well-known perceived usefulness and perceived ease of use constructs of TAM significantly increased the explained variance in adopting smart grids. As such, the above studies have adopted an approach that complements the technological perspective, mainly with motivational factors and environmental concerns. On the other hand, some studies focused more on the innovation aspects of the technology and used the technology readiness index theory (TRI) and privacy concerns to explain adoption (Hmielowski et al., 2019; Will & Schuller, 2016). These studies also try to offer a more holistic view, combining factors from different theories, which, in this case, are more focused on privacy- and innovation-related dimensions. Moreover, most studies are based on quantitative data collection, and almost no studies apply a mixed-methods design. In conclusion, due to the complexity and specific characteristics of sustainable technologies, prior research is fragmented. There is not a complete view of these technologies, as most studies tend to use TAM or TPB and end up focusing on specific perspectives of the technology, lacking in providing a comprehensive understanding of the determinants of sustainable technologies acceptance and use. Only more recently, Wunderlich et al. (2019) investigated metering technology using both qualitative and quantitative approaches, ending up with stronger inferences about metering technology adoption. We will complement such prior research with a more contextualized UTAUT2 using qualitative insights to provide a holistic study.

2.3. Unified theory of technology acceptance and use of technology 2

As referred above, past literature on sustainable technologies is fragmented, focused on isolated perspectives influencing sustainable technologies adoption and use. Indeed, many studies have used TAM or TPB, which tend to concentrate on specific aspects of the technology, such as perceived usefulness, and fail to capture the full spectrum of relevant factors affecting users' decisions regarding sustainable technologies. Therefore, when no single theory or framework can accurately explain sustainable technologies use, there is a need for a new or

Table 1
Prior research on sustainable technologies.

Source	TAM	TPB	TRA	NAM	TRI	DOI	PR	SN	PC	K	EC	A	B	PS
Chen (2016)		X								X				**X**
Hmielowski et al. (2019)					X			X	X					
Girginkaya Akdag & Maqsood (2019)	X				X									**X**
Kapoor & Dwivedi (2020)						X								
Bhutto et al. (2021)		X					X	X					X	
Perri et al. (2020)		X												
Tan et al. (2017)		X					X	X		X	X			
Taso et al. (2020)			X				X					X		
Hua & Wang (2019)	X	X												
Judge et al. (2019)		X												
Will & Schuller (2016)					X				X	X	X		X	
Hamzah & Tanwir (2021)		X		X										
Shin et al. (2018)	X					X			X					
Kranz & Picot (2011)		X									X			

Notes: TAM - Technology acceptance model; TPB - Theory of planned behavior; TRA - Theory of reasoned action; TRI - Technology readiness index; DOI - Diffusion of innovations theory; PN - Personal norms; SN - Social norms; PC - Privacy concerns; K - Knowledge; EC - Environmental concerns; A - Awareness; B - Benefits; PS - Policy support.

extended theoretical framework (Pentina et al., 2023). To address this gap, a model that can capture a wide set of relevant variables is necessary. Thus, we propose extending an existing theory by adding the missing relevant factors. In fact, the extension of a theory adding new relevant constructs that can better explain a behavior has been used before in the information systems field, and more recently, making use of a mixed-methods approach with developmental purpose (Zhou et al., 2023).

Regarding the available theories for technology adoption, this is one of the most mature areas of IS research. This body of work focuses on understanding the predictors of behavioral intention. More recently, researchers have studied the adoption of smart and household technologies, gathering usual technology acceptance models such as TAM or TPB, as previously seen. However, these theories are limited, and more comprehensive theories are available. As such, especially in the IS field, the unified theory of technological acceptance and use of technology (UTAUT) has emerged as a theory that combines several models, including TAM (Davis, 1989), TPB (Ajzen, 1985), theory of reasoned action (TRA) (Fishbein & Ajzen, 1977), innovation diffusion theory (DOI) (Rogers, 2010), the model of PC utilization (Thompson et al., 1991) and the social cognitive theory (Wood & Bandura, 1989). UTAUT was then tailored to the consumer context in the second version published about a decade after the first one: UTAUT2 (see Venkatesh et al., 2012). UTAUT2, an extension of the original UTAUT, has demonstrated a higher predictive power by being more suitable for individual/consumer contexts. Sustainable technologies are complex, with several different characteristics and myriad ways of interacting with the user, making UTAUT2 an appropriate ground theory to understand better and increase sustainable technology adoption and use. In fact, UTAUT2 has been successfully used across several contexts, proving its robustness and high quality (Weber, 2012). Tamilmani et al. (2021) has deeply analyzed the UTAUT2 and an extensive set of articles applying UTAUT2. The study highlights the importance of UTAUT2 extension studies, emerging from the wide range of technologies for consumers and its different variants and purposes. In fact, in Tamilmani et al. (2021), they discuss various ways of contextualizing a theory. One of those is the "technology class", in which the distinct features of the technology serve as motivation to add external variables to UTAUT2, as it has occurred with several studies like FinTech's or social networking sites. Therefore, following this rationale, recognizing the high-quality theory of UTAUT2 and the distinctiveness of sustainable technologies (for example, the relevancy of energy literacy or the existence of possible energy and monetary savings), we use UTAUT2 as the focal theory. Moreover, Venkatesh et al. (2012) recognized that future research could build on UTAUT2 for different technologies, possibly identifying other relevant factors that may help increase the applicability of UTAUT2 to other consumer technology use contexts.

Therefore, we conclude that UTAUT2 fulfils these gaps because (1) it is a comprehensive integration of several well-known technology acceptance theories, (2) it has proven efficacy across different contexts, demonstrating robustness and flexibility, (3) it is focused on the user, and (4) it is flexible for extension due the nature of the relationships without compromising the model integrity. Table 2 summarizes the main factors of decision/gaps identified in the UTAUT2 and how the extended version of the model would be more adequate to explain sustainable technologies use.

Given this, we conducted a qualitative study as the first step of the mixed-methods approach to examine the relevance of UTAUT2 and potentially add new relevant factors to it. Given the wide range of possible factors explaining sustainable technologies use, the qualitative study allowed us to confirm and identify the most relevant ones through a large-scale quantitative analysis. Afterward, the third phase of our approach consisted of a second qualitative study conducted to corroborate our findings across the five European countries. This strategy has already been used in other studies that contextualized IS theories for some types of sustainable technologies, such as Wunderlich et al. (2019).

Table 2
Decision factors of UTATU2.

Decision factors	UTAUT2	Extended UTAUT2
Robustness	UTAUT2 has been successfully used across several contexts, proving its robustness and high quality (Weber, 2012).	An extended version of the UTAUT2 for sustainable technologies, respecting the original relationships, will not compromise the model's integrity and robustness.
Distinct features of the technologies as motivation to add external variables (Tamilmani et al., 2021)	Sustainable technologies present unique characteristics that are not fully captured by UTAUT2's existing constructs (for example, energy literacy, savings, among others, specific to these technologies).	Addition of relevant constructs to explain sustainable technologies adoption and use. Here, we identify and incorporate key perspectives that are vital for adopting and using sustainable technologies but are overlooked in the original model.
New context to apply a theory	Future research could build on UTAUT2 for different technologies, increasing the applicability of this theory to other contexts of consumer technology use (Venkatesh et al., 2012).	The extended version of UTAUT2 for the context of sustainable technologies will demonstrate both the applicability of this theory to a new context and the need to extend/ contextualize theories for specific sets of technologies.

Further details on our methodological approach regarding the mixed-methods design can be seen in the next section.

Regarding UTAUT2 constructs, we retain the original hypotheses in the research model to explain behavioral intention and use. However, these will not be explicitly hypothesized on the research model because (1) these are already extensively well-documented, and given the extension of the research model, we found it unnecessary to increase the complexity by restating these well-known relationships, and (2) the focus of the study is on the additional variables derived from the qualitative study. Nevertheless, although not presented as hypotheses in the research model, we decided to include an explanation of the suitability of UTAUT constructs.

The first construct of UTAUT2 is performance expectancy, which refers to the perception of the consumer in terms of the improvement of performance by using sustainable technologies. It is similar to the perceived usefulness of TAM (Venkatesh et al., 2003). In the case of sustainable technologies, we expect that individuals may be able to manage better and control their energy consumption. Therefore, we believe performance expectancy will positively influence behavioral intention. Another well-known variable is effort expectancy, and it reflects the user perception of how difficult it is to use sustainable technologies, similar to the perceived ease of use from TAM (Venkatesh et al., 2003). Suppose users perceive the use of the technologies as easy and not complex. In that case, the intention to use the technology will be higher. Thus, effort expectancy will positively influence behavioral intention. Also, social influence has been used as an explanatory variable of the intention to use technologies. Social influence represents the perception the consumer has that its relatives, such as friends and family, think that it should use a certain technology (Venkatesh et al., 2003). Specifically to sustainable solutions, there is a certain status and lifestyle connected to these types of technologies, but also some reluctance to adopt them due to the unawareness of their benefits (Kapoor & Dwivedi, 2020; Nikou, 2019), so a positive impact of social influence on the intention to use sustainable technologies is expected. Regarding facilitating conditions, this refers to the user's perception that they have the resources and support to use the technology (Venkatesh et al., 2012). In the case of sustainable technologies, as the subject is complex, there can be a greater need for support. Also, many of these solutions should integrate and be compatible with the rest of the house or require certain house conditions. Moreover, facilitating conditions can vary a lot with the user according to the technology/service used. In this context, this variable is very similar to perceived behavioral control in TPB, which will influence both intention and use. Therefore, it can be a factor to consider when choosing to use these types of solutions or not. Consequently, we believe it will have a positive impact on both intention and use. Regarding hedonic motivations, this dimension represents the enjoyment and fun the user perceives to have by using a particular solution (Venkatesh et al., 2012). This variable has proved to be relevant, especially in smart and innovative technologies, as it presents a great dynamic between the technology and the user. In the case of sustainable technologies, most of these solutions are intelligent and provide feedback to the user, even with infrequent interaction. Thus, hedonic motivations will positively influence behavioral intention. Moreover, price value is theorized to have a positive impact on the intention to use sustainable technologies. Price value reflects the trade-off the consumer needs to make between the price of the technology and its benefits (Venkatesh et al., 2012). If perceived as positive, it means that the benefits surpass the monetary costs. Specifically for sustainable technologies, the initial investment can be somewhat high, and the benefits may only be felt after a long time (Bergman & Foxon, 2020), which can make it difficult to cognizance of the benefits over the price. However, if the benefits are perceived as higher than the costs, then the price value positively influences behavioral intention. Habit is defined as the tendency of consumers to use a certain technology automatically because of habit and learning (Venkatesh et al., 2012). It assumes that the repeated performance of a certain behavior can create a certain attitude or intention triggered by a stable and favorable environment, which will guide the use without the need of conscience to participate in the decision. This factor means that the user can create an optimistic view that can then be triggered in favourable environments without actually thinking about it. Thus, if the user creates a routine of use in a stable environment, it is expected that they will use the solution frequently. Finally, we posit that behavioural intention will significantly influence the use positively, as consistent with the intention models based on UTAUT (Venkatesh et al., 2003). Therefore, a higher intention will lead to higher use.

3. Mixed-methods design

This study employs a mixed-methods multi-phase approach consisting of an exploratory-confirmatory-corroboratory study. A mixed-methods study includes both qualitative and quantitative methodologies. This design should be employed when researchers want to holistically explain a phenomenon for which prior research is fragmented (Venkatesh et al., 2013, 2016, 2023). Additionally, combining the strengths of both methods provides richer insights than a single method or perspective. Specific to sustainable technologies, as shown in the literature section, prior research is fragmented on several perspectives, providing a wide range of factors that can influence individuals' adoption of sustainable technologies. This fact is even more relevant in our study since we include data from five different European countries, each with different geographic characteristics that influence sustainable technology adoption. Hence, mixed methods are a suitable design for our work that is grounded in a particular theory while looking for opportunities to contextualize.

