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The Impact of Sustainable Technologies in the Perceived Well-being: The Role of Intrinsic Motivations

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ABSTRACT
Sustainable technologies are increasingly being introduced into consumers' life as a mitigation effort against environmental problems. However, the study of the main factors that influence its use and satisfaction, but especially their impact on well-being has not been yet fully explored. In fact, post-adoption stages are infrequently studied on this topic. To fill this gap, this study aims to explain the consumers' inner motivations for sustainable technology use and satisfaction and the impact of those technologies on consumers' perceived well-being. Moreover, the moderating impact of intrinsic motivations is explored. A contextualized model is created based on a mixed-methods approach. We tested our model using 400 observations from Greece. The work found the significance of all hypotheses, except the moderation between use and perceived well-being. The study provides valuable insights into the understanding of the consumers' motivations to use sustainable technologies, as well as the role of technologies in more humanistic outcomes.

KEYWORDS
Sustainable technologies; energy; motivations; well-being; mixed-methods

1. Introduction

Nowadays, sustainable technologies have faced increased interest from researchers and consumers. Directives from the European Union (EU) are increasingly searching for ways to mitigate environmental problems and climate change (European Parliament, 2019). Several studies are focusing on the importance of natural resources, as well as the impact energy use has on the environment quality (Liu, Alharthi, et al., 2022; Liu, Khan, et al., 2022), showing the increasing relevance of investigating this topic. Many strategies rely on sustainable technologies, reinforcing the important role of technology in sustainability goals (Butler, 2011). Hence, sustainable technologies have become one of the better ways to control resource utilization, contributing to greater consumer awareness and more sustainable habits (Jakučionytė-Skodienė et al., 2022; Marikyan et al., 2019). Especially with the Covid-19 pandemic, several studies have investigated how this situation actually positively promoted pro-environmental behavior intention (Mi et al., 2021), strengthening even more the importance of studying the interaction of citizens with sustainable technologies.

However, in the last instance, one can say that a great purpose of sustainable technologies is to improve individuals' well-being. Nevertheless, very few studies have evaluated the performance of these technologies and their impact on well-being. Most studies have focused on the adoption of sustainable technologies (e.g., Wunderlich et al., 2019), neglecting the other post-adoption stages, such as use or performance, clearly indicating a gap in the literature. Moreover, when it comes to well-being studies, many of them are related to general technologies or energy poverty contexts (e.g., Kumareswaran et al., 2021; Nie et al., 2021; Zhang et al., 2021). Few works have studied the relationship between pro-environmental behaviors and well-being, but once more focused on behaviors and practices, and not on technologies themselves (e.g., Capstick et al., 2022; Guillen-Royo, 2019; Mock et al., 2019). Therefore, given the strong relevance of studying alternative ways to combat climate change (Azam et al., 2023; Tauseef Hassan et al., 2023), especially focusing on the role technologies may have, and the inexistence of studies that evaluate this in light of the consumer well-being perspective, this study commits to contributing to the extension of the current body of knowledge on the topic, focusing on answering the following research questions:

RQ1: What are the inner motivations of consumers to use sustainable technologies?

RQ2: What is the impact of sustainable technologies on individuals' well-being?

However, given the wide range of possible motivators, we resort to a mixed-methods design in an attempt to provide stronger conclusions (Venkatesh et al., 2016). The model is tested with a sample from Greece. This country is especially

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relevant to study given that the Greek government is much more focused on implementing reform in the energy sector toward decarbonization, in line with the EU objective of becoming the world's first climate-neutral continent by 2050 (Administration, 2021). Also, Greece exceeded the 2020 EU set target for renewable energy production, revealing a strong effort toward a sustainable energy transition. For these reasons, it is ideal to also study post-adoption stages, such as the impact of sustainable technologies on well-being. The model is tested by resorting to structural equation modeling. To the best of our knowledge, this is one of the first articles that focuses on the impact of sustainable technologies on a humanistic outcome, such as well-being, resorting to a mixed-methods design, reinforcing the studies that investigate both the antecedents, but also outcomes of technology use and how they can affect human's life.

The contributions of this article are the following. First, it contributes to the overall research on sustainable technologies, reinforcing the importance of studying the motivators for consumers' use of technologies that can, among others, contribute to a sustainable environment, and extending the research to the joint field of technology and energy (Watson et al., 2010). Second, by following the suggestion of Venkatesh et al. (2013), our research is enriched by using both qualitative and quantitative insights, enhancing the understanding of the phenomena. This analysis is one of the first to understand the antecedents of sustainable technologies using qualitative and quantitative methods. Third, it reinforces the research of technological impacts on humanistic outcomes, following the current tendency of linking instrumental factors related to the use of technologies with humanistic outcomes, such as well-being (Sarker et al., 2019). In fact, understanding not only the antecedents of use, but the outcomes of technology use are of main relevance, but rarely studied. Therefore, well-being will be studied as the main humanistic outcome. Fourthly, the study's findings may help practitioners and policymakers understand the inner motivations for sustainable technologies use, as well as its perceived impact on consumer well-being, and therefore help formulate strategies toward sustainable technologies use and increase well-being.

The article is structured as follows. The next section presents the theoretical background, the mixed-methods approach, and the hypotheses. Section 3 presents the research model, together with a description of the methods and data collection. Section 4 presents the data analysis and results. Section 5 discusses the findings of the work, along with their implications and limitations. Finally, conclusions are presented in Section 6.

2. Background and hypothesis development

2.1. Sustainable technologies definition

The current environmental paradigm imposes several challenges, so efforts have been conducted toward sustainable goals. Several works have investigated the relevant factors that can affect environmental sustainability and protection (Awan et al., 2022). Overall, some studies found that environmental sustainability is a result of socio-economic development of countries, whose natural resources and economic growth strongly influence the country's footprint (Jie et al., 2023). Nevertheless, the adoption of some sustainable technologies can indeed have an impact on the environmental performance. For example, Wang et al. (2020) found the relevance of financial support, and awareness to adopt biogas technology. Therefore, some strategies have undoubtedly passed by both the use of more efficient and sustainable technologies, as well as a more efficient use of the overall technologies and systems (Adu-Gyamfi et al., 2022). We will focus our study on the first ones. Sustainable technologies have been defined differently through several works. Nevertheless, an accepted definition may pass by being 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 that can help consumers to change their behavior through more active actions based on metering technologies, for example, Barreto et al. (2014). Sustainable technologies are somewhat considered a complex type of technology (Wunderlich et al., 2019), distinguished from the remain by having a strong innovative and smartness component, sometimes requiring some knowledge by the user, and many of them also able to collect users' data. Moreover, sustainable technologies are categorized in several areas, from energy to water and air quality purposes. For this work, we will only focus on sustainable energy technologies since energy consumption, especially energy demand, is intensively increasing, demonstrating a strong need to transit the energy system and change consumers' energy behavior (Ritchie et al., 2020).

2.2. Mixed methods

Given the wide variety of factors that may determine sustainable technologies use and satisfaction, we resort to a mixed-methods design, implying the inclusion of both qualitative and quantitative methodologies. This approach is used when prior research is fragmented or when a single method, theory, or perspective is not enough to explain the complexity of the phenomenon (Venkatesh et al., 2016). Therefore, we believe this approach will strengthen the understanding of consumers' inner motivations for sustainable technologies. The purpose of the mixed-methods design is developmental since the qualitative study results will be used to develop the research model. Overall, the qualitative study will allow to better develop the research model, while the quantitative study will allow to test the model for a greater sample. A sequential design will be used, starting with the qualitative study and followed by the quantitative one, which is dominant (Venkatesh et al., 2016). Finally, given the general somewhat limited knowledge of the topic and the convenience of qualitative data collection, a purposive sampling is used for the qualitative study and a probability sampling for the quantitative study. Data analysis also follows a sequential design. Below, qualitative study methodology and results will be shown, presenting the resulting hypothesis to be tested in the quantitative study.