The purpose of the first two phases is developmental, as the results from the first qualitative phase (exploratory) will be used to develop the model by potentially going beyond existing literature and subsequently empirically testing it using data from 2003 individuals across five European countries (confirmatory study). Hence, we follow a multiple paradigm stand in terms of epistemology. For the first qualitative phase, we follow an interpretivism/constructivism paradigm (Venkatesh et al., 2013, 2016, 2023). In the (second) quantitative study, we follow a positivist paradigm. In the third and last phase, employed for the sake of corroboration, especially across the five European countries, we return to the interpretivism/constructivism paradigm. Thus, in terms of time orientation, we follow a sequential design, starting with the qualitative study, then quantitative, and finally qualitative again for corroboration of the previous findings (see Fig. 1).

In terms of methodological approach, we follow a dominant - less dominant design, with the quantitative study being the dominant part (Venkatesh et al., 2013, 2016, 2023). Regarding sampling design strategies, we followed purposive sampling for the two qualitative studies and probability sampling for the quantitative one. In the qualitative studies, the data collection was accomplished by using open-ended questions following a semi-structured interview script. A closed-ended survey questionnaire was used for the quantitative study. Data analysis was also conducted sequentially.

The reason for this three-phase methodological approach is related to both the complexity of sustainable technology and the geographical reach of our study. In the first place, the adoption of sustainable technology may take place in many forms, from using efficient heating systems at home (e.g., energy-efficient devices like heating pumps) to sustainable transportation (e.g., electric vehicles). Secondly, as our study covers five European countries, it is crucial to have a holistic, comprehensive approach that covers the idiosyncrasies of each country, reason why the corroboration phase is so essential as we include participants from every included country in our study.

4. Study 1: exploratory

4.1. Methods (Study 1)

The purpose of the qualitative study is to identify relevant factors affecting the use of sustainable technologies, potentially going beyond existing literature. Therefore, semi-structured interviews were conducted because they allow a set of open questions and an opportunity for the interviewer to explore better and deepen specific topics or responses. Hence, an interview script was developed (please see Appendix A for the interview script). This type of qualitative method has also been used previously in mixed-methods studies with developmental purposes on the topic of sustainable technologies (Wunderlich et al., 2019). In terms of data collection, we interviewed 18 individuals from the countries under study – Italy, Germany, Greece, Portugal, and the United Kingdom. We selected experts whose occupations are related to the energy sector (8 interviewees) and some consumers (10 interviewees) interested in sustainable technologies. By interviewing experts and consumers, it is possible to understand different views of the needs and concomitant drivers for this technology adoption. The interviewees were primarily responsible for the decision to adopt technologies in their households. They were interested professionals in the energy sector. As such, we believe that the qualitative sample is adequate for our purpose of complementing existing knowledge. The number of interviews was based on data saturation, i.e., when no further information is being generated and, therefore, no additional coding is needed. A saturation grid was used to assess when data saturation was achieved, listing the main topics mentioned by the interviewees (Brod et al., 2009). Each interview lasted 30 min, and all interviewees agreed to be recorded. The interviews were transcribed for the analysis. See Table B.1 in Appendix B for the interviewees' details.

4.2. Results (Study 1)

For the analysis of qualitative data, we followed an open coding methodology. First, we segmented data into quotes and associated them with a category. Therefore, a list of categories (codes) was created based on the interview transcriptions and notes. The principal codes were recorded, and a set of respondent quotes was saved for each code. Appendix C presents the interviewees' quotes recorded for each category.

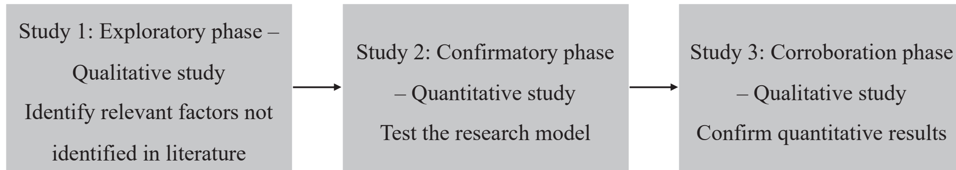

Fig. 1. Sequential mixed-methods design.

From those, high-level categories were created. These categories assemble codes with similar meanings (Miles & Huberman, 1994). We believe it is a good approach, as using inductive coding has shown to be valuable in prior research (Wunderlich et al., 2019).

From the qualitative data, several known variables used to explain technology adoption, including those that were part of UTAUT2, were confirmed: *performance expectancy, effort expectancy,* and *social influence*. Besides, new variables may be relevant to explain the behavioral intention and use of sustainable technologies. The following high-level categories were created based on grouping coded with similar meanings: financial factors, informational factors, privacy factors, and personal characteristics.

Financial factors were consistently referred to as possible drivers for adoption. This element includes *financial incentives* and expected monetary and energy *savings* individuals may obtain. For example, interviewee 4 (I4) referred the following: "However, I would say that we need to receive some incentives from our utility to better, let us say, adopt that. Maybe financial incentives." – indicating the need for financial incentives to motivate the adoption behavior. Interviewee 6 (I6) also referred to: "Any reason that makes people adopt that kind of equipment? If you show that the savings throughout the life cycle of the use of the equipment are positive or if you can get enough savings that can offset the investment that you make." – indicating that a return on their investment in the type of savings was a great justification for the initial investment in the technology, which is aligned with previous studies (Dadzie et al., 2018; Popescu et al., 2012).

Additionally, informational factors include two variables from different perspectives. First, they refer to the *consumer's environmental knowledge*. For example, interviewee 11 (I11) referred to the following: "Is it about people actually knowing how to manage, how not, how to install? (…) how to actually get benefits from the technologies and use it in the most correct (…) way." Second, contrary to what was said before, they can also refer to the lack of knowledge and, therefore, the need to have information. For example, the same interviewee continued and referred to the following: "Possibly people need to have more information available or maybe more demonstrations and so on, like more information about these overall." Thus, information provision was also referred to as a significant matter from this category. Most sustainable technologies require a certain familiarity and know-how to understand which technology to choose, which may be factors that are not easy to understand. As such, and related to the previously mentioned antecedents, the interviewees consistently referred to *information provision* and support. Interviewees revealed difficulty finding and understanding information related to the installation needs, features, and benefits of sustainable technologies, stating the importance of providing those types of informational support.

Interviewees also raised a particular concern about protecting privacy. For example, interviewee 8 (I8) referred to the following: "I'm concerned about privacy using devices, free apps, or that kind of thing, and my children think I'm a dinosaur, but I am concerned; I think you should. It shouldn't be known when you were in the house or when you were not. These kinds of things, isn't it?". *Perceived risks to personal privacy* have been previously investigated, especially in smart home technologies (Warkentin et al., 2017), with the possibility of collecting data from the household and its decisions. Interviewees expressed concerns about disclosing their private information when using these technologies.

Personal characteristics refer to user characteristics relevant to using sustainable technologies. As noted, sustainable technologies are smart and innovative, and many consumers perceive them as complex and challenging to install and use (Crosno & Cui, 2014). Interviewees also raised the *perceived innovativeness* as a relevant personal factor towards sustainable technology adoption. The literature also suggests that interest in innovative technologies is a strong predictor, mainly for smart technologies (Nikou, 2019). For example, interviewee 6 (I6) was consistent with this factor, saying that "If you are motivated to try new things and trying to understand how things work and stuff like that, I think it is really important for this kind of adoption.".

The addition of these constructs to UTAUT2 provides an opportunity to produce a richer combination of different but complementary views of the determinants of the use of sustainable technologies. We thus shed light on the importance of investigating other factors such as financial, informational, privacy, and personal ones. Overall, we are able to holistically explain the phenomenon, especially when prior research on these new constructs is still fragmented. Therefore, the extension of UTAUT2 based on qualitative results allows for a more robust and holistic analysis (Venkatesh et al., 2016).

5. Research model

Our holistic research model is grounded in UTAUT2 as a foundational theory to understand the primary determinants of sustainable technology adoption, with the constructs identified in the qualitative study being integrated. Integrating UTAUT2 with qualitative study fills a gap in the literature on the acceptance of sustainable technologies. Due to the complexity of the solutions, a contextualized model for sustainable technologies requires the integration of constructs from more than just the technological perspective. Therefore, resorting to qualitative data from experts and consumers is very important, as it uncovers factors that can also be relevant to understanding sustainable technology acceptance. Fig. 2 presents our research model. The following subsections present the new hypotheses that go beyond the ones presented in UTAUT2.

The qualitative study identified several variables potentially impacting both intention and use of sustainable technologies. The reasons for this are manifold. First, we aim to maintain the UTAUT2 comprehensive nature, capturing a broad range of factors affecting either use behavior, intention, or both. Given the nature of this research, we decided to hypothesize relationships for both variables. Second, the constructs were identified from the qualitative interviews with some respondents who were technology users. Therefore, the identified variables were found to be relevant factors affecting both the intention and use behavior. Finally, from a practical perspective, by understanding which constructs influence intention and use, the model can better provide insights to promote sustainable technologies at different stages of the adoption process.

From the financial factors, interviewees referred to the importance of financial incentives to adopt sustainable technologies. Due to the price of these technologies or their sustainable characteristics, governments have been providing financial incentives to increase the adoption of these solutions. Although being related to the price of the technology, it is essential to discern the differences between financial incentives and

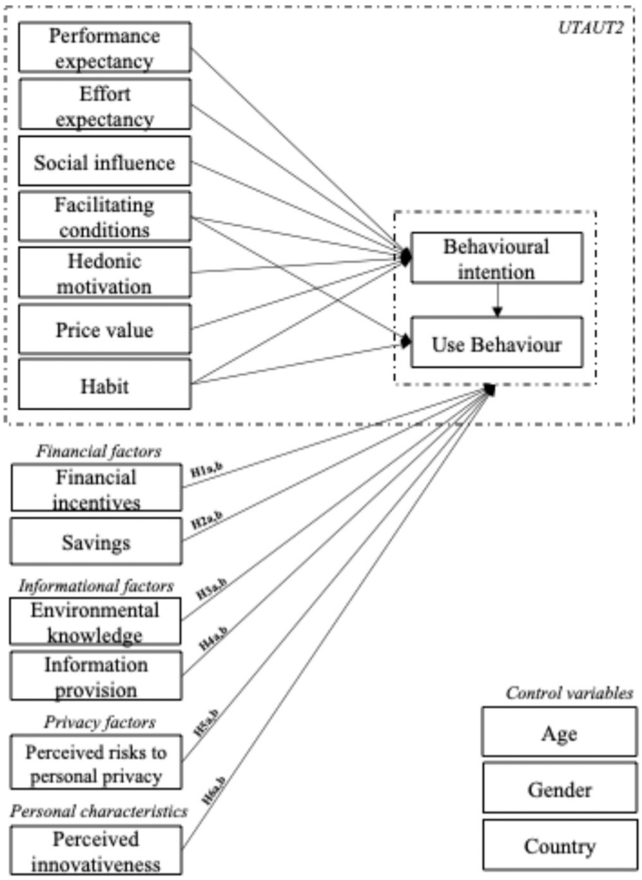

Fig. 2. Research model.

price value. Price value assesses if a technology provides good value for its cost. In contrast, financial incentives are aimed at facilitating technology adoption through exemptions or subsidies, for example. While price value involves a subjective evaluation of both tangible and intangible benefits, financial incentives are solely tied to monetary factors. Additionally, price value focuses on the benefits provided by the technology, while financial incentives originate from governments or institutions and, therefore, do not come from the use of the technology itself. Previous studies found the significance of incentives on purchase intentions for electric vehicles (Wang et al., 2021). Given its strong relevance, several studies have been developed to determine what incentives to offer in order to maximize the demand for a technology while remaining under the public predefined budget (van Blommestein et al., 2018), as well as which type of economic incentives should be developed (Meisel & Merfeld, 2018). In the qualitative study, the idea was reinforced: *"And right now, thinking about maybe a future electric vehicle with the incentives from the government. It is also a good part of trying to move us toward it. They are relevant because they help us surpass the economic factors and the economic difficulties in adopting these technologies, especially the most expensive ones"* (I18). Thus, we hypothesize:

H1a. : Financial incentives will positively influence behavioral intention to use sustainable technologies.

Regarding the use itself, financial incentives do not necessarily refer to some help in the initial investment that could only benefit the user in the acquisition of the equipment. Instead, they can refer to exemptions or subsidies associated with the use of sustainable technologies. For example, Maki et al. (2016) found that financial incentives can positively influence sustained sustainable behavior. Also, Wang et al. (2021) found that households use energy-efficient appliances when financial incentives schemes exist. This supports the idea that financial incentives might not only be relevant in the purchase or adoption of a technology, but also in promoting its sustained use. Thus, we hypothesize:

H1b. : Financial incentives will positively influence sustainable technology use.

Overall, sustainable technologies have a vast potential for monetary and energy savings, and this has been identified as a crucial factor in individuals' decision processes in previous research. Michelsen & Madlener (2012) suggested that awareness of possible savings is a key predictor of energy-saving behaviors/investments. Also, Neves & Oliveira (2021a) found that potential saving positively influences individuals' intention to adopt efficient appliances. The interviews supported this hypothesis: *"Is there any reason people adopt that equipment? If you show that the savings throughout the life cycle of using the equipment are positive or if you can get enough savings to offset your investment."* (I6). Thus, we hypothesize:

H2a. : Savings will positively influence the behavioral intention to use sustainable technologies.

Regarding use behavior, Ek & Söderholm Patrik (2010) found that promoting more information about concrete energy-saving measures can impact individuals' actual behavior, in that case, on-demand response programs, leading to a hypothesis about the use behavior. Supporting this, Bergman & Foxon (2020) referred that, very often, savings can only be felt after long-term use of the technologies. This can, therefore, lead an individual to potentially want to use more sustainable technologies in an attempt to obtain those benefits more rapidly. Thus, we hypothesize:

H2b. : Savings will positively influence sustainable technology use.

Individuals, when not well informed or not knowing, find it much more challenging to engage in pro-environmental behaviors, and therefore, it can be seen as a barrier if there is a lack of knowledge (Hamzah & Tanwir, 2021). Also, Koo and Chung (2014) found that eco-technological knowledge and familiarity with smart green IT facilitates environmental action and the intention to use smart green IT. This study underscores the relevance of individuals possessing information and being familiar with a technology, understanding its benefits, to take action. The qualitative study pointed out this effect: "For example, if someone installed a sort of a solar panel in my home, and I see like a digital panel where all the data are, but it is unreadable. Probably I would not use it because I would not understand."; "If it is not something I can read, something I can understand, probably we will get disinterested." (I18). Thus, we hypothesize:

H3a. : Environmental knowledge will positively influence the behavioral intention to use sustainable technologies.

Regarding use, we also acknowledge that the greater the environmental knowledge, the greater the use of sustainable technologies since awareness of features and benefits can lead to greater interest and more often use of the technology. For example, Saleem & Zhang (2024), while studying solar panel technologies, found that knowledge about the technology and its benefits can help individuals increase their sustainable consumption behavior, as it makes them more reassured of the solar panel technology. Also, Saleem and Zhang (2024) found that knowledge of solar energy influences the household use of solar energy home systems, showing that this will grow as the user learns more about the technology. Thus, we hypothesize:

H3b. : Environmental knowledge will positively influence sustainable technology use.

Information provision was reiterated in the qualitative study as an essential driver for sustainable technology adoption. Consumers need guidance and clarity about sustainable technologies, showing specific information about those. Respondents affirmed this: "I think that the main thing would be to explain the advantages of one of the solutions currently available in the market and explain how much a consumer could save if they adopt it."; "Because that is what consumers want to know. If I choose this equipment, what would I benefit from it? The main thing? What are the advantages of the technology? Can he benefit from that technology?" (I7). In prior research, the provision of information was found relevant in studying consumer attitudes regarding electric vehicles (Wang et al., 2021), suggesting that information on the technology features, needs, and requirement is essential in creating a greater intention toward the use of technology. Saleem and Zhang (2024) also noted the need for information on the features, benefits, and practicality of the technology to promote the adoption of renewable solar systems. Thus, we hypothesize:

H4a. : Perceptions of information provision policies will positively influence the behavioral intention to use sustainable technologies.

On the other hand, studies have found that the provision of information and feedback has also influenced actual consumption behaviors beyond intentions (Bae et al., 2023). The provision of information about features and performance, especially in real-time, if possible, can encourage greater use of sustainable technologies or adjustment of the use according to the informed needs. Moreover, information provision fosters trust and confidence in the reliability and effectiveness of sustainable technologies, addressing potential concerns or uncertainties that may negatively impact the use, as well as creating a more stable attitude regarding the technology (Hobman & Ashworth, 2013). Thus, we hypothesize:

H4b. : Perceptions of information provision policies will positively influence sustainable technology use.

The interviews also raised some privacy issues. The role of privacy concerns in technology adoption has been examined in previous research and, recently, even more in intelligent technologies, including sustainable technologies (Warkentin et al., 2017). In the context of sustainable solutions, there is a clear collection of user and household data. For example, smart metering technology collects data in real-time. There is an emphatic concern about how that data can be used, how safe it is, and who can access it (Hmielowski et al., 2019; Wunderlich et al., 2019). Therefore, perceived risks to personal privacy have been examined as a significant barrier to adopting technologies. In the qualitative study, the interviewees reinforced this: "It is an issue because it is private data; one gets to know everything. From evaluating the consumption profile of a family, you can understand when they are home or not. That is critical information. You can learn a lot."; "I would say you need to be very careful, and you need to be quite certain of how your data is being processed and effectively how private it is or not." (I5). Thus, we hypothesize:

H5a. : Perceived risks to personal privacy will negatively influence the behavioral intention to use sustainable technologies.

When individuals feel that their privacy may be compromised through the use of sustainable technologies, they can limit or contain their use as a way of protecting their personal data. These privacy concerns often suggest feelings of mistrust and vulnerability, leading users to hesitate or avoid using sustainable technologies very often. For example, Tu et al. (2021) found that privacy concerns are negatively related to the stated adoption of smart thermostats, also reducing the acceptance of remote functionalities. This has led to the development of several blockchain-based technologies, especially in energy trading systems, to create a greater sense of privacy protection and, therefore increase energy technology use (Guan et al., 2021). Thus, we hypothesize:

H5b. : Perceived risks to personal privacy will negatively influence sustainable technology use.

Finally, regarding personal characteristics, innovativeness was central to complex, smart, and innovative technologies. The role of innovativeness is already known in several fields and can be defined as the degree to which individuals are open to innovations (Venkatesh et al., 2012). The innovative and smart aspects of sustainable technologies are prominent, so consumer innovativeness is expected to impact the intention to use sustainable technologies (Aldossari & Sidorova, 2018). For example, Wang et al. (2022) found the level of innovativeness of the citizens influence their intention to participate in renewable energy communities, with the most innovative ones being the most willing to participate. The interviewees similarly suggested the impact of innovativeness: "If you are motivated to try new things and try to understand how things work and stuff like that, I think it is really important for this kind of adoption" (I6). Thus, we hypothesize:

H6a. : Innovativeness will positively influence the behavioral intention to use sustainable technologies.

Regarding use behavior, it is expected that an individual who is open to trying new things might also want to use technology more deeply or frequently. For example, while studying smart thermostats, Tu et al. (2021) found evidence that consumer innovativeness reinforces the acceptance of technical attributes, like feedback functionalities or remote temperature control, of the technology. Moreover, openness to innovation tends to promote collaboration and knowledge-sharing about use experiences among consumers, which can also foster greater use of sustainable technologies (Gluch et al., 2013). Thus, we hypothesize:

H6b. : Innovativeness will positively influence sustainable technology use.

In technology usage studies, some variables must be included as controls, especially socio-demographic parameters. Age and gender were selected following prior studies (Brown & Venkatesh, 2005; Hoehle et al., 2022). Additionally, country was also selected as control variable reducing possible bias due to country variations (Ganju et al., 2016).

6. Study 2: confirmatory

6.1. Measurement and data (Study 2)

We collected quantitative data using a questionnaire to test the model. The questionnaire was developed based on the measures available for the constructs in our model, which was a combination of UTAUT2 and the qualitative study. The questionnaire comprised the items used to measure each construct (see Table D.1. in Appendix D). Most questions used a seven-point Likert scale (1 – completely disagree; 7 – completely agree). The questionnaire was in English and then reviewed by peers. Then, based on the English version, the questionnaire was translated into the languages of the other four European countries – German, Greek, Italian, and Portuguese. The versions were translated backrom English to the respective language and back to English to ensure equivalence (Brislin, 1970). We collected data using an online tool. An introductory video was presented at the beginning of the questionnaire to ensure that all respondents understood the meaning of sustainable technologies. In addition, we conducted a pilot study that received 200 responses. For the pilot study, we analyzed the reliability of scales, verifying the composite reliability and the average variance extracted, being greater than 0.7 and 0.5, respectively. We have also evaluated the loadings, confirming the reliability of all items per construct. Finally, measures of discriminant validity were also analyzed (Fornell-Larcker criterion, the cross-loadings, and the Heterotrait-Monotrait Ratio), establishing discriminant validity and, therefore, confirming that the items are measuring the intended constructs. Hence, the pilot study showed that the items were adequate and measured the constructs well, demonstrating the validity and reliability of the questionnaire.

The questionnaire was administered in five European countries for one month (July 2021). Residents from each country were invited to participate in the survey via email from a market research database consisting of individuals who were responsible or co-responsible for the decision to adopt sustainable technologies in their household (Wunderlich et al., 2019). In this selection, quotas for age and gender were also established according to each country's characteristics. After data cleaning and removing incomplete responses, a total of 2003 responses were obtained. Also, common-method bias was examined in two ways. First, using Harman's one-factor test (Podsakoff et al., 2003), none of the indicators individually explained more than 50 % of the variance. Second, a theoretically irrelevant marker variable was added (Lindell & Whitney, 2001), presenting a maximum shared variance with other variables of 0.137 (13.7 %), which is a reasonable value (Johnson et al., 2011). Therefore, no significant common method bias was found in our data.

Table 3 shows an approximately equal number of men and women and an average age of 50. Quotas were set in terms of age and gender so that the sample would have proportions similar to the country's population. In addition, a Chi-Square test was conducted, verifying no statistically significant difference between each country's home sample and population regarding age and gender (see Table E.1 in Appendix E). In terms of area of living, most respondents live in urban areas and buildings with flats. More than 50 % of the respondents are homeowners, consistent with many energy studies (e.g., (Musti et al., 2011; Wilson et al., 2015). The average number of individuals living in the household is three, with an average of one child, which aligns with the EU statistics regarding household composition statistics (Eurostat, 2019).

6.2. Results (Study 2)

Partial least squares (PLS) were used to estimate the model. This technique is adequate when we want to predict and identify key driver constructs and when the research is more exploratory research or an extension of an existing theory (Hair et al., 2011), as it is in the present study. Therefore, PLS was selected. First, the measurement model will be analyzed, followed by the structural model. Smart PLS 3.0 was used to test the model (Ringle et al., 2018).

6.2.1. Model fit

Regarding model fit, we should check on the standardized root mean square residual (SRMR), which should be 0.08 or smaller. In our case, it is 0.044, confirming the criteria. Also, we can examine the normal fit index (NFI), which is 0.874, supporting then a good model fit.

6.2.2. Measurement model

To assess the measurement model, several measures need to be

Table 3
Sample characteristics.

Descriptive statistics		
Gender	Men	49 %
	Women	51 %
Age (average)		50
Urban area		72 %
Building Type	Terrace	13 %
	Detached	22 %
	Semi-detached	15 %
	Flat	49 %
	Other	1 %
Homeowner		62 %
Number of individuals living in the household (average)		3
Number of children (average)		1
CountryItaly		400
Germany		401
Greece		400
UK		401
Portugal		401

Table 4
Mean, standard deviation, CR, and Fornell-Lacker table. The diagonal elements are the square root of AVE.