2.2.1. Qualitative study hypothesis development

The purpose of the qualitative study is to identify consumers' inner motivations for sustainable technologies use and satisfaction. Given that, 18 individuals, both experts and consumers, responsible for the decision to adopt technologies in their households were interviewed. Therefore, we believe that the sample is representative (Wunderlich et al., 2019). The number of interviews was based on data saturation (Fusch & Ness, 2015), which can be achieved when there is no more capacity to obtain new information. To achieve data saturation, a saturation grid was used, listing the main topics referred per interviewee (Brod et al., 2009). See Appendix A for interviewees' details. In terms of data analysis, an open coding methodology was followed. We segmented data into quotes and associated them with a category. Thus, a list of categories was created based on the transcriptions and notes from the interviews. The main codes were recorded, and a set of quotes from respondents was saved for each. We believe this is a good approach, as the use of inductive coding has proved to be acceptable in prior research (Wunderlich et al., 2019).

Through the qualitative data analysis, perceived usefulness was one of the most referred factors in the interviews. For example, interviewee 5 referred: "*Yeah, the most important thing I would say is the functionality and what I can take from the technology.*" Also, interviewee 7 stated that: "*I think that the utilitarian part is very important 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 behaviors. So, I think that's the most important thing.*" Moreover, interviewee 9 referred: "*I think that's the main part if I can like reduce my consumes and at the same time gain something in it ... .*" Perceived usefulness is defined as the perceived utility and performance improvement by using a technology and is considered to be an external motivator (Venkatesh et al., 2003). In fact, some studies recognize two types of motivations: extrinsic and intrinsic. Extrinsic motivation is therefore driven by external factors (Ryan & Deci, 1985). Prior research has proven that perceived usefulness is one of the greatest external motivators for sustainable behaviors and sustainable technologies adoption (e.g., Gimpel et al., 2020; Kamolsook et al., 2019; Wang et al., 2020), determining an extrinsically motivated behavior. Therefore, we hypothesize that:

H1a: Perceived usefulness will positively impact sustainable technologies use

H1b: Perceived usefulness will positively impact sustainable technologies satisfaction

Along with the perceived usefulness, perceived enjoyment was also referred. Several works have examined the role of enjoyment in increasing engagement and satisfaction with technologies (e.g., Gimpel et al., 2020; Girod et al., 2017; Wunderlich et al., 2013). For example, in the case of sustainable technologies, gamifying technologies is an emerging phenomenon to improve the user experience to be more entertaining, significantly impacting individuals to adopt more sustainable behaviors (Ke et al., 2019). Therefore, perceived enjoyment may play a key role in understanding sustainable technologies use and satisfaction. This finding was also confirmed in the interviews. For example, interviewee 3 said, "*Yeah, I think of course that if we split the population into different categories, there are people that are more interested in having fun (...). To the biggest group, you need to provide them fun and a real benefit on using this technology.*" Interviewee 4 also stated: "*Ok, so basically the information we should pass is like easy to install, easy to use and fun to use. I was in a conference some years ago and it was a guy there that stood up and said something very correct: energy is a boring product, so you need to create a fun and entertainment layer around energy. If you make it funny or entertainer, yes, I think that the awareness will rise, definitely.*" Interviewee 5 also agreed, stating: " ... *definitely that's super cool because I get to control exactly my energy needs.*" Perceived enjoyment has also been studied as one of the most used intrinsic motivations. An intrinsically motivated behavior is performed because it is stimulating or pleasing (Ryan & Deci, 1985). This aspect is related to individuals' psychological and cognitive processes, such as achievement, enjoyment, and fulfillment. Perceived enjoyment is defined as the degree to which performing a behavior is enjoyable and, to some extent, provides fun (Venkatesh et al., 2003). In sustainable technologies, as supported in the qualitative study, users' experience might create an intrinsic feeling of achievement and enjoyment, leading to higher use and satisfaction. Therefore, we hypothesize the following:

H2a: Perceived enjoyment will positively impact sustainable technologies use

H2b: Perceived enjoyment will positively impact sustainable technologies satisfaction

2.3. Post-adoption behavior hypothesis development

Although the study of the antecedents is of great relevance, most studies have examined this stage of the adoption of sustainable technologies. Thus, few have investigated the impact of these technologies on more humanistic outcomes, such as well-being (Sarker et al., 2019). Nevertheless, during the context of Covid-19 and its implications for citizens, several studies started to investigate other concepts infrequently studied and included in theories, such as health and well-being (Mi et al., 2021; Nasseef et al., 2022). The definition of well-being has been somewhat debated and might involve different perspectives (Sequeiros et al., 2022). Several authors have discussed this concept, tracing its roots to hedonia and eudaemonia perspectives. Nevertheless, an overall accepted definition is that well-being is the positive outcome of a certain behavior. Some studies have associated the concept of well-being with life satisfaction and the positive quality of life effects certain behaviors might have (El Hedhli et al., 2013; Lee et al., 2002). Our study will follow this last definition. In fact, few studies examine the impact of technologies on this outcome. Overall, most studies are related to general technologies or energy poverty contexts (Kumareswaran et al., 2021; Nie et al., 2021; Zhang et al., 2021). For example, Yoon and Kim (2022) studied how the interaction with some technology can influence the well-being and positive states, and more recently, Ozmen Garibay (2023) stated as grand challenge, the importance of considering human well-being while developing new technologies. Few works have studied the relationship between pro-environmental behaviors and well-being, focusing more on the impact of sustainable habits than the impact of technologies (e.g., Capstick et al., 2022; Guillen-Royo, 2019; Mock et al., 2019).

Many times, the use of sustainable technologies implies an activity to pursue a purpose. Energy and monetary savings, renewable energy production, and cost reduction are the main objectives consumers aim to pursue while using sustainable technologies (Rasmussen, 2017). Therefore, when a consumer completes or is a step closer to those goals and feels a certain degree of tranquility and achievement, the consumer is adopting a behavior to engage in a state of well-being. In fact, previous studies have found that adopting pro-environmental behaviors positively influences the state of well-being (Guillen-Royo, 2019), suggesting a positive relationship between these two factors across a wide range of countries worldwide (Capstick et al., 2022). Therefore, we hypothesize:

H3: Sustainable technologies use will positively impact the perceived well-being

However, to have a more complete explanation of perceived well-being, not only the use of technologies might influence well-being but also the satisfaction with the use of those technologies. If the consumer is satisfied with using the energy solution, an increase in well-being is expected. In fact, previous studies examined that the satisfaction of needs has a relevant role in perceived well-being (e.g., Deci & Ryan, 2002). Also, Mock et al. (2019) suggested that there is a strong link between well-being and people already engaged in sustainable initiatives. Even in the qualitative study, some interviewees agreed with this proposition, stating that: "So it's like a confirmation of expectations or satisfaction with the initial expectations that you cannot know at the beginning" (I5). Thus, if the consumer is satisfied with the sustainable technologies used, this will create a better state of well-being. Hence, we hypothesize:

H4: Sustainable technologies satisfaction will positively impact the perceived well-being