	CR	AVE	Mean	STD	PE	EE	SI	FC	HM	PV	HT	BI	FI	S	K	IP	PR	I	Use
PE	0.96	0.86	4.68	1.50	**0.93**														
EE	0.94	0.79	5.07	1.21	0.65 * **	**0.89**													
SI	0.96	0.90	4.57	1.29	0.71 * **	0.64 * **	**0.95**												
FC	0.89	0.67	4.45	1.32	0.68 * **	0.72 * **	0.68 * **	**0.82**											
HM	0.94	0.85	4.84	1.45	0.76 * **	0.69 * **	0.68 * **	0.67 * **	**0.92**										
PV	0.94	0.85	4.17	1.50	0.68 * **	0.56 * **	0.62 * **	0.67 * **	0.67 * **	**0.92**									
HT	0.92	0.74	3.92	1.52	0.76 * **	0.60 * **	0.70 * **	0.76 * **	0.68 * **	0.73 * **	**0.86**								
BI	0.98	0.94	4.36	1.72	0.63 * **	0.50 * **	0.57 * **	0.61 * **	0.57 * **	0.54 * **	0.68 * **	**0.97**							
FI	0.93	0.77	5.46	1.24	0.47 * **	0.41 * **	0.38 * **	0.30 * **	0.47 * **	0.29 * **	0.32 * **	0.34 * **	**0.87**						
S	0.97	0.94	4.80	1.47	0.55 * **	0.55 * **	0.50 * **	0.47 * **	0.57 * **	0.46 * **	0.49 * **	0.48 * **	0.44 * **	**0.97**					
K	0.93	0.81	4.62	1.31	0.61 * **	0.65 * **	0.55 * **	0.65 * **	0.57 * **	0.50 * **	0.62 * **	0.57 * **	0.41 * **	0.63 * **	**0.90**				
IP	0.96	0.86	5.24	1.20	0.48 * **	0.43 * **	0.40 * **	0.39 * **	0.47 * **	0.34 * **	0.34 * **	0.40 * **	0.60 * **	0.46 * **	0.49 * **	**0.93**			
PR	0.95	0.79	3.84	1.52	−0.09 * *	−0.04	−0.02	0.01	−0.09 * *	−0.06 *	0.05	−0.05	−0.09 * **	−0.07 * *	0.02	−0.10	**0.89**		
I	0.91	0.77	4.21	1.43	0.49 * **	0.47 * **	0.49 * **	0.62 * **	0.52 * **	0.42 * **	0.54 * **	0.52 * **	0.34 * **	0.43 * **	0.52 * **	0.24 * **	0.04	**0.88**	
Use	0.96	0.90	3.82	1.70	0.60 * **	0.48 * **	0.54 * **	0.67 * **	0.54 * **	0.54 * **	0.72 * **	0.71 * **	0.25 * **	0.45 * **	0.61 * **	0.31 * **	0.05 *	0.50 * **	**0.95**

Notes: PE – Performance expectancy; EE – Effort expectancy; SI – Social influence; FC – Facilitating conditions; HM – Hedonic motivations; PV – Price value; HT – Habit; BI – Behavioural intention; FI – Financial incentives; S – Savings; K – Environmental knowledge; IP – Information provision; PR – Perceived risks to personal privacy; I – Perceived innovativeness; Use – Use behaviour. $^*p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$; all other correlations are insignificant.

analyzed. Table 4 shows the mean and standard deviation of the constructs, as well as the composite reliability (CR) and the average variance extracted (AVE). Regarding CR, all constructs were higher than 0.7, indicating that the scales were reliable and an AVE higher than 0.5, suggesting convergent validity (Fornell & Larcker, 1981; Hair et al., 2011). Two loadings were between 0.4 and 0.6 (Hair et al., 2016). After verifying the other measures, one item from the savings construct (S1) and one from the perceived innovativeness construct (I3) were deleted.

To test discriminant validity, three criteria were used: the Fornell-Larcker criterion, the cross-loadings, and the Heterotrait-Monotrait Ratio (HTMT). The first criterion states that the diagonal elements representing the squared root of AVE should be higher than the correlation between the constructs (Fornell & Larcker, 1981). This criterion was satisfied. To assess the second criterion, all loadings should be higher than the cross-loadings, as verified (see Table F.1. in Appendix F), satisfying this criterion (Chin, 1998). Finally, we need to assess the HTMT. Table F.2 in Appendix F shows that the diagonal values were lower than 0.9, establishing discriminant validity. Consequently, all constructs can be used to test the structural model.

6.2.3. *Structural model*

Before examining the structural model, the variance inflation factor (VIF) assessed the multicollinearity between all constructs. All values are between 1.057 and 4.168, below five, indicating no multicollinearity issues among variables (Hair et al., 2016). The path coefficients are presented in Table 5. Bootstrapping with 5000 iterations of resampling was performed to assess the significance of the path coefficients (Hair et al., 2011).

The model explained 55.9 % of the variance in behavioral intention and 64.4 % in the use of sustainable technologies. Regarding behavioral intention, many of the variables from UTAUT2 were statistically significant, except for social influence ($\widehat{\beta}$=0.047; p > 0.10), hedonic motivations ($\widehat{\beta}$=0.016; p > 0.10), and price value ($\widehat{\beta}$=−0.040; p > 0.10). Also, although statistically significant, the effect of effort expectancy was in the opposite direction to UTAUT2 prediction, as it had a negative effect on behavioral intention ($\widehat{\beta}$=−0.80; p < 0.01). From the set of variables identified in the qualitative study, we found several to be significant: savings ($\widehat{\beta}$=0.074; p < 0.01), environmental knowledge ($\widehat{\beta}$=0.093; p < 0.01), information provision ($\widehat{\beta}$=0.081; p < 0.01), perceived risks to personal privacy ($\widehat{\beta}$=−0.050; p < 0.01) and perceived innovativeness ($\widehat{\beta}$=0.123; p < 0.01). Thus, H2a, H3a, H4a, H5a and H6a were supported. Only financial incentives were not statistically significant, thus not supporting H2a.

Regarding use, from the UTAUT2 variables, the habit was statistically significant ($\widehat{\beta}$=0.347; p < 0.01), as well as behavioral intention ($\widehat{\beta}$=0.377; p < 0.01). From the set of variables identified in the qualitative study, we found that environmental knowledge ($\widehat{\beta}$=0.171; p < 0.01), information provision ($\widehat{\beta}$=−0.036; p < 0.10), perceived risks to personal privacy ($\widehat{\beta}$=0.031; p < 0.05) and perceived innovativeness ($\widehat{\beta}$=0.074; p < 0.01) were significant. Finally, we found that financial factors were insignificant, thus not supporting H1b and H2b.

Moreover, the UTAUT2 and UTAUT2 with the qualitative study variables model were compared using the adjusted R-squared. The R-squared measure will always increase when the number of explanatory variables increases, regardless of their significance. On the other side, the adjusted R-squared will only increase if the new variables indeed improve the model. Therefore, to compare models with a different number of independent variables, one should use the adjusted R-squared. Table 4 presents the adjusted R-squares for both models. Based on that measure, we can conclude that the proposed holistic model performs somewhat better than just UTAUT2 in the context of sustainable technologies, with an approximate increase of 3 % and 2 % in intention and use, respectively. The slight increase in variance explained should not be seen as a small contribution, as there are some powerful findings in the change of what is significant. Especially powerful is that other constructs from our qualitative study replace the effect of social influence in UTAUT2′s prediction of behavioral intention; similarly, the effect of facilitating conditions in UTAUT2′s prediction of use is replaced by other constructs from our qualitative study. Thus, using only UTAUT2 could lead to the erroneous conclusion that social influence and facilitating conditions are important when, in reality, several other newly identified constructs are. Additionally, the model's predictive power was analyzed using the f-square measure (Cohen, 1988). Values are reported in Appendix G, revealing a small to medium effect size, with a large effect of behavior intention to use behavior. Although we recognize that there are few large effects, these values seem satisfactory given the wide number of independent variables. Further, the inclusion of those variables, even with small f-square, is supported by both theoretical and practical implications, providing meaningful theoretical and practical insights, creating a model that is both comprehensive and robust as a whole, as shown by the R-square measure.

Since we acknowledge that results might change from country to country, in order to evaluate the robustness of the results found and identify possible consistencies or differences across countries, a comparison between countries was also performed. Thus, this country comparison allows us to (1) understand the possible robustness of the model, ensuring its validity across different contexts, (2) comprehend possible differences between countries and identify factors that are generally relevant and others that are context-specific, (3) inform policymakers and organizations to develop tailored strategies towards the adoption of sustainable technologies, and (4) contribute to a homogeneous adoption of sustainable technology across the European Union, especially considering the importance that environmental sustainability has to the European Commission, as stated in the Renewable Energy Directive (European Commission, 2023). Table 6 presents the results by country. Overall, all the most substantial effects for both behavioral intention and use behavior in the individual models are also significant in the model with all sample observations. Habit appears statistically significant for all countries in both dependent variables. Perceived innovativeness and savings also appear statistically significant in four countries for behavioral intention. In terms of the use of behavior, behavioral intention is significant in all countries. Environmental

Table 5
Comparison of models (*p < 0.10; **p < 0.05; ***p < 0.01).

	UTAUT2	UTAUT2 + qualitative study
Behavioural intention (adjusted r-squared)	**52.3 %**	**55.5 %**
Performance expectancy	0.18 * **	0.12 * **
Effort expectancy	−0.02	−0.08 * **
Social influence	0.06 * *	0.05
Facilitating conditions	0.16 * **	0.12 * **
Hedonic motivations	0.07 * *	0.02
Price value	−0.05	−0.04
Habit	0.35 * **	0.33 * **
Financial incentives	-	−0.01
Savings	-	0.07 * **
Environmental knowledge	-	0.09 * **
Information provision	-	0.08 * **
Perceived risks to personal privacy	-	−0.05 * **
Perceived innovativeness	-	0.12 * **
Use (adjusted r-squared)	**62.1 %**	**64.2 %**
Facilitating conditions	0.07 * **	−0.00
Habit	0.41 * **	0.35 * **
Behavioral intention	0.41 * **	0.36 * **
Financial incentives	-	−0.03
Savings	-	0.02
Environmental knowledge	-	0.17 * **
Information provision	-	−0.04 *
Perceived risks to personal privacy	-	0.03 * *
Perceived innovativeness	-	0.08 * **

Table 6
Path coefficients per country.

	Germany	Greece	Italy	Portugal	United Kingdom
Behavioral intention (R-squared)	53.3 %	51.6 %	66.1 %	43.6 %	62.1 %
Performance expectancy	0.12	0.06	0.17 * *	0.06	0.11
Effort expectancy	−0.15 * *	−0.16 * **	−0.07	−0.08	0.06
Social influence	0.02	0.14 * *	0.07	−0.00	0.02
Facilitating conditions	0.08	0.18 * *	0.34 * **	0.09	0.03
Hedonic motivations	0.08	−0.10	−0.03	−0.01	0.12
Price value	−0.00	0.12 *	−0.14 * *	−0.05	−0.19 * **
Habit	0.32 * **	0.24 * **	0.27 * **	0.34 * **	0.49 * **
Financial incentives	−0.06	0.01	0.00	0.03	−0.00
Savings	0.12 * *	0.12 *	0.11 *	0.14 * *	−0.03
Environmental knowledge	0.17 * **	0.03	−0.03	0.09	0.12 * *
Information provision	0.03	0.14 * *	0.15 * **	0.08	0.06
Perceived risks to personal privacy	−0.07	−0.05	−0.01	−0.02	−0.08 * *
Perceived innovativeness	0.15 * **	0.16 * **	0.11 * *	0.11 * *	0.04
Use (R-squared)	64.6 %	58.9 %	74.2 %	58.4 %	71.6 %
Facilitating conditions	−0.09 *	0.05	0.02	−0.09	0.08
Habit	0.27 * **	0.26 * **	0.48 * **	0.38 * **	0.27 * **
Behavior intention	0.41 * **	0.35 * **	0.29 * **	0.35 * **	0.45 * **
Financial incentives	0.05	−0.07 *	−0.05	−0.06	0.04
Savings	0.14 * **	0.03	−0.04	−0.06	0.02
Environmental knowledge	0.21 * **	0.20 * **	0.17 * **	0.25 * **	0.04
Information provision	−0.09 *	−0.07	−0.06	0.00	−0.02
Perceived risks to personal privacy	0.01	−0.00	0.03	0.11 * **	0.01
Perceived innovativeness	0.04	0.09 * *	0.09 * *	0.06	0.08 * *

knowledge and perceived innovativeness are also significant in four and three countries, respectively. This outcome reinforces the relevance of individuals' knowledge of the energy topic and this type of solution, as well as the strong impact of being open to innovations as a solid personal characteristic of both potential and most frequent users.