Finally, previous studies have proven the relevance of intrinsic motivations for certain behaviors (e.g., Sangroya & Nayak, 2017; Sequeiros et al., 2022). However, few studies evidence the possible moderating effect this motivation might have on other factors. Some studies in the organizational and psychological field have examined the moderating role of intrinsic motivations, suggesting that the higher the intrinsic motivation, the greater the effect of other factors that might positively influence the use or satisfaction (e.g., Dysvik & Kuvaas, 2011). The direct effect of intrinsic motivation on behavior has already been tested before. Nevertheless, this motivation might indirectly influence the impact of other factors. In fact, use, satisfaction, and perceived well-being are somewhat related to the sense of happiness and enjoyment, especially the latest. Therefore, we believe that for the consumers that experience higher levels of intrinsic motivations, other factors like perceived usefulness, use, and satisfaction might have a greater impact on the dependent variables. Thus, we hypothesize that:

H5a: Perceived enjoyment moderates the relationship between perceived usefulness and sustainable technologies' use

H5b: Perceived enjoyment moderates the relationship between perceived usefulness and sustainable technologies' satisfaction

H5c: Perceived enjoyment moderates the relationship between sustainable technologies' use and perceived well-being

H5d: Perceived enjoyment moderates the relationship between sustainable technologies' satisfaction and perceived well-being

Given the complexity of the phenomenon, we resorted to qualitative data to better understand consumer motivations and identify the main drivers of behavior. This qualitative study allowed us to create a research model that attempts to understand the role of intrinsic and extrinsic motivations in sustainable technologies' use and satisfaction. Also, following the suggestion of Sarker et al. (2019), the research model follows the current tendency in information systems studies by exploring the impact of technologies on one of the most important humanistic outcomes—perceived well-being. Moreover, the role of intrinsic motivation is examined as a possible moderator. Figure 1 presents the research model. Having the model built, this will be tested in the quantitative study.

2.4. Control variables

The study of consumer behavior is usually controlled by some variables, especially socio-demographic parameters (e.g., Davis, 2011; Erell et al., 2018; Yang & Zhao, 2015). Age and gender were selected as control variables in the model. These attributes will preserve the impacts on explanatory variables.

3. Data and methods

3.1. Measurement

For the quantitative study, an online questionnaire was built, composed of the items of each construct, and adapted accordingly (see Appendix B). Most questions were measured on a seven-point numerical scale (1-completely

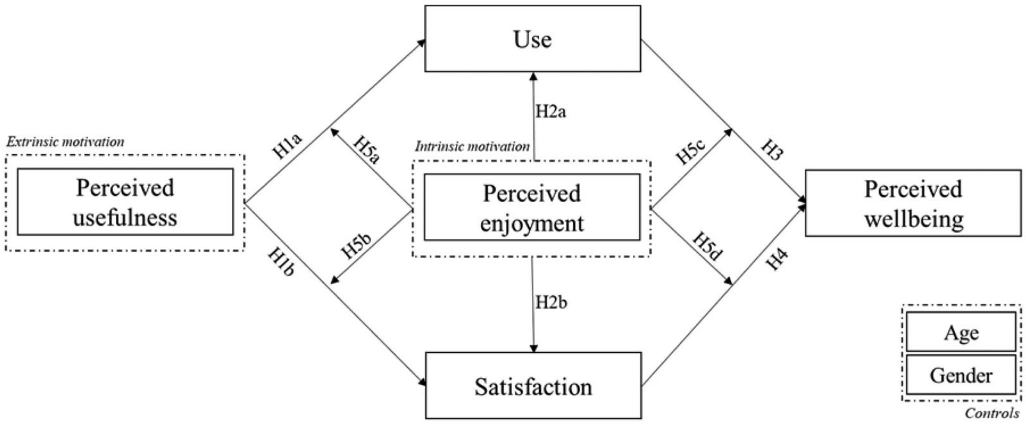

Figure 1. Research model.

disagree; 7-completely agree). The questionnaire was first developed in English and then translated into Greek. The questionnaire was reworded from English to the correspondent language and vice-versa, ensuring that all questions had the same meaning (Cha et al., 2007). Finally, a pilot test was performed using a total of 50 responses, confirming that the items adequately measured the constructs. Therefore, the questionnaire was considered valid and reliable.

3.2. Data collection

The questionnaire was administered for one month (July 2021). The sample consisted of randomly selected residents who were also participants in the decision to adopt technologies in their households, consisting of a probabilistic sample (Wunderlich et al., 2019). After data cleansing and removal of incomplete responses, 400 responses were obtained. We have followed the sample size recommendations and rules of thumb in PLS-SEM, such as having at least ten times more observations per predictor, which is verified, as well as following the power analysis (Hair et al., 2014). The a priori power analysis, with a power of 80%, a significance level of 5%, and five latent variables requires at least 200 responses. On the other side, the *post-hoc* power analysis shows that the achieved power with the current sample size is approximately of 90%. Thus, using the above criteria, we can determine an adequate sample size. Moreover, following other previous research, the Kaiser–Meyer–Olkin (KMO) sampling adequacy test was also calculated presenting a value of 0.93, surpassing the minimum acceptable value of 0.6 (Çop et al., 2020, 2021), and therefore establishing sampling adequacy. The common-methods bias was also examined using Harman's one-factor test (Podsakoff et al., 2003), where no indicator individually explained more than 50% of the variance. Thus, no significant common-method bias was verified.

Table 1 presents the sample characteristics, showing that respondents present an equality of gender and an average age of 50 years. Quotas were set to have similar gender and age class proportions between the country sample and the population. Moreover, a chi-square test was performed, concluding no statistical difference between the country sample and population (see Appendix C). Moreover, 88% of the respondent live in an urban area, preferring a flat type of building. The average number of individuals living in a household is 3, with an average of 1 child, which is in agreement with the EU statistics on household composition (Eurostat, 2019). Finally, the majority of respondents are homeowners, as is usual in previous studies on the topic (Warkentin et al., 2017).

Table 1. Sample characteristics.

Sample characteristics	Descriptive statistics	
Gender	Female	52%
	Male	48%
Age (average)		50
Urban area		88%
Building type	Terrace	12%
	Detached	22%
	Semi-detached	8%
	Flat	58%
	Other	1%
Employment	Student	6%
	Employed worker	43%
	Self-employed	15%
	Unemployed/Retired	37%
Homeowner		65%
Number of individuals living in the household (average)		3
Number of children (average)		1

4. Results

The partial least squares (PLS) technique of structural equation modeling was used to estimate the research model. This strategy is an adequate method since it is used to test research models that have not yet been tested before (Ke et al., 2009), which is the case of this exploratory research and does not require any strong distribution assumption (Fornell & Bookstein, 1982). Smart PLS 3.0 was used to test the model (Ringle et al., 2018). First, the measurement model will be analyzed, followed by the structural model.

4.1. Measurement model

Several measures were examined to assess the measurement model. Table 2 presents the mean and standard deviation of the constructs, along with the composite reliability (CR) and

Table 2. Mean, standard deviation, CR, and Fornell-Lacker table.

	Mean	STD	CR	PE	PW	PU	SAT	Use
Perceived enjoyment (PE)	5.21	1.25	0.96	**0.95**				
Perceived well-being (PW)	4.06	1.67	0.96	0.50	**0.93**			
Perceived usefulness (PU)	5.13	1.25	0.95	0.69	0.51	**0.91**		
Satisfaction (SAT)	4.83	1.31	0.98	0.65	0.63	0.69	**0.96**	
Use	3.81	1.67	0.97	0.45	0.72	0.44	0.57	**0.96**

Bold values are the square root of AVE.