7. Discussion

Given the increasing relevance of the role of technology in meeting sustainability goals, the need to understand consumer behavior regarding the acceptance and use of sustainable technologies also increases (Dwivedi et al., 2022). A contextualized version of UTAUT2 for sustainable technologies highlighted the relevance of other new factors to understand sustainable technologies' adoption and use. These findings are relevant to both science and practice, as they provide insights to help formulate strategies for consumer adoption and establish a theoretical basis for future studies on sustainable technologies.

Regarding UTAUT2 variables, performance expectancy was statistically significant for behavioral intention as the fourth-highest effect. This finding is consistent with previous research (Gimpel et al., 2020). Interestingly, effort expectancy was significant but had a negative effect. Contrary to what is usually found in technology adoption studies, where the effect of effort expectancy is positive, our results suggest a different relationship for sustainable technologies. One possible reason is that some technologies, such as solar panels or smart plugs, may not require much interaction with the user for the installation process and the use itself. Therefore, individuals may not need specific knowledge or additional effort to use the technologies, so even without knowing how to use the technology comprehensively, individuals are willing to use it.

Social influence was found to be not significant. This finding suggests that the opinions of important others are not necessarily relevant in this context. Therefore, as proved in previous studies, for these types of solutions, communication from more reliable sources has a much more preponderant effect on consumers' consideration of using sustainable technologies (Neves & Oliveira, 2021). Hedonic motivations were also found to be non-significant. This is perhaps in line with the fact that these technologies are not necessarily designed to enhance fun and enjoyment but rather serve functional purposes, albeit in a more energy-efficient manner.

Conversely, utilitarian outcomes are more important, such as increasing performance. Also, the price value was found to be non-significant. Price value results from evaluating individuals between the benefits and the monetary cost of using the technology. Therefore, the cost-benefit relation is not relevant for behavioral intention, suggesting that users may understand that sustainable technologies may not be so expensive, so it is not a significant influencing factor.

Facilitating conditions is the variable with the second highest impact on behavioral intention. This means that the extent to which individuals have the necessary resources or support significantly influences the intention to use sustainable technologies. This is consistent with the literature (Girod et al., 2017). The most significant predictor of behavioral intention and use is habit. This conclusion suggests the need for experience with the solutions or at least trialability. So, users who have already tried or had an experience with any solution will possibly be more willing to use them. Someone who has already used or was part of a household with sustainable technologies is also much more likely to adopt a sustainable energy solution (Venkatesh et al., 2023). However, that may not always be the case, and that is where trialability enters. Trialability can be described as the ease with which potential users can explore solutions (Rogers, 2010), and it has been widely used to explain the adoption of innovations. Potential users may want to see how the solution may work. Of course, this is only valid for some digital solutions. Most of the time, in solutions/innovations, the user may not be completely aware of how they work or their benefits, so trialability, when possible, can be an optimal strategy.

Regarding the qualitative factors, and to help in the interpretation of the quantitative results, an additional qualitative corroboratory study (phase 3) was performed. Seven consumers and experts from the five countries under analysis, all users of sustainable technologies, were interviewed to comment on the obtained results and add additional insights. Interviews were performed during May 2025 and lasted approximately 30 min. They were performed through an online video-conferencing platform. Table 7 summarizes the main findings and compares them to the quantitative results obtained.

From the set of variables identified in the qualitative study, only financial incentives were not found to be significant. Environmental knowledge and information provision (informational factors) had the strongest effect on behavioral intention among this set of variables. Regarding financial factors, only savings present an impact on behavioral intention. Financial incentives are not significant for both dependent variables. Although previously shown to be a good strategy (Kastner & Stern, 2015), when tested with other variables in a more

Table 7
Comparison between quantitative results and qualitative confirmatory results.

Qualitative study 1 factor	Proposed hypotheses	Quantitative study 2 result	Comparison (study 1 vs. study 2)	Possible explanation (Qualitative corroboration study 3)	Comparison (study 2 vs. study 3)
Financial incentives	Positive impact on intention and use	Not statistically significant for both intention and use	Inconsistent finding	"Yeah, I think financial incentives probably could [be relevant], but I would say not maybe the main driver, at least for my point of view, because [for adopting a sustainable technology] it's also a time commitment." (I1) "(…) you have to get to the point in your decision process where they got important, because at first, even if there is a big incentive and the product does not work for your life, then it is not suitable. (…) In the beginning, there is a need for good information and at least a basic understanding of the technology. And after all, when you say: "ok, this product is good and fits in my life, I think if there is an incentive" (I3) "I think it is because financial incentives are associated with just a short-term reward. Like, here in Portugal, if you buy an EV, you might get an exemption, but only if you are the first one doing that (…) Also, I know many people who will buy sustainable technologies even if there are not financial incentives due to the benefits they will get, but this requires people to know this…" (I5)	Consistent with quantitative study 2, referring financial incentives as not the main driver
Savings	Positive impact on intention and use	Statistically significant only for intention	Semi-consistent finding	"Getting savings is important, but from experience, they can only be felt after some time, so I agree, I would not use more just because of the savings" (I5) "[when using a technology] I am not mainly focused on my financial gains on them, but the personal [benefits] for the society at all" (I7)	Consistent with the quantitative study 2, referring to savings as not relevant for the use behavior
Environmental knowledge	Positive impact on intention and use	Statistically significant for both intention and use	Consistent finding	"Maybe one of the most important factors, because I will never use something I do not understand (…)" (I5) "So as a user, I like to know what the technology can bring to me." (I7)	Consistent with the quantitative study 2
Information provision	Positive impact on intention and use	Statistically significant only for intention	Semi-Consistent finding	"The better approach is to get in touch with the technology and afterward maybe some [deeper] information [like] calculations, etc. (…)" (I2) "(…) this is not important [for use] because if they already know it will work, then it's not important how it works" (I3) "It's important, but it's not a crucial thing to use because it might be very detailed and condensed. (…) but this information should exist and be easily available if I want to" (I5)	Semi-consistent with the quantitative study 2, referring that information is essential but not a crucial factor for the use behavior – it is important for the decision to adopt the technology
Perceived risks to personal privacy	Negative impact on intention and use	Statistically significant for both intention and use (positive impact on use)	Semi-Consistent finding	"[using a sustainable technology] will require some amount of personal data. There's no getting around it, but if the benefits outweigh the risks, it's this trade off. I will keep my personal data, but I will need to know the benefits" (I4) "I understand privacy as a concern, but compared to the benefits we get [by using the technology] (…) it will not have a big role in how I use the technology (…)" (I5) "Any technology that you want to acquire will always have that privacy perspective. So, I do not think it is a is a very well exclusively related to this type of technology" (I6) "I think a way to mitigate this concern is to inform the user how their information is going to be treated and how it is going to be handled. Who is going to be the providers? Who is going to use that information? And	Semi-consistent with the quantitative study 2, referring that it is important to mitigate the risks related to personal privacy for the ones that feel it. However, compared to the benefits provided by the technology, this factor becomes irrelevant

(*continued on next page*)

Table 7 (*continued*)

Qualitative study 1 factor	Proposed hypotheses	Quantitative study 2 result	Comparison (study 1 vs. study 2)	Possible explanation (Qualitative corroboration study 3)	Comparison (study 2 vs. study 3)
				they have strict, very strict regulations." (I7)	
Perceived innovativeness	Positive impact on intention and use	Statistically significant for both intention and use	Consistent finding	"It's a fundamental characteristic for this type of technologies that are trending (…) we need to be able to embrace new innovations" (I5) "I agree (…) For the "conservative" people, you need to change the culture, probably they are not aware (…) or don't believe in the effectiveness of the technology, so it's better to spread more information about the benefits" (I6)	Consistent with the quantitative study 2

Note: I1 – Italy & Consumer; I2 – Germany & Expert (Researcher); I3 – Germany & Expert (Energy Engineer); I4 – Greece & Expert (Project manager); I5 – Portugal & Consumer; I6 – Portugal & Expert (Researcher); I7 – UK & Consumer.

holistic model, they are not as relevant as some other factors, such as the facilitating conditions or informational factors. In the qualitative study (study 3), some interviewees acknowledged that financial incentives were indeed relevant. However, they emphasized that these incentives were not as significant as information or knowledge on benefits, as they identified these factors as the primary driver influencing their decisions. Therefore, only after deciding to use a technology would they search for any existing incentives. Therefore, financial drivers were not significant when compared to non-financial ones.

Savings represent consumer awareness about the possible energy and monetary savings they may obtain by using a sustainable energy solution. Savings were found statistically significant for behavioral intention. As shown in previous studies, informing individuals about possible savings is an excellent approach to engaging individuals in these solutions (Neves & Oliveira, 2021). However, the same was not found for use behavior itself, where savings were not a statistically significant predictor. This result suggests that being aware of the savings will not influence the extent of use behavior. One possible explanation is that substantial savings may only be felt after prolonged use (Bergman & Foxon, 2020). Therefore, while being aware of possible savings might increase intention to use these technologies, individuals may ultimately prioritize other factors influencing use behavior itself since the awareness of savings does not immediately translate into benefits of use.

Environmental knowledge represents the third-highest effect on use and is also one of the most relevant for intention. Individuals knowledgeable on energy topics and sustainable technologies are more willing to use them. That is a big issue for the area because some of the sustainable solutions are challenging to understand. When not well-informed or not knowledgeable, individuals find it much more challenging to engage in pro-environmental behaviors, which can be seen as a barrier to sustainable technologies (Hamzah & Tanwir, 2021). For this reason, substantial investment in education and information provision policies is critical to increasing the adoption and use of sustainable technologies (Papagiannidis & Marikyan, 2022).

The energy literacy of individuals is minimal, which is precisely one of the reasons individuals may not even think about adopting a sustainable energy solution, especially if they already have some other technology/solution that satisfies their basic needs, like thermal comfort, among others. Even for individuals who feel a particular responsibility for the environment, some studies proved that the lack of knowledge is a barrier to adopting sustainable behaviors (Simmons & Widmar, 1990). Therefore, there is an imperative need to provide information to people about the capacities and benefits of using sustainable technologies (Stieglitz et al., 2023), also confirming the relevance of information provision policies towards behavioral intention. Conversely, our results suggest that these policies and support negatively impact use. This finding suggests that information provision policies may only be relevant initially.

Regarding the use itself, results show that the current user does not need information on features, performance, or installation needs, suggesting that information can also be overwhelming and, therefore, harmful. That may happen when the information is provided. However, for example, the consumer does not understand it and, therefore, will negatively influence its use. Therefore, the amount of information and how it is transmitted should be carefully planned. The results of the qualitative study suggested two aspects: the first is related to the fact that once the user knows how to use the technology, it does not need much more information on it. The second point referred to was that information should be clear and available but only at the request of the user.

Personal innovativeness is a relevant characteristic of potential and current users, being the third and the fourth highest effects on behavioral intention and use behavior, respectively. The individual characteristic of being open to new technologies is fundamental, especially in new and innovative solutions. As was expected, an individual who likes to try and use innovative technologies will be more willing to use sustainable technologies, as found in previous studies (Wunderlich et al., 2019). This facet is crucial because some of these solutions are complex and perceived as problematic. So, one relevant consumer trait is whether they are open to innovations. Someone with that profile will perceive the complexities of the technology much more positively (Aldossari & Sidorova, 2018). Results from the third qualitative study suggest that although people who are more open to innovation are "easier" users, there is still a need to engage less innovative people. Some strategies are passed by spreading more information about the benefits and effectiveness of the technology, as well as getting them in touch with the technology. More than just informing, it is making them see the benefits.