Table 3. Heterotrait-Monotrait Ratio.

	PE	PW	PU	SAT	Use
PE					
PW	0.526				
PU	0.736	0.537			
SAT	0.677	0.649	0.720		
Use	0.475	0.756	0.462	0.593	

PE: perceived enjoyment; PW: perceived well-being; PU: perceived usefulness; SAT: satisfaction.

average variance extracted (AVE). All constructs present a CR higher than 0.7 and an AVE higher than 0.5, confirming the reliability of scales and convergent validity (Fornell & Larcker, 1981; Hair et al., 2011). Next, we tested for discriminant validity. First, the Fornell-Larcker criterion was followed, confirming that the squared root of the AVE is higher than the correlation between constructs (Fornell & Larcker, 1981). Secondly, the Heterotrait-Monotrait Ratio (HTMT) was analyzed in Table 3, verifying that all diagonal values were lower than 0.9. Finally, the loadings were checked against the cross-loadings, being always greater than the latest (Chin, 1998) (see Appendix D). Therefore, discriminant validity was established.

4.2. Structural model

Before examining the structural model, the multicollinearity between constructs was assessed using VIF. All values were lower than 5, indicating no multicollinearity issues (Hair et al., 2016). Figure 2 presents the path coefficients, whose significance was assessed through the means of bootstrapping with 5000 iterations of resampling (Hair et al., 2016). The model explains 24.6% of the variation in sustainable technologies use, 54.6% of the variation in sustainable technologies satisfaction, and 60.2% in perceived well-being. Both extrinsic and intrinsic motivations are statistically significant, with a positive impact on both sustainable technologies use [H1a ($\hat{\beta} = 0.256,\ p < 0.01$), H2a ($\hat{\beta} = 0.252,\ p < 0.01$)], and satisfaction [H1b ($\hat{\beta} = 0.477,\ p < 0.01$), H2b ($\hat{\beta} = 0.344,\ p < 0.01$)], supporting the hypotheses H1a, H1b, H2a, and H2b. Also, both sustainable technologies use, and satisfaction present a positive statistically significant impact on the perceived well-being, supporting H3 ($\hat{\beta} = 0.534,\ p < 0.01$), and H4 ($\hat{\beta} = 0.103,\ p < 0.1$). Finally, statistically significant moderation from intrinsic motivation was found. Three of the four moderators are statistically significant [H5b ($\hat{\beta} = 0.073,\ p < 0.05$), H5c ($\hat{\beta} = 0.078,\ p < 0.1$), H5d ($\hat{\beta} = 0.107,\ p < 0.01$) except H5a ($\hat{\beta} = 0.041,\ p > 0.1$)]. Hence, all hypotheses are supported, with except H5a.

5. Discussion

Given the increased relevance of mitigation strategies to environmental problems, the need to understand the role of technologies in those solutions, as well as their impact, also increases. Therefore, resorting to a mixed-methods approach, this work examined the inner motivations for sustainable technologies use and satisfaction and the consequent impact on perceived well-being. To the best of our knowledge, this is one of the first articles that focuses on the impact of sustainable technologies on a humanistic outcome, such as well-being, resorting to a mixed-methods design.

Regarding extrinsic and intrinsic motivations, both are significant to sustainable technologies use and satisfaction. This finding is not surprising since previous studies on household technologies have found the significance of perceived usefulness and enjoyment in increasing the technologies use and satisfaction (e.g., Joo et al., 2018; Venkatesh et al., 2012; Yoon, 2018; Yoon & Cho, 2016). Between the two, we can observe that perceived usefulness has a greater impact on satisfaction than enjoyment. This result suggests that users consider a more satisfactory user experience, especially when the solutions can fulfill their needs in terms of better energy performance and control of energy consumption, instead of when they provide an enjoyable interaction. Also, it is essential to understand them clearly to have an enjoyable interaction with the energy solutions, which requires a certain energy literacy and awareness that not all users might have.

In recent years, several studies have tried to understand the factors that impact well-being and its interaction with sustainability (Abu Bakar et al., 2015). Thus, both use and satisfaction are statistically significant concerning the antecedents of perceived well-being. Although both are relevant, use has a much higher impact on well-being than on satisfaction. Therefore, this suggests that the benefits that the use of sustainable technologies brings to the user are very relevant and even more important than creating a satisfactory user experience. Therefore, even if the experience of using the energy solutions was not so satisfactory, the benefits of use, such as energy and monetary savings or environmental benefits, have much more weight. This finding is in agreement with previous research, where well-being was found to be one of the principal benefits individuals get from engaging in sustainable initiatives (Mock et al., 2019). Also, Guillen-Royo (2019) suggested that sustainable development is associated with continuous well-being provision. Thus, as the main conclusion, the use of sustainable energy solutions significantly and positively impacts the well-being of its users, increasing the quality of life and positively fulfilling household needs. Therefore, the well-being of households has started to be prioritized in housing policies (Kumareswaran et al., 2021).

Finally, moderating effects were found. First, as shown in Figure 3, intrinsic motivations influence the relationship between extrinsic motivations and satisfaction. When an individual's intrinsic motivation level is high, the weight that the individual attributes to extrinsic motivation are higher,

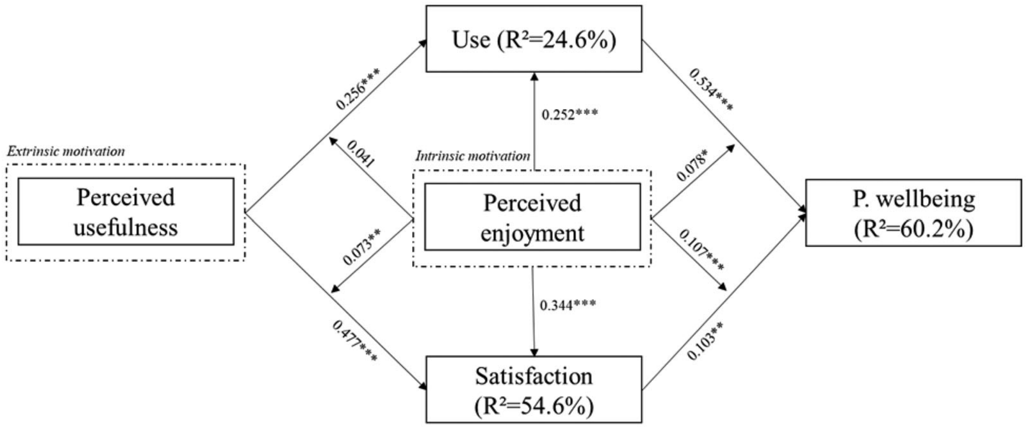

Figure 2. Structural model results (*Note:* ***$p < 0.01$; **$p < 0.05$, *$p < 0.1$).

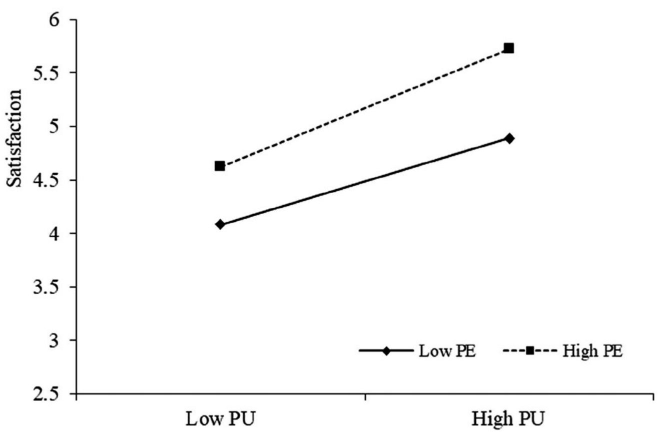

Figure 3. Moderation of perceived enjoyment (PE) between perceived usefulness (PU) and satisfaction.

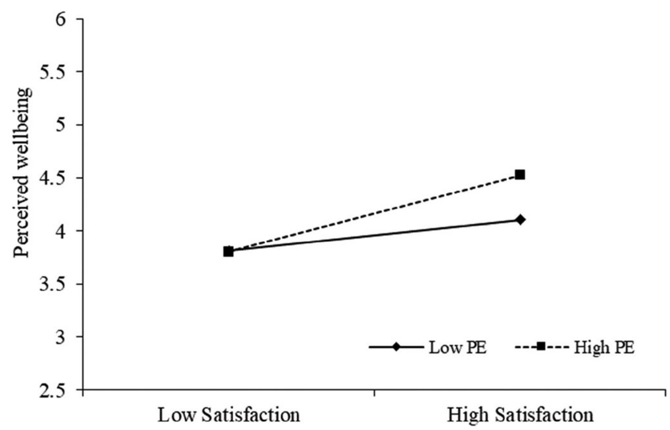

Figure 5. Moderation of perceived enjoyment (PE) between satisfaction and perceived well-being.

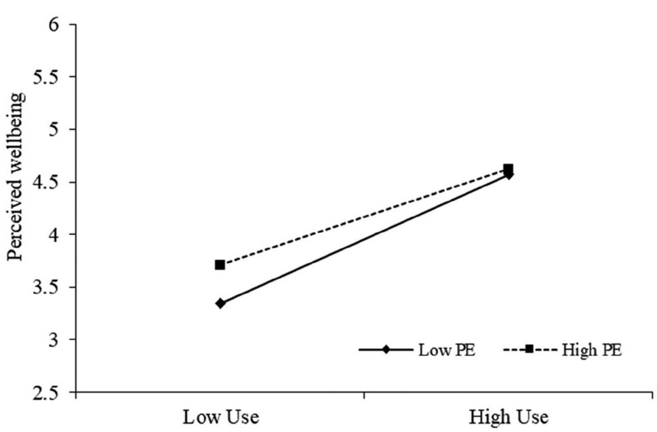

Figure 4. Moderation of perceived enjoyment (PE) between use and perceived well-being.

which in turn leads to greater satisfaction. At low levels of intrinsic motivation, the positive influence of this variable continues to be notable. This contingent effect of intrinsic motivations on extrinsic motivations is also supported by the literature, where it was found that great intrinsic motivations may lead to an increased impact of other factors (Dysvik & Kuvaas, 2011). Also, moderating effects were found between use and satisfaction with perceived well-being, as presented in Figures 4 and 5. When intrinsic motivations are high, the impact of the use on perceived well-being is also high, proving that intrinsic motivations strengthen the relationship between use and perceived well-being (Figure 4). Following the same reasoning, when an individual has high levels of intrinsic motivation, the greater the effect of satisfaction in perceived well-being (Figure 5), demonstrating the positive moderating effect of intrinsic motivation again. Overall, results suggest that intrinsic motivations are a strong factor that highly influences the relationships between (1) extrinsic motivations and satisfaction; (2) use and perceived well-being; (3) satisfaction and perceived well-being. This outcome suggests that the impact of intrinsic motivations is much more relevant than its direct effect. In fact, strategies that improve the user experience to be more enjoyable will reflect benefits on the impact of sustainable technologies in fulfilling the users and household's quality of life.

5.1. Theoretical and practical contributions

First, to the best of our knowledge, this is one of the first studies exploring the impact of sustainable technologies on perceived well-being, contributing to the current research examining technology's impact on humanistic outcomes, especially perceived well-being. Second, we contribute to the research on the antecedents of sustainable technologies use and satisfaction. Third, we extend the research on sustainable technologies use and perceived well-being, by proving the relevant moderator impact of intrinsic motivations. The findings demonstrate once more that consumer behavior is very complex. Therefore, the impact of moderators should be further examined, especially in sustainable-related behavior that is driven by a great amount of individual and shared motivations. Finally, we prove the relevance of using a mixed methods design, demonstrating the importance of both qualitative and quantitative methods in the investigation of consumer behavior, which we hope will encourage the application of this approach in further investigation.

Concerning practical implications, the findings of the developed model suggest three main implications based on the antecedents of sustainable technologies, the moderating role of intrinsic motivations, and the impact of sustainable technologies on perceived well-being. First, by identifying the antecedents of sustainable technologies used, the findings of this work are particularly useful as the basis for organizations and policymakers to create several consumer-targeted strategies to improve sustainable technologies use, and thus well-being, recognizing the role of sustainable technologies on the quality of life. Based on the findings, strategies should pass by promoting the use of sustainable technologies, together with their benefits in terms of performance and enjoyable interaction. For example, specifying a set of measures on how effective these technologies can be in monitoring and reducing energy consumption, is extremely relevant information for consumers. Secondly, results suggest that the greater the intrinsic motivation, the greater the impact of other factors. Thus, this study recommends that improving the user experience with sustainable technologies is essential, for example, by adding gamification features that might create a more enjoyable and fun experience. Gamified solutions might attract positive feelings in the consumers, making them more entertained, or simplify the use itself, conducting to a positive experience (Ke et al., 2019). Finally, this study clearly shows the relevance of sustainable technologies in fulfilling user and household needs and creating a positive environment. In fact, in the last instance, consumers might see the investment in sustainable technologies as an investment in well-being. Based on this, results suggest that developing more informative strategies, like demonstrations, workshops, or forums, is relevant to create more informed consumers. Additionally, the clear specification on how these technologies can improve someone's well-being can indeed increase the consumers' engagement.

5.2. Limitations and future research

One of the first limitations of this study resides in the fact that the qualitative study was restricted to individuals with a certain knowledge and interest in sustainable technologies and thus may not fully represent the general opinion. Therefore, other motivations might have arisen from different interviews. Also, this study was just conducted in one country, which might implicate the generalization of results. Thus, further studies could also investigate a country comparison, for which the authors encourage the inclusion of cultural factors in future studies. Finally, it is important to note that well-being might be influenced by other psychological and lifestyle factors (Guillen-Royo, 2019), which were not included in these studies. Nevertheless, the focus was on the impact of sustainable technologies on perceived well-being, for which we believe we provide remarkable results.

6. Conclusions

In conclusion, this study provides relevant findings about the consumer drivers for engaging in sustainable technologies, proving the impact of these types of solutions on one's perceived well-being, resorting to a mixed-methods design. As the main findings, the model suggests that intrinsic and extrinsic motivations positively impact sustainable technology use and satisfaction. In consequence, both positively affect consumers' perceived well-being. This finding is extremely relevant, contributing to the research on the impact of technologies on humanistic outcomes. Also, it emphasizes the important role of intrinsic motivations as a moderator. Overall, for users with greater intrinsic motivations, sustainable technologies use and satisfaction present greater effects on well-being. Therefore, enjoyable use experiences with sustainable technologies should be developed, suggesting the presence of gamification features. These factors might create not only more ease of use but also a more enjoyable interaction. Also, creating more informative strategies, like demonstrations and workshops that clearly specify how these technologies can improve someone's well-being is extremely important for their engagement, explaining the great performance these technologies might have in the short and/or long term. Finally, this model provides a good basic framework for future research on the impact of sustainable behaviors on consumer well-being.