Finally, perceived risks to personal privacy harm behavioral intention. In the case of sustainable technologies, weariness about data protection may arise, especially for smart appliances, wearable devices, or even electric vehicles that easily collect data about the user or household. Essentially, most of the time, the problem is not in the technology itself but in the trust of the user in the company/retailer that has access to that data. Therefore, energy providers/companies should take privacy concerns seriously and include these concerns in advertising campaigns, as consumers with higher perceived risks in terms of data protection will be less willing to accept sustainable technologies. Surprisingly, in terms of use, this variable had a positive effect on use behavior. One possible explanation is that, although individuals may consider privacy risks as possible and essential if consumers do a cost/benefit analysis (privacy calculus theory) between the privacy disclosure and the benefits they currently enjoy, consumers may weigh the benefits and, therefore, use the technologies very frequently, as they perceive these solutions as providing significant benefits. This may especially happen in countries with relatively new sustainable technologies (Wunderlich et al., 2019). Also, the privacy calculus has been proven to strongly affect the adoption of environmentally friendly technologies (Xu et al., 2009). The corroboratory study suggested that indeed privacy is a concern, but (1) not specifically to sustainable technologies, but indeed most technologies nowadays, and (2) there are several regulations on how data is used, so once the individual decides to adopt and use a sustainable technology, it might not be a concern, especially compared with the benefits they can take from the technology.

Additionally, for use behavior, as expected, behavioral intention is the one with the highest impact, followed by habit, as previously discussed. Again, environmental knowledge is very relevant, occupying the third place, followed by perceived innovativeness. This result reinforces the role of being knowledgeable of energy topics and this type of solution and being open to trying new solutions.

Although these conclusions are generally consistent across the countries studied, it should be noted that the way consumers are approached may differ from country to country, as they differ in some other effects. For example, Greece shows a significant positive effect of social influence. The importance of the opinions of friends and family also depends on the level of familiarity the individuals have with them and if, for example, it is expected to have sustainable solutions and share experiences. This is something specific to that country. Also, environmental knowledge is statistically significant in Germany and the UK, where information provision policies are irrelevant, and vice versa for the remaining countries. This is especially interesting for several reasons. First, Germany is particularly interesting to study due to its several environmental policies and values the government leverages. Both Germany and the UK present a generally higher baseline environmental knowledge due to greater education efforts, media, and historical environmental policies (Wunderlich et al., 2019). Therefore, consumers in these countries are expected to have greater knowledge and familiarity with energy-related topics and technologies.

In contrast, information provision policies affect use only in countries where environmental knowledge is not significant. This is true for Greece and Italy, which might reveal a greater need for information due to a possible lower level of familiarity with sustainable technologies. In fact, these countries present high levels of energy poverty (Papada & Kaliampakos, 2016), reflecting their lower environmental knowledge and greater need for information policies. Therefore, again, strategies should be customized for each country. Nevertheless, educating consumers is still transversally crucial because, in any case, an increase in knowledge positively affects both intention and use. However, information cannot be overwhelming and, therefore, has the contrary effect of presenting this solution as even more complex than what consumers already think.

Additionally, a relevant difference is the effect of price value. The models suggest a positive effect for Greece but a negative one for the United Kingdom. This indicates that, in Greece, individuals perceive sustainable technologies as a good value for the money, which might be particularly appealing in a country such as Greece where (1) economic conditions may make benefits of the technology, such as cost savings, highly attractive, and (2) due to its geographical position and climate, the exploitation of sustainable technologies such as renewable energy systems has great potential (Kyriakopoulos et al., 2018). This result again suggests the different views individuals of countries have of this type of solution, reinforcing that strategies should not be equal for all countries.

7.1. Theoretical implications

Regarding theoretical implications, first, it is relevant to emphasize the significant theoretical advance by developing a holistic model for complex technologies. This strategy allowed for a comprehensive understanding of sustainable technologies use that was missing in the literature. The existence of a holistic model that comprises several types of factors highlights the need to integrate multiple perspectives to address real-world problems.

Second, by developing a model that integrates UTAUT2 and contextualizes it to sustainable technologies through qualitative data, we demonstrate the need to complement the UTATU2 perspective to better explain this type of technology context. Moreover, it reinforces the need to extend and/or contextualize theories to fit the distinctiveness of technologies or behaviors better. Our findings highlight the importance of informational factors and perceived innovativeness. At the same time, UTAUT2 variables like social influence and hedonic motivations lose significance when contextualized within sustainable technology adoption. This highlights the need to complement the UTAUT2 framework with context-specific considerations to explain behavior in this domain better. For UTAUT2, this study paves the way for a more complete understanding of technology usage behaviors beyond the original constructs.

Third, by empirically testing the extended UTAUT2 for sustainable technologies individually in multiple countries, we provided insights into the robustness and versatility of the model, shedding light on key differences and similarities between them. This fact provided valuable insights into the common and specific factors influencing sustainable technology use in different countries. Such differences are conssitent with those observed in other technology adoption studies in previously unexplored countries (Thongpapanl et al., 2021; Venkatesh et al., 2016, 2010).

Finally, we have demonstrated the relevance of using a mixed methods design, reinforcing the importance of employing both qualitative and quantitative methods in the investigation of sustainable technologies. In fact, apart from some works (Wunderlich et al., 2019), the joint field of energy and technology has tended to rely on either quantitative or qualitative methods. We, therefore, demonstrate the importance of applying mixed methods for different purposes of the research.

7.2. Practical implications

Concerning practical implications, the developed model allows us to understand better the behavioral intention and use of sustainable technologies and, therefore, has the possibility of being the basis of several strategies and promotions to enhance the adoption of sustainable technology solutions. This research provides essential findings for policymakers and practitioners.

The most significant predictor of behavioral intention and use was habit, suggesting the need for experience or some sort of trialability with the technologies. Some recommendations pass by offering trial periods or the opportunity to participate in pilot programs, either provided by the municipalities or the vendors themselves. These will allow the user to increase familiarity with the technology without fully committing to its acquisition. When the user cannot try the technology, then the existence of demonstrations, developed either by vendors, organizations, or municipalities, can be the solution. These demonstrations can also improve individuals' familiarity and understanding of the technologies.

Besides habit, facilitating conditions show a strong impact on behavioral intention. Therefore, recommendations are focused on increasing the resources and support available. Vendors should enhance accessibility and availability, for example, by expanding partnerships with local organizations that individuals can resort to for support, offering training and educational materials. Additionally, established forums and support networks can contribute to this feeling of ease in getting help from others when needed. Municipalities should focus on creating events where users can connect with peers, share experiences, and seek assistance. This would also contribute to the increased knowledge of individuals on sustainable technologies. Finally, vendors should also ensure the availability of assistance when needed throughout the whole process, from installation and integration to use daily.

In fact, the strategies mentioned above are very much related to the environmental knowledge dimension and information provision policies found to be relevant in shaping individuals' intentions. Local organizations and energy agencies, among others, should put a great effort into education campaigns aimed at increasing energy literacy, either through workshops, online courses, informational websites, or community events. Also, the implementation of behavioral nudges can increase users' awareness. Overall, making more informed individuals might reflect in more empowered users since they feel greater levels of competence, encouraging greater use of these technologies. Nevertheless, care should be taken when providing information that is sometimes complex to its users. Information overload, or feelings of exhaustion and/or frustration by not being able to capture and process all information available, can have the contrary effect and lead to lower use levels (Pang & Ruan, 2023).

Finally, personal innovativeness proved to be a relevant characteristic of potential and current users, being the third and the fourth highest effects on behavioral intention and use behavior, respectively. Strategies should pass by highlighting the new, innovative, or smart features of the technologies, particularly from the vendor's perspective. This can be achieved through offering demonstrations or trials, in which individuals can experience the most recent advances in sustainable technologies, as well as showcasing success stories that demonstrate the transformative impact of innovation while overall fostering an innovation mindset. However, it is important to acknowledge that personal innovativeness may inherently vary among individuals, posing challenges in addressing this trait uniformly.

7.3. Limitations and future research

This study is not without limitations. First, we are studying sustainable technologies overall and not a specific technology. Although each sustainable technology might have its specificities, we believe studying overall sustainable technologies allows us to comprehend the broader picture of different technologies. By focusing on predominant characteristics and commonalities, we were able to gain a holistic understanding of sustainable technologies, making it easier to adapt to changes in technology. Second, the qualitative study was restricted to a small set of consumers and experts from the five countries. Although they are from different cultures, they may not fully represent general opinions. Therefore, although finding the significance of several constructs identified in the qualitative study, other important factors could have possibly emerged if we had conducted a significantly larger number of interviews. Thirdly, as we are studying a complex set of technologies with different characteristics, other theories could also be relevant to explain the phenomenon instead of UTAUT2. Additionally, only 83 % of the sample identified themselves as users of sustainable technologies. This inconsistency raises the possibility of sample bias, as individuals who do not currently use sustainable technologies may have different perspectives or motivations. Finally, further studies could extend the comparison between countries. We encourage the study of other countries and a more granular measurement of culture in future studies (Rai et al., 2009).

8. Conclusion

This work provides insights into the main factors influencing sustainable technology adoption and use using a model that integrates UTAU2 and constructs based on a qualitative study. Three studies were conducted: qualitative study 1 (exploratory), quantitative study 2 (confirmatory), and qualitative study 3 (corroboration). Our study was conducted with data collected in five European countries. As the main finding, the model suggests the relevance of non-financial factors over financial ones. The profile of a consumer who is much more willing to use these solutions is, therefore, someone who is open to innovations. These consumers perceive the benefits as much more important than the costs and confront the complexities of the solutions much more pragmatically. Also, environmental knowledge is one of the most critical variables. Thus, individuals' education and engagement are significant for using these technologies and should be carefully planned according to countries' characteristics. Direct actions toward the education of individuals on the topic of energy should be developed, comprehensively demystifying these solutions. We found evidence that adding the constructs that emerged from the qualitative study to UTAUT2 increased the predictive power above what the baseline UTAUT2 offered. More importantly, the constructs identified in the qualitative study displaced some of the key UTAUT predictors. Finally, the findings across countries showed several consistencies, suggesting the robustness of our model; however, there were enough differences to suggest that local contexts in different countries need to be considered as we confront the critical issue of sustainability and achievement of SDGs through technology. Our model offers a basis for future research and practical solutions for the adoption and use of sustainable technologies.

CRediT authorship contribution statement

Tiago Oliveira: Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Frederico Cruz-Jesus:** Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Viswanath Venkatesh:** Writing – review & editing, Supervision, Conceptualization. **Catarina Neves:** Writing – original draft, Methodology, Formal analysis, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. – Interview script

Do you use any sustainable technology?

a. If yes, which? Why? How was/is your experience with it?

1. Which characteristics of sustainable technologies do you like? Which do you not like?
2. Which motives would be relevant to you in adopting a sustainable technology?

a. What is the importance of your personal values in the adoption of sustainable technologies?
b. What is the importance of your interest in innovations in adopting sustainable technologies?
c. What is the importance of social opinion in the adoption of sustainable technologies?
d. What is the importance of the benefits of adopting sustainable technologies?
e. What is the importance of price and financial issues in adopting sustainable technologies?
f. What is the importance of privacy and data security in adopting sustainable technologies?

3. Do you think information about sustainable technologies is easily accessible?
4. What should organizations do to engage more people in these sustainable technologies?
5. Which aspects would be improved for you to adopt a sustainable technology?
6. If you could, would you adopt a sustainable technology? (if not yet adopted)

Appendix B. – Interviewees details

Table B1
Interviewees details.

ID	Country	Role	Occupation	Household role	User
I1	Italy	Expert	University professor	Responsible for the decision to adopt technologies	Yes
I2	Italy	Expert	Researcher	Responsible for the decision to adopt technologies	Yes
I3	Italy	Expert	Researcher	Responsible for the decision to adopt technologies	Yes
I4	Greece	Expert	Head of applied research and innovation	Responsible for the decision to adopt technologies	Yes
I5	Portugal	Expert	Environmental engineer	Responsible for the decision to adopt technologies	Yes
I6	Portugal	Expert	Researcher	Responsible for the decision to adopt technologies	Yes
I7	Portugal	Expert	Project manager	Responsible for the decision to adopt technologies	Yes
I8	United Kingdom	Expert	Sustainability manager	Responsible for the decision to adopt technologies	No
I9	Italy	Consumer	Unemployed	Not responsible for the decision to adopt technologies	Yes
I10	Italy	Consumer	Communication department employee	Responsible for the decision to adopt technologies	No
I11	Italy	Consumer	Mechanical engineer	Not responsible for the decision to adopt technologies	Yes
I12	Greece	Consumer	Marketing assistant	Responsible for the decision to adopt technologies	Yes
I13	Greece	Consumer	Marketing and communication officer	Responsible for the decision to adopt technologies	Yes
I14	Germany	Consumer	Project leader	Responsible for the decision to adopt technologies	Yes
I15	Germany	Consumer	Self-employed baker	Responsible for the decision to adopt technologies	No
I16	Germany	Consumer	Mechanical engineer	Responsible for the decision to adopt technologies	Yes
I17	Portugal	Consumer	University professor	Responsible for the decision to adopt technologies	Yes
I18	Portugal	Consumer	IT consultant	Responsible for the decision to adopt technologies	No

Appendix C. – Main codes and selected quotes

Table C1
Main codes and selected quotes.