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References

Abu Bakar, A. A., Osman, M. M., Bachok, S., Ibrahim, M., & Mohamed, M. Z. (2015). Modelling economic wellbeing and social wellbeing for sustainability: A theoretical concept. *Procedia*

Environmental Sciences, *28*(2014), 286–296. https://doi.org/10.1016/j.proenv.2015.07.037

Administration, I. T. (2021). *Greece – Energy*. Retrieved from https://www.trade.gov/country-commercial-guides/greece-energy

Adu-Gyamfi, G., Song, H., Nketiah, E., Obuobi, B., Adjei, M., & Cudjoe, D. (2022). Determinants of adoption intention of battery swap technology for electric vehicles. *Energy*, *251*, 123862. https://doi.org/10.1016/j.energy.2022.123862

Awan, A., Sadiq, M., Hassan, S. T., Khan, I., & Khan, N. H. (2022). Combined nonlinear effects of urbanization and economic growth on CO_2 emissions in Malaysia. An application of QARDL and KRLS. *Urban Climate*, *46*, 101342. https://doi.org/10.1016/j.uclim.2022.101342

Azam, W., Khan, I., & Ali, S. A. (2023). Alternative energy and natural resources in determining environmental sustainability: A look at the role of government final consumption expenditures in France. *Environmental Science and Pollution Research International*, *30*(1), 1949–1965. https://doi.org/10.1007/s11356-022-22334-z

Barreto, M. L., Szóstek, A., Karapanos, E., Nunes, N. J., Pereira, L., & Quintal, F. (2014). Understanding families' motivations for sustainable behaviors. *Computers in Human Behavior*, *40*, 6–15. https://doi.org/10.1016/j.chb.2014.07.042

Bhattacherjee, A. (2001). Understanding information systems continuance: An expectation-confirmation model. *MIS Quarterly*, *25*(3), 351. https://doi.org/10.2307/3250921

Brod, M., Tesler, L. E., & Christensen, T. L. (2009). Qualitative research and content validity: Developing best practices based on science and experience. *Quality of Life Research*, *18*(9), 1263–1278. https://doi.org/10.1007/s11136-009-9540-9

Butler, T. (2011). Compliance with institutional imperatives on environmental sustainability: Building theory on the role of Green IS. *The Journal of Strategic Information Systems*, *20*(1), 6–26. https://doi.org/10.1016/j.jsis.2010.09.006

Capstick, S., Nash, N., Whitmarsh, L., Poortinga, W., Haggar, P., & Brügger, A. (2022). The connection between subjective wellbeing and pro-environmental behaviour: Individual and cross-national characteristics in a seven-country study. *Environmental Science & Policy*, *133*(February), 63–73. https://doi.org/10.1016/j.envsci.2022.02.025

Cha, E. S., Kim, K. H., & Erlen, J. A. (2007). Translation of scales in cross-cultural research: Issues and techniques. *Journal of Advanced Nursing*, *58*(4), 386–395. https://doi.org/10.1111/j.1365-2648.2007.04242.x

Chin, W. W. (1998). Issues and opinion on structural equation modeling. *MIS Quarterly*, *22*(1), vii–xvi.

Çop, S., Alola, U. V., & Alola, A. A. (2020). Perceived behavioral control as a mediator of hotels' green training, environmental commitment, and organizational citizenship behavior: A sustainable environmental practice. *Business Strategy and the Environment*, *29*(8), 3495–3508. https://doi.org/10.1002/bse.2592

Çop, S., Olorunsola, V. O., & Alola, U. V. (2021). Achieving environmental sustainability through green transformational leadership policy: Can green team resilience help? *Business Strategy and the Environment*, *30*(1), 671–682. https://doi.org/10.1002/bse.2646

Crosno, J. L., & Cui, A. P. (2014). A multilevel analysis of the adoption of sustainable technology. *Journal of Marketing Theory and Practice*, *22*(2), 209–224. https://doi.org/10.2753/MTP1069-6679220213

Dadzie, J., Runeson, G., Ding, G., & Bondinuba, F. K. (2018). Barriers to adoption of sustainable technologies for energy-efficient building upgrade-Semi-structured interviews. *Buildings*, *8*(4), 57. https://doi.org/10.3390/buildings8040057

Davis, L. W. (2011). Evaluating the slow adoption of energy efficient investments: Are renters less likely to have energy efficient appliances? In D. Fullerton & C. Wolfram (Eds.), *The design and implementation of US climate policThe design and implementation of US climate policy* (pp. 301–316). University of Chicago Press.

Deci, E. L., & Ryan, R. M. (2002). *Handbook of self-determination research*. Retrieved from https://psycnet.apa.org/record/2002-01702-000

Dysvik, A., & Kuvaas, B. (2011). Intrinsic motivation as a moderator on the relationship between perceived job autonomy and work performance. *European Journal of Work and Organizational Psychology*, *20*(3), 367–387. https://doi.org/10.1080/13594321003590630

El Hedhli, K., Chebat, J. C., & Sirgy, M. J. (2013). Shopping well-being at the mall: Construct, antecedents, and consequences. *Journal of Business Research*, *66*(7), 856–863. https://doi.org/10.1016/j.jbusres.2011.06.011

Erell, E., Portnov, B. A., & Assif, M. (2018). Modifying behaviour to save energy at home is harder than we think…. *Energy and Buildings*, *179*, 384–398. https://doi.org/10.1016/j.enbuild.2018.09.010

European Parliament (2019). 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU. *Official Journal of the European Union*, *62*, 125–199. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2019:158:TOC

Eurostat (2019). *Household composition statistics*. Eurostat-Statistics Explained. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Household_composition_statistics

Fornell, C., & Bookstein, F. L. (1982). Two structural equation models: LISREL and PLS applied to consumer exit-voice theory. *Journal of Marketing Research*, *19*(4), 440–452. https://doi.org/10.2307/3151718

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18*(1), 39–50. https://doi.org/10.2307/3151312

Fusch, P. I., & Ness, L. R. (2015). Are we there yet? Data saturation in qualitative research. *The Qualitative Report*, *20*(9), 1408–1416. http://www.nova.edu/ssss/QR/QR20/9/fusch1.pdf

Gimpel, H., Graf, V., & Graf-Drasch, V. (2020). A comprehensive model for individuals' acceptance of smart energy technology – A meta-analysis. *Energy Policy*, *138*, 111196. https://doi.org/10.1016/j.enpol.2019.111196

Girod, B., Mayer, S., & Nägele, F. (2017). Economic versus belief-based models: Shedding light on the adoption of novel green technologies. *Energy Policy*, *101*(May 2016), 415–426. https://doi.org/10.1016/j.enpol.2016.09.065

Guillen-Royo, M. (2019). Sustainable consumption and wellbeing: Does on-line shopping matter? *Journal of Cleaner Production*, *229*, 1112–1124. https://doi.org/10.1016/j.jclepro.2019.05.061

Hair, J., Hult, G. T., Ringle, C., & Sarstedt, M. (2016). *A primer on partial least squares structural equation modeling (PLS-SEM)* (Joseph F. Hair, Jr., G. Tomas, M. Hult, Christian Ringle, & Marko Sarstedt, Eds.). Sage.