UTAUT2
Performance expectancy
I5
"Yeah, the most important thing I would say is the functionality and what I can take from the technology."
I7
"I think that the utilitarian part is essential because if I have this notion that if I want to get better at something, I need to monitor that behavior. That these kinds of technologies allow me to track to get some feedback regarding my energy consumption regarding my energy behaviours. I think that is the most important thing."
I9
"I think that's the main part if I can, like, reduce my consumption and at the same time gain something in it…"
Effort expectancy
I1
"I think this is very, very important. If the technology wants to spread in the market in a way or be really used, they have to be easy to use, plug, change, test, or verify it."
I2
"The interaction with the user should be kept to a minimum."
I5
"I'm interested in using them. It should be easy for me because my day is full, so I do not really have time to read big books about how to use things. If it's easy for me to use, it makes sense for me to use it."
Social influence
I4
"I would say that the social network effect is quite important. So if let's say, friends of mine or the surrounding family environment want to adopt or are willing to adopt that. I would also go for it, so the social pressure or the social comparison. It's quite important for me."
I5
"I guess that also knowing from family and friends is also very important. Of course, if someone else is adopting, I will obviously have a look at what they are using…"

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Table C1 (*continued*)

Financial factors
Financial incentives
I1
"At the government level, there can be incentives to something like that because it generally works."
I4
"However, I would say that we need to receive some incentives from our utility to better, let's say, adopt that. Maybe financial incentives."
"But I think that the financial incentives specifically, in a specific group of people or in specific social norms, it's quite important."
I12
"… and to give maybe some economic incentives to the consumers."
I18
"And right now, I am thinking about maybe a future electric vehicle with the incentives from the government. It's also a good part of trying to move us toward it. They are relevant because they help us surpass the economic factors and the economic difficulties in adopting these technologies, especially the most expensive ones."
Savings
I1
"Others more correlated to the building itself, like solar panels, renewable energy sources or, electric cars, possibility to recharge or something like that, that's more correlated to the lifespan of the technology, so the possibility to have a payback time is relevant."
I6
"Any reason that makes people adopt that kind of equipment? If you show that the savings throughout the life cycle of the use of the equipment are positive or if you can get enough savings that can offset the investment that you make."
I7
"I think that the main thing would be to explain the advantages of which one of the solutions that are currently available in the market, and that would explain how much a consumer could save."
I12
"For me, this is the major motive and not only for me. I think for everyone."
I18
"Why do I use this solution if I'm not getting any savings or any profits?"
Informational factors
Environmental knowledge
I4
"I do not think it's too much understandable. I think there has been some work towards that direction, but we still need more things to be done."
I11
"Is it about people actually knowing how to manage, how not, how to install? Because they usually do not install, but how to actually get benefits from the technologies and use it in the most correct, let's say correct way."
I18
"For example, if someone installed a sort of solar panel in my home, and I see like a digital panel where it's all the data, but it's unreadable. Probably, I would not use it because I wouldn't understand."
"If it's not something I can read, something I can understand, probably we will get disinterested."
Information provision
I4
"There is a lot of lack of awareness from the people. So, I think they should be as we say in the US, they should be brain dead, so it's going to be simple, very easy to use…".
"We need to raise the awareness of the people towards that direction. To make them believe and to train them that this is something that is not up to you. It is going to be easy. It is going to be transparent, so we need to train people towards that direction to make them believe and train them."
I5
"They have to relate the technologies to the solution, so I think it is quite important that we have the ability to explain technical terms in easy-to-understand means. Make people relate to the solutions when people understand exactly what we are talking about."
I7
"I think that the main thing would be to explain the advantages of which one of the solutions that are currently available in the market and explain how much a consumer could save if they adopt it."
"Because that's what consumers want to know. If I choose this equipment, what would I benefit from that exactly? The main thing? What are the advantages of the technology now? Can he benefit from that technology?"
"I think that there should be more understanding of the energy hierarchy."
I11
"Possibly people need to have more information available or maybe more demonstrations and so on, like more information about these overall."
I12
"It's not very easy to have access to information like this, and it's a little bit difficult to understand the information that they break down."
Privacy factors
Perceived risks to personal privacy
I4
"We have to be very careful of what kind of data we're taking out of the house. Especially in Europe, GDPR and privacy issues they're playing a very, very important role. We have to pay very much attention."
"Because there are too many articles around. You know. Mentioning that with your smart meter, we can actually monitor whatever you do in your house. So, I think there are plenty of articles and plenty of fake news around that that they can actually raise the fear."
I5
"It is an issue because it's private data; one gets to know everything, from evaluating the consumption profile from a family you can understand when they are home or not. That is critical information. You can learn a lot."
"I would say you need to be very careful, and you need to be quite certain of how your data is being processed and effectively how private it is or not."

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Table C1 (*continued*)

I7
"The GDPR issues are more present nowadays. And sadly, we see much news regarding some privacy issues of social networks, and I think it's something that I take into consideration more often. And I think it would be something that I look at during the adoption phase because if I can be sure that it will have no privacy issues, I will go forward, but if I'm not sure, I know there will be privacy issues, I won't even buy it so that it wouldn't be an option."
I8
"I'm concerned about privacy using devices, free apps, or that kind of thing, and my children think I'm a dinosaur, but I am concerned; I think you should. It shouldn't be known when you were in the house or when you were not. These kinds of things, isn't it?"
I14
"I really like the EU approach of taking data privacy seriously. It puts it to a higher standard regarding smart home devices like Amazon Alexa, for instance, to do intelligent light steering, while I know that the data is probably stored. Like how much data could that be of use for someone besides the advertising algorithms?"
"It's always a tradeoff. You pay a little bit for the product, and you pay the rest in data, and people need to be aware of it."
Personal characteristics
Innovativeness
I5
"I like to evaluate them, and if they are within my purchase possibilities, I will definitely try to adopt it."
I6
"If you are motivated to try new things and trying to understand how things work and stuff like that, I think it's really important for this kind of adoption."
I11
"It's like a smartphone, or it's like just a car. So nowadays we don't change our cars because they don't work anymore. We change it because we want to have the new technology in the car itself because they can still drive with the car right now."

Appendix D. – Survey items

Table D1
Survey items.

Construct	Acronym	Item
Performance expectancy (Bhattacherjee, 2001; Venkatesh et al., 2012)	PU1	Using sustainable technologies improves my performance in managing energy consumption
	PU2	Using sustainable technologies increases my productivity in managing energy consumption
	PU3	Using sustainable technologies enhances my effectiveness in managing energy consumption
	PU4	Overall, sustainable technologies are useful in managing energy consumption
Effort expectancy (Venkatesh et al., 2012)	EE1	Learning how to use sustainable technologies is easy for me
	EE2	My interaction with sustainable technologies is clear and understandable
	EE3	I find sustainable technologies easy to use
	EE4	It is easy for me to become skillful at using sustainable technologies
Social influence (Venkatesh et al., 2012)	SI1	People who are important to me think that I should adopt sustainable technologies
	SI2	People who influence my behavior think that I should adopt sustainable technologies
	SI3	People whose opinions that I value prefer that I adopt sustainable technologies
Facilitating conditions (Venkatesh et al., 2012)	FC1	I have the resources necessary to use sustainable technologies
	FC2	I have the knowledge necessary to use sustainable technologies
	FC3	sustainable technologies are compatible with other technologies I use
	FC4	I can get help from others when I have difficulties using sustainable technologies
Hedonic motivation (Venkatesh et al., 2012)	HM1	Using sustainable technologies is fun
	HM2	Using sustainable technologies is enjoyable
	HM3	Using sustainable technologies is very entertaining
Price value (Venkatesh et al., 2012)	PV1	Sustainable technologies are reasonably priced
	PV2	Sustainable technologies are a good value for the money
	PV3	At the current price, sustainable technologies provides a good value
Habit (Venkatesh et al., 2012)	HT1	The use of sustainable technologies has become a habit for me
	HT2	I am addicted to using sustainable technologies
	HT3	I must use sustainable technologies
	HT4	Using sustainable technologies has become natural to me
Financial incentives (Wang et al., 2021)	FI1	For adopting sustainable technologies, a government direct subsidy policy is attractive to me
	FI2	For adopting sustainable technologies, exemptions are valuable to me
	FI3	For adopting sustainable technologies, exemption from sales tax is helpful to me
	FI4	For adopting sustainable technologies, exemption from VAT is useful to me
Savings (Neves & Oliveira, 2021)	S1	I would be more likely to adopt sustainable technologies, if I received a subsidy to finance the adoption (dropped)
	S2	I am aware of the total energy savings over the sustainable technologies' lifetime
	S3	I am aware of the total monetary savings over the sustainable technologies' lifetime
Environmental knowledge (Hamzah & Tanwir, 2021)	K1	I am familiar with sustainable technologies
	K2	I am knowledgeable about energy topic and the environment
	K3	I know how to select sustainable technologies
Information provision (Wang et al., 2021)	IP1	For adopting sustainable technologies, information on the practicality and reliability of sustainable technologies is helpful to me
	IP2	For adopting sustainable technologies, information on the installation needs of sustainable technologies is important to me
	IP3	For adopting sustainable technologies, information on the features of sustainable technologies is helpful to me

(*continued on next page*)

Table D1 (*continued*)

Construct	Acronym	Item
	IP4	For adopting sustainable technologies, information on the energy consumption and environmental performance of sustainable technologies is valuable to me
Perceived risks to personal privacy (Malhotra et al., 2004)	PR1	Sustainable technologies would collect too much information about a user
	PR2	I would be concerned about my privacy when using sustainable technologies
	PR3	I have doubts as to how well my privacy is protected while using sustainable technologies
	PR4	My personal information would be misused when using sustainable technologies
	PR5	My personal information would be accessed by unknown parties when using sustainable technologies in my everyday life
Perceived innovativeness (Agarwal & Prasad, 1998)	I1	If I heard about a new technology, I would look for ways to experiment with it
	I2	Among my peers, I am usually the first to try out new technologies
	I3	In general, I am hesitant to try out new technologies (dropped)
	I4	I like to experiment with new technologies
Behavioural intention (Venkatesh et al., 2012)	BI1	I intend to use sustainable technologies in the next months
	BI2	I predict I would use sustainable technologies in the next months
	BI3	I plan to use sustainable technologies in the next months
Use Behaviour (Venkatesh et al., 2012)	UB1	I often use sustainable technologies in my household
	UB2	I often use sustainable technologies to manage my energy consumption
	UB3	I often use sustainable technologies to monitor my energy consumption

Appendix E. – Age and gender distribution per country

Table E1
Age and gender distribution.

Country	Age/Gender	Population [1]	Sample	Chi-squared (p-value)
Germany	18 –24	9%	9%	0.04 (0.98)
	25 –49	37%	37%	
	> 50	53%	53%	
	Female	51%	51%	0.00 (0.96)
	Male	49%	49%	
Greece	18 –24	9%	9%	0.04 (0.98)
	25 –49	40%	40%	
	> 50	52%	52%	
	Female	51%	51%	(>0.99)
	Male	49%	49%	
Italy	18 –24	8%	8%	0.00 (0.98)
	25 –49	38%	38%	
	> 50	55%	55%	
	Female	52%	52%	(>0.99)
	Male	48%	48%	
Portugal	18 –24	9%	9%	0.02 (0.99)
	25 –49	39%	39%	
	> 50	53%	53%	
	Female	52%	52%	0.00 (0.96)
	Male	48%	48%	
UK	18 –24	11%	11%	0.00 (0.99)
	25 –49	42%	42%	
	> 50	47%	47%	
	Female	51%	51%	0.00 (0.96)
	Male	49%	49%	

Notes[1]: Source: http://appssoeurostateceuropaeu/nui/showdo?dataset=demo_pjan (EUROSTAT: Population on 1 January by age and sex (The last update was 27.04.21 and extracted on 20.05.21)

Appendix F. – Loadings and cross-loadings

Table F1
Loadings and cross-loadings.

	PE	EE	SI	FC	HM	PV	HT	BI	FI	S	K	IP	PR	I	Use
PE1	**0.94**	0.61	0.67	0.65	0.7	0.63	0.74	0.60	0.44	0.50	0.58	0.44	−0.06	0.47	0.58
PE2	**0.95**	0.62	0.69	0.66	0.71	0.65	0.75	0.61	0.42	0.53	0.59	0.42	−0.05	0.49	0.60
PE3	**0.96**	0.61	0.68	0.66	0.71	0.66	0.73	0.62	0.43	0.51	0.58	0.44	−0.07	0.48	0.59
PE4	**0.87**	0.58	0.6	0.57	0.70	0.60	0.59	0.52	0.47	0.51	0.50	0.53	−0.15	0.40	0.47
EE1	0.54	**0.88**	0.53	0.59	0.57	0.45	0.49	0.40	0.39	0.47	0.57	0.40	−0.02	0.38	0.38
EE2	0.55	**0.89**	0.55	0.60	0.59	0.45	0.49	0.42	0.36	0.48	0.58	0.39	−0.02	0.38	0.41
EE3	0.63	**0.91**	0.61	0.68	0.68	0.56	0.59	0.48	0.37	0.50	0.58	0.37	−0.06	0.44	0.47
EE4	0.60	**0.91**	0.62	0.69	0.64	0.53	0.58	0.49	0.36	0.52	0.61	0.41	−0.02	0.46	0.46

(continued on next page)

Table F1 (*continued*)

	PE	EE	SI	FC	HM	PV	HT	BI	FI	S	K	IP	PR	I	Use
SI1	0.67	0.63	**0.95**	0.66	0.64	0.60	0.67	0.55	0.36	0.47	0.52	0.38	0.00	0.48	0.52
SI2	0.66	0.60	**0.95**	0.63	0.64	0.58	0.66	0.53	0.34	0.47	0.50	0.37	−0.01	0.46	0.50
SI3	0.69	0.61	**0.95**	0.65	0.66	0.60	0.68	0.56	0.38	0.48	0.53	0.40	−0.03	0.49	0.52
FC1	0.52	0.48	0.55	**0.84**	0.48	0.61	0.68	0.54	0.14	0.33	0.46	0.22	0.04	0.40	0.55
FC2	0.53	0.69	0.53	**0.84**	0.53	0.48	0.60	0.48	0.26	0.44	0.66	0.37	0.03	0.46	0.52
FC3	0.64	0.65	0.61	**0.86**	0.62	0.56	0.66	0.56	0.35	0.45	0.58	0.37	−0.06	0.50	0.53
FC4	0.55	0.53	0.55	**0.74**	0.58	0.54	0.53	0.41	0.25	0.33	0.45	0.34	0.03	0.34	0.42
HM1	0.71	0.65	0.64	0.64	**0.94**	0.62	0.63	0.54	0.43	0.50	0.55	0.44	−0.07	0.50	0.52
HM2	0.70	0.65	0.64	0.62	**0.93**	0.60	0.60	0.51	0.45	0.55	0.53	0.48	−0.12	0.45	0.47
HM3	0.70	0.63	0.63	0.61	**0.92**	0.65	0.67	0.53	0.44	0.54	0.52	0.40	−0.06	0.51	0.50
PV1	0.59	0.49	0.55	0.61	0.57	**0.92**	0.67	0.47	0.21	0.36	0.43	0.25	−0.01	0.40	0.49
PV2	0.68	0.55	0.60	0.63	0.67	**0.94**	0.68	0.52	0.33	0.46	0.49	0.37	−0.09	0.41	0.50
PV3	0.62	0.52	0.58	0.61	0.62	**0.92**	0.67	0.49	0.26	0.46	0.47	0.34	−0.08	0.39	0.51
HT1	0.67	0.55	0.64	0.73	0.61	0.69	**0.93**	0.64	0.23	0.45	0.59	0.28	0.05	0.49	0.70
HT2	0.58	0.45	0.56	0.63	0.54	0.63	**0.89**	0.53	0.17	0.37	0.49	0.21	0.13	0.47	0.61
HT3	0.65	0.46	0.57	0.50	0.56	0.54	**0.72**	0.53	0.45	0.39	0.44	0.37	−0.06	0.45	0.44
HT4	0.73	0.60	0.66	0.73	0.65	0.65	**0.91**	0.65	0.30	0.49	0.63	0.34	0.04	0.51	0.69
BI1	0.62	0.49	0.56	0.60	0.56	0.52	0.66	**0.97**	0.34	0.47	0.56	0.40	−0.05	0.51	0.69
BI2	0.62	0.48	0.56	0.59	0.55	0.52	0.67	**0.98**	0.34	0.47	0.56	0.39	−0.04	0.51	0.69
BI3	0.61	0.49	0.55	0.60	0.56	0.52	0.66	**0.98**	0.33	0.47	0.55	0.39	−0.05	0.51	0.69
FI1	0.43	0.36	0.33	0.27	0.42	0.25	0.26	0.29	**0.86**	0.39	0.36	0.58	−0.14	0.26	0.21
FI2	0.46	0.39	0.36	0.28	0.44	0.29	0.33	0.33	**0.88**	0.43	0.40	0.54	−0.07	0.35	0.23
FI3	0.39	0.33	0.32	0.25	0.39	0.24	0.29	0.30	**0.88**	0.34	0.34	0.48	−0.03	0.30	0.22
FI4	0.38	0.35	0.31	0.25	0.40	0.22	0.24	0.28	**0.88**	0.38	0.34	0.52	−0.09	0.28	0.21
S2	0.53	0.53	0.48	0.45	0.55	0.44	0.46	0.46	0.44	**0.97**	0.60	0.45	−0.07	0.41	0.43
S3	0.54	0.53	0.49	0.47	0.56	0.46	0.49	0.48	0.42	**0.97**	0.62	0.45	−0.07	0.44	0.45
K1	0.55	0.59	0.49	0.62	0.52	0.48	0.59	0.55	0.35	0.62	**0.91**	0.44	−0.02	0.47	0.59
K2	0.56	0.58	0.49	0.54	0.55	0.43	0.52	0.48	0.44	0.51	**0.88**	0.48	0.02	0.48	0.49
K3	0.54	0.60	0.50	0.61	0.50	0.45	0.59	0.51	0.33	0.57	**0.92**	0.43	0.05	0.48	0.57
IP1	0.46	0.40	0.38	0.36	0.43	0.33	0.33	0.39	0.54	0.43	0.48	**0.92**	−0.08	0.33	0.31
IP2	0.44	0.40	0.37	0.36	0.43	0.31	0.31	0.35	0.55	0.42	0.44	**0.93**	−0.10	0.32	0.28
IP3	0.46	0.41	0.37	0.37	0.45	0.32	0.31	0.37	0.57	0.44	0.46	**0.94**	−0.10	0.32	0.29
IP4	0.46	0.41	0.38	0.37	0.46	0.33	0.32	0.39	0.58	0.43	0.46	**0.93**	−0.10	0.31	0.29
PR1	0.00	0.06	0.05	0.07	0.02	0.01	0.11	0.00	−0.01	0.00	0.08	−0.02	**0.81**	0.10	0.09
PR2	−0.11	−0.06	−0.04	0.00	−0.12	−0.08	0.04	−0.06	−0.11	−0.11	−0.01	−0.13	**0.92**	0.03	0.03
PR3	−0.09	−0.04	−0.02	0.01	−0.10	−0.06	0.04	−0.05	−0.09	−0.08	0.01	−0.08	**0.93**	0.04	0.05
PR4	−0.10	−0.06	−0.03	−0.01	−0.11	−0.08	0.03	−0.06	−0.11	−0.08	0.00	−0.12	**0.93**	0.04	0.05
PR5	−0.09	−0.05	−0.03	−0.01	−0.11	−0.08	0.02	−0.05	−0.09	−0.06	0.01	−0.10	**0.90**	0.05	0.04
I1	0.46	0.42	0.46	0.44	0.48	0.39	0.48	0.47	0.36	0.39	0.46	0.35	0.06	**0.88**	0.42
I2	0.40	0.37	0.43	0.48	0.40	0.37	0.51	0.46	0.20	0.33	0.46	0.21	0.13	**0.89**	0.50
I4	0.46	0.45	0.44	0.46	0.51	0.39	0.48	0.47	0.35	0.44	0.48	0.36	−0.04	**0.89**	0.44
UB1	0.57	0.47	0.51	0.60	0.52	0.52	0.69	0.70	0.25	0.44	0.60	0.34	0.04	0.48	**0.94**
UB2	0.59	0.47	0.52	0.59	0.52	0.52	0.68	0.67	0.24	0.43	0.57	0.29	0.05	0.50	**0.97**
UB3	0.57	0.45	0.51	0.59	0.50	0.51	0.68	0.65	0.22	0.42	0.56	0.26	0.07	0.48	**0.95**

Notes: PE – Performance expectancy; EE – Effort expectancy; SI – Social influence; FC – Facilitating conditions; HM – Hedonic motivations; PV – Price value; HT – Habit; BI – Behavioural intention; FI – Financial incentives; S – Savings; K –Environmental knowledge; IP – Information provision; PR – Perceived risks to personal privacy; I – Perceived innovativeness; Use – Use behavior

Table F2
Heterotrait-Monotrait ratio (HTMT).

	PE	EE	SI	FC	HM	PV	HT	BI	FI	S	K	IP	PR	I	Use
PE															
EE	0.69														
SI	0.74	0.68													
FC	0.76	0.81	0.76												
HM	0.81	0.75	0.73	0.76											
PV	0.73	0.60	0.66	0.75	0.72										
HT	0.83	0.66	0.77	0.86	0.75	0.80									
BI	0.65	0.52	0.59	0.67	0.60	0.56	0.73								
FI	0.51	0.44	0.41	0.34	0.51	0.31	0.37	0.36							
S	0.58	0.59	0.52	0.53	0.61	0.49	0.53	0.50	0.48						
K	0.65	0.71	0.59	0.75	0.63	0.55	0.69	0.61	0.46	0.68					
IP	0.52	0.46	0.42	0.44	0.50	0.36	0.37	0.41	0.65	0.49	0.54				
PR	0.10	0.06	0.03	0.05	0.10	0.07	0.08	0.05	0.10	0.07	0.04	0.10			
I	0.54	0.52	0.55	0.60	0.58	0.48	0.63	0.57	0.38	0.48	0.60	0.38	0.09		
Use	0.63	0.51	0.56	0.69	0.57	0.57	0.77	0.73	0.26	0.47	0.65	0.32	0.05	0.56	

Notes: PE – Performance expectancy; EE – Effort expectancy; SI – Social influence; FC – Facilitating conditions; HM – Hedonic motivations; PV – Price value; HT – Habit; BI – Behavioural intention; FI – Financial incentives; S – Savings; K –Environmental knowledge; IP – Information provision; PR – Perceived risks to personal privacy; I – Perceived innovativeness; Use – Use behaviour

Appendix G. – f-square values

	f-square
Behavioural intention	
Performance expectancy	0.011
Effort expectancy	0.005
Social influence	0.002
Facilitating conditions	0.010
Hedonic motivations	0.000
Price value	0.001
Habit	0.055
Financial incentives	0.000
Savings	0.006
Environmental knowledge	0.010
Information provision	0.000
Perceived risks to personal privacy	0.005
Perceived innovativeness	0.021
Use	
Facilitating conditions	0.000
Habit	0.114
Behavioral intention	0.176
Financial incentives	0.003
Savings	0.000
Environmental knowledge	0.030
Information provision	0.000
Perceived risks to personal privacy	0.003
Perceived innovativeness	0.009

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