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2014). *A primer on partial least squares structural equation modeling (PLS-SEM)*. SAGE Publications.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *Journal of Marketing Theory and Practice*, *19*(2), 139–152. https://doi.org/10.2753/MTP1069-6679190202

Jakučionytė-Skodienė, M., Krikštolaitis, R., & Liobikienė, G. (2022). The contribution of changes in climate-friendly behaviour, climate change concern and personal responsibility to household greenhouse gas emissions: Heating/cooling and transport activities in the European Union. *Energy*, *246*, 123387. https://doi.org/10.1016/j.energy.2022.123387

Jie, H., Khan, I., Alharthi, M., Zafar, M. W., & Saeed, A. (2023). Sustainable energy policy, socio-economic development, and ecological footprint: The economic significance of natural resources, population growth, and industrial development. *Utilities Policy*, *81*, 101490. https://doi.org/10.1016/j.jup.2023.101490

Joo, Y. J., So, H. J., & Kim, N. H. (2018). Examination of relationships among students' self-determination, technology acceptance, satisfaction, and continuance intention to use K-MOOCs. *Computers & Education*, *122*, 260–272. https://doi.org/10.1016/j.compedu.2018.01.003

Kamolsook, A., Badir, Y. F., & Frank, B. (2019). Consumers' switching to disruptive technology products: The roles of comparative economic value and technology type. *Technological Forecasting and Social Change*, *140*, 328–340. https://doi.org/10.1016/j.techfore.2018.12.023

Ke, X., Du, H. S., Wagner, C. (2019). Encouraging individuals to go green by gamification: An empirical Study. In *Proceedings of the*

23rd Pacific Asia Conference on Information Systems: Secure ICT Platform for the 4th Industrial Revolution, PACIS 2019.
Ke, W., Liu, H., Wei, K. K., Gu, J., & Chen, H. (2009). How do mediated and non-mediated power affect electronic supply chain management system adoption? The mediating effects of trust and institutional pressures. *Decision Support Systems*, *46*(4), 839–851. https://doi.org/10.1016/j.dss.2008.11.008
Kumareswaran, K., Rajapaksha, I., & Jayasinghe, G. Y. (2021). Energy & Buildings Energy poverty, occupant comfort, and wellbeing in internally displaced people's residences in Sri Lanka. *Energy and Buildings*, *236*, 110760. https://doi.org/10.1016/j.enbuild.2021.110760
Lee, D.-J., Sirgy, M. J., Larsen, V., & Wright, N. D. (2002). Developing a subjective measure of consumer well-Being. *Journal of Macromarketing*, *22*(2), 158–169. https://doi.org/10.1177/0276146702238219
Liu, H., Alharthi, M., Atil, A., Zafar, M. W., & Khan, I. (2022). A nonlinear analysis of the impacts of natural resources and education on environmental quality: Green energy and its role in the future. *Resources Policy*, *79*, 102940. https://doi.org/10.1016/j.resourpol.2022.102940
Liu, H., Khan, I., Zakari, A., & Alharthi, M. (2022). Roles of trilemma in the world energy sector and transition towards sustainable energy: A study of economic growth and the environment. *Energy Policy*, *170*, 113238. https://doi.org/10.1016/j.enpol.2022.113238
Marikyan, D., Papagiannidis, S., & Alamanos, E. (2019). A systematic review of the smart home literature: A user perspective. *Technological Forecasting and Social Change*, *138*, 139–154. https://doi.org/10.1016/j.techfore.2018.08.015
Mi, L., Zhao, J., Xu, T., Yang, H., Lv, T., Shang, K., Qiao, Y., & Zhang, Z. (2021). How does COVID-19 emergency cognition influence public pro-environmental behavioral intentions? An affective event perspective. *Resources, Conservation, and Recycling*, *168*, 105467. https://doi.org/10.1016/J.RESCONREC.2021.105467
Mock, M., Omann, I., Polzin, C., Spekkink, W., Schuler, J., Pandur, V., Brizi, A., & Panno, A. (2019). "Something inside me has been set in motion": Exploring the psychological wellbeing of people engaged in sustainability initiatives. *Ecological Economics*, *160*(February), 1–11. https://doi.org/10.1016/j.ecolecon.2019.02.002
Nasseef, O. A., Baabdullah, A. M., Alalwan, A. A., Lal, B., & Dwivedi, Y. K. (2022). Artificial intelligence-based public healthcare systems: G2G knowledge-based exchange to enhance the decision-making process. *Government Information Quarterly*, *39*(4), 101618. https://doi.org/10.1016/j.giq.2021.101618
Nie, P., Li, Q., & Sousa-Poza, A. (2021). Energy poverty and subjective well-being in China: New evidence from the China Family Panel Studies. *Energy Economics*, *103*(August), 105548. https://doi.org/10.1016/j.eneco.2021.105548
Ozmen Garibay, O., Winslow, B., Andolina, S., Antona, M., Bodenschatz, A., Coursaris, C., Falco, G., Fiore, S. M., Garibay, I., Grieman, K., Havens, J. C., Jirotka, M., Kacorri, H., Karwowski, W., Kider, J., Konstan, J., Koon, S., Lopez-Gonzalez, M., Maifeld-Carucci, I., … Xu, W. (2023). Six human-centered artificial intelligence grand challenges. *International Journal of Human–Computer Interaction*, *39*(3), 391–437. https://doi.org/10.1080/10447318.2022.2153320
Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *The Journal of Applied Psychology*, *88*(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879
Rasmussen, J. (2017). The additional benefits of energy efficiency investments—A systematic literature review and a framework for categorisation. *Energy Efficiency*, *10*(6), 1401–1418. https://doi.org/10.1007/s12053-017-9528-1
Ringle, C. M., Wende, S., Becker, J.-M. (2018). *SmartPLS 3. 2015*. Website. Retrieved from http://www.smartpls.com
Ritchie, H., Roser, M., Rosado, P. (2020). *Energy*. Our World in Data. Retrieved from https://ourworldindata.org/energy-production-consumption
Ryan, R. M., & Deci, E. L. (1985). *Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being self-determination theory*. Ryan.
Sangroya, D., & Nayak, J. K. (2017). Factors influencing buying behaviour of green energy consumer. *Journal of Cleaner Production*, *151*, 393–405. https://doi.org/10.1016/j.jclepro.2017.03.010
Sarker, S., Chatterjee, S., Xiao, X., & Elbanna, A. (2019). The sociotechnical axis of cohesion for the IS discipline: Its historical legacy and its continued relevance. *MIS Quarterly*, *43*(3), 695–719. https://doi.org/10.25300/MISQ/2019/13747
Sequeiros, H., Oliveira, T., & Thomas, M. (2022). The impact of IoT smart home services on psychological well-being. *Information Systems Frontiers*, *24*(3), 1009–1026. https://doi.org/10.1007/s10796-021-10118-8
Tauseef Hassan, S., Wang, P., Khan, I., & Zhu, B. (2023). The impact of economic complexity, technology advancements, and nuclear energy consumption on the ecological footprint of the USA: Towards circular economy initiatives. *Gondwana Research*, *113*, 237–246. https://doi.org/10.1016/j.gr.2022.11.001
Venkatesh, V., Brown, S. A., & Bala, H. (2013). Bridging the qualitative-quantitative divide: Guidelines for conducting mixed methods research in information systems. *MIS Quarterly*, *37*(1), 21–54. https://doi.org/10.25300/MISQ/2013/37.1.02
Venkatesh, V., Brown, S. A., & Sullivan, Y. W. (2016). Guidelines for conducting mixed-methods research: An extension and illustration. *Journal of the Association for Information Systems*, *17*(7), 435–494. https://doi.org/10.17705/1jais.00433
Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly: Management Information Systems*, *27*(3), 425–478. https://doi.org/10.2307/30036540
Venkatesh, V., Thong, J. Y. L., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the unidied theory of acceptance and use of technology. *MIS Quarterly*, *36*(1), 157–178. https://doi.org/10.2307/41410412
Wang, Z., Ali, S., Akbar, A., & Rasool, F. (2020). Determining the influencing factors of biogas technology adoption intention in Pakistan: The moderating role of social media. *International Journal of Environmental Research and Public Health*, *17*(7), 2311. https://doi.org/10.3390/ijerph17072311
Wang, X., McGill, T. J., & Klobas, J. E. (2020). I want it anyway: Consumer perceptions of smart home devices. *Journal of Computer Information Systems*, *60*(5), 437–447. https://doi.org/10.1080/08874417.2018.1528486
Warkentin, M., Goel, S., & Menard, P. (2017). Shared benefits and information privacy: What determines smart meter technology adoption? *Journal of the Association for Information Systems*, *18*(11), 758–786. https://doi.org/10.17705/1jais.00474
Watson, R. T., Boudreau, M. C., & Chen, A. J. (2010). Information systems and environmentally sustainable development: Energy informatics and new directions for the is community. *MIS Quarterly: Management Information Systems*, *34*(1), 23–38. https://doi.org/10.2307/20721413
Wunderlich, P. J., Kranz, J. J., Veit, D. J. (2013). Beyond carrot-and-stick: How values and endogenous motivations affect residential green is adoption. In *International Conference on Information Systems (ICIS 2013): Reshaping Society through Information Systems Design* (pp. Vol. 1, pp. 585–603). Retrieved from https://www.researchgate.net/publication/258909427
Wunderlich, P., Veit, D. J., & Sarker, S. (2019). Adoption of sustainable technologies: A mixed-methods study of German households. *MIS Quarterly*, *43*(2), 673–691. https://doi.org/10.25300/MISQ/2019/12112
Yang, S., & Zhao, D. (2015). Do subsidies work better in low-income than in high-income families? Survey on domestic energy-efficient and renewable energy equipment purchase in China. *Journal of Cleaner Production*, *108*, 841–851. https://doi.org/10.1016/j.jclepro.2015.07.022
Yoon, C. (2018). Extending the TAM for Green IT: A normative perspective. *Computers in Human Behavior*, *83*, 129–139. https://doi.org/10.1016/j.chb.2018.01.032
Yoon, J. K., & Kim, C. (2022). Positive emodiversity in everyday human-technology interactions and users' subjective well-being.

International Journal of Human–Computer Interaction. Advance online publication. https://doi.org/10.1080/10447318.2022.2121564

Yoon, S. B., & Cho, E. (2016). Convergence adoption model (CAM) in the context of a smart car service. *Computers in Human Behavior*, *60*, 500–507. https://doi.org/10.1016/j.chb.2016.02.082

Zhang, Q., Appau, S., & Lord, P. (2021). Energy poverty, children's wellbeing and the mediating role of academic performance: Evidence from China. *Energy Economics*, *97*, 105206. https://doi.org/10.1016/j.eneco.2021.105206

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Appendix A—Interviewees' details

Table A1. Interviewees' details.

ID	Role	Occupation
I1	Expert	University professor
I2	Expert	Researcher
I3	Expert	Researcher
I4	Expert	Head of applied research and innovation
I5	Expert	Environmental engineer
I6	Expert	Researcher
I7	Expert	Project manager
I8	Expert	Sustainability manager
I9	Consumer	Unemployed
I10	Consumer	Communication department employee
I11	Consumer	Mechanical engineer
I12	Consumer	Marketing Assistant
I13	Consumer	Marketing and communication officer
I14	Consumer	Project leader
I15	Consumer	Self-employed baker
I16	Consumer	Mechanical engineer
I17	Consumer	University professor
I18	Consumer	IT consultant

Appendix B—Survey items

Table B1. Survey items.

Variable		Item	Source
Perceived usefulness	PU1	Using sustainable energy solutions improves my performance in managing energy consumption	Venkatesh et al., 2012
	PU2	Using sustainable energy solutions increases my productivity in managing energy consumption	
	PU3	Using sustainable energy solutions enhances my effectiveness in managing energy consumption	
	PU4	Overall, sustainable energy solutions are useful in managing energy consumption	
Perceived enjoyment	PE1	Using sustainable energy solutions is fun	
	PE2	Using sustainable energy solutions is enjoyable	
	PE3	Using sustainable energy solutions is very entertaining	
Satisfaction		How do you feel about your overall experience with sustainable energy solutions use:	Bhattacherjee, 2001
	SAT1	1-Very dissatisfied 2 3 4 5 6 7-Very satisfied	
	SAT2	1-Very displeased 2 3 4 5 6 7-Very pleased	
	SAT3	1-Very frustrated 2 3 4 5 6 7-Very contented	
	SAT4	1-Absolutely terrible 2 3 4 5 6 7-Absolutely delighted	
Use Behavior	UB1	I often use sustainable energy solutions in my household.	Venkatesh et al., 2012
	UB2	I often use sustainable energy solutions to manage my energy consumption.	
	UB3	I often use sustainable energy solutions to monitor my energy consumption	
Perceived well-being		Overall, sustainable energy solutions …	El Hedhli et al., 2013
	PW1	Have satisfied my overall household needs	
	PW2	Have played a very important role in my social well-being	
	PW3	Have played a very important role in my leisure well-being	
	PW4	Have played an important role in enhancing the quality of life in my household	

Appendix C—Age and gender distribution

Table C1. Age and gender distribution.

Age/gender	Population (%)[a]	Sample (%)	Chi-squared (*p*-value)
18–24	9	9	0.0377 (0.9813)
25–49	40	40	
>50	52	52	
Female	51	51	(>0.9999)
Male	49	49	

[a]Source: http://appssoeurostateceuropaeu/nui/showdo?dataset=demo_pjan (EUROSTAT: Population on 1 January by age and sex (The last update was April 27, 2021 and extracted on May 20, 2021).

Appendix D—Loadings and cross-loadings

Table D1. Loadings and cross-loadings.

	PE	PW	PU	SAT	Use
PE1	**0.937**	0.443	0.653	0.590	0.409
PE2	**0.966**	0.481	0.675	0.635	0.422
PE3	**0.935**	0.485	0.631	0.616	0.447
PW1	0.459	**0.919**	0.479	0.600	0.694
PW2	0.458	**0.916**	0.439	0.555	0.639
PW3	0.467	**0.949**	0.457	0.569	0.673
PW4	0.466	**0.938**	0.531	0.600	0.670
PU1	0.583	0.385	**0.884**	0.550	0.350
PU2	0.645	0.541	**0.930**	0.670	0.468
PU3	0.664	0.532	**0.944**	0.684	0.461
PU4	0.614	0.379	**0.878**	0.591	0.303
SAT1	0.633	0.626	0.705	**0.943**	0.577
SAT2	0.641	0.623	0.675	**0.971**	0.557
SAT3	0.600	0.579	0.627	**0.968**	0.535
SAT4	0.619	0.570	0.642	**0.962**	0.528
UB1	0.454	0.705	0.433	0.565	**0.959**
UB2	0.432	0.664	0.438	0.544	**0.961**
UB3	0.406	0.695	0.397	0.531	**0.949**

PE: perceived enjoyment; PW: perceived well-being; PU: perceived usefulness; SAT: satisfaction.
Bold values are the loadings of each construct; non-bold values are cross-loadings.