Consumer engagement plan

D4.2

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Deliverable

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Consumer engagement plan

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Statement of Originality

This deliverable contains original, unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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Executive Summary

The present work was carried out by the Nova University of Lisbon (UNL) – Nova Information Management School Team, within the scope of the TwinERGY project, funded by the HORIZON 2020 Programme of the European Commission under Grant Agreement No. 957736. This report documents all tasks and results achieved for Task 4.2 – Consumer engagement strategies assessment and development. This task aims to obtain an in-depth understanding of consumer behaviour regarding engagement in the project technologies and participation in local energy markets. The report details all followed approaches and results to understand consumer behaviour regarding engagement in local energy markets. A research model was developed with the factors that may influence consumers to participate in these types of energy markets/communities. Consumer segmentation was also conducted to better profile consumers for engagement purposes. The model's results are examined at both the European level and for each country considered in the pilot – Germany, Greece, Italy, and the UK – adding Portugal as the country of the researchers.

The report describes the following tasks:

- Understanding the implications of consumer behaviour analysis for the consumer engagement process.
- Understanding relevant dimensions for consumers to engage in local energy communities.
- Treatment, exploration, and analysis of data.
- Segmentation analysis.
- Provision of engagement recommendations.

In order to accomplish these goals, a review of consumer behaviour analysis was conducted as a part of the consumer engagement cycle, focusing on clear recommendations before and during engagement. A research model for participation in local energy communities was built and tested in the five European countries. The data was analysed resorting to the partial least squares' structural equation modelling technique (PLS-SEM). Results suggest citizen empowerment, pro-environmental behaviour, and wellbeing as main drivers of the intention to participate in local energy communities. As part of the consumer engagement cycle, consumer segmentation was performed, suggesting 5 types/groups of citizens with different levels of use of sustainable energy solutions and intention to participate in local energy communities. Finally, the knowledge created from this task will govern the whole project, especially in implementing use cases and pilots (WP7 and WP9).

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Twinergy has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957736

Abbreviation List

Abbreviation	Definition
LEC	Local energy community
PLS-SEM	Partial least square technique of structural equation modelling
KMO	Kaiser-Meyer-Olkin (measure of data adequacy for factor analysis)

1/ Introduction

1.1 Scope of deliverable

The scope of this document revolves around a pivotal challenge for the success of any strategy/technology development that involves citizens' cooperation: consumer engagement. Especially on solutions that require the active participation of consumers, the need to initiate and maintain individuals engaged is crucial for an initiative's success. Specifically, to the project, the participation of the communities in the pilots is of substantial impact. Therefore, this task first examined the consumer behavioural analysis regarding the technologies needed for use cases and pilot implementations, and therefore, its implications for the engagement process. After that, a deep analysis was developed to understand the main dimensions that should be tackled in the engagement approach for consumers to participate in local energy communities, and thus, suggesting recommendations for the new business models that will be developed in the project. Finally, consumer segmentation was performed. Consumers may respond differently to a single approach. Therefore, profiling different types of consumers will add customisation to the engagement plan, identifying and classifying them according to the most relevant factors found in the consumer behaviour analysis.

This work follows the suggestions of previous successful projects and/or working groups (e.g., BRIDGE working group) as a means to find consistent conclusions and provide relevant recommendations for the engagement approaches. The conclusions of this task will be not only beneficial for the successful implementation of the pilots and use cases but also provide comprehensive insights for future implementations and actions towards the engagement in local energy communities and/or other energy-related projects.

1.2 Methodology

The followed methodology varies according to the analysis. Overall, this work follows the recommended methodology of the BRIDGE working group on customer engagement and therefore following the best practices and suggestions of previous and current projects (see Figure 1). A mixed-methods approach was followed to test a newly built research model for consumer analysis regarding participation in the local energy communities. For the quantitative study, the partial least squares technique of structural equation modelling was implemented. For the segmentation analysis, a factor and cluster analysis were the techniques applied. A combination of hierarchical and non-hierarchical methods was used in the cluster analysis, as this approach usually presents better results. A probability sampling design was utilised for both analyses, and a closed-ended questionnaire (questions that can only be answered be selecting from a limited set of choices) was conducted to ensure optimum feedback.

Figure 1. Methodology

1.3 Structure

Several steps were conducted to achieve the intended results. The first step of this work was understanding what consumers value the most (1) and the possible barriers to engagement (2). These two are achieved by examining the consumer behavioural analysis regarding crucial technologies for use cases and the pilot implementation. Then, a model for understanding the most critical dimensions that affect citizen participation in local energy communities was built and tested. A questionnaire was then devised and validated. After data collection, a sample of each country was analysed. Through the means of structural equation modelling, the model was tested and validated. After that, a segmentation analysis was performed to classify and profile different sets of individuals (3). Finally, engagement recommendations were extracted (4). Figure 2 illustrates an overview of all steps covered within this task. Each method is described explicitly in later sections.

This document is structured as follows. Chapter 2 contains the necessary concepts of consumer engagement and the examination of consumer behaviour analysis implications for the engagement process. It also introduces the participation in the local energy communities topic. Chapter 3 explains the research model and developed hypotheses for the participation in local energy communities. Chapter 4 refers to the quantitative study, explaining the methodology, survey, and sample size, as well as presenting exploratory analysis on the data. Chapter 5 analyses the research model results, presenting the measurement and structural model of the overall model and the results per country. Chapter 6 presents the segmentation analysis, followed by the profiling of the consumers and its implications (chapter 7). Finally, Chapter 8 describes the main recommendations, summarising the main findings for the engagement plan.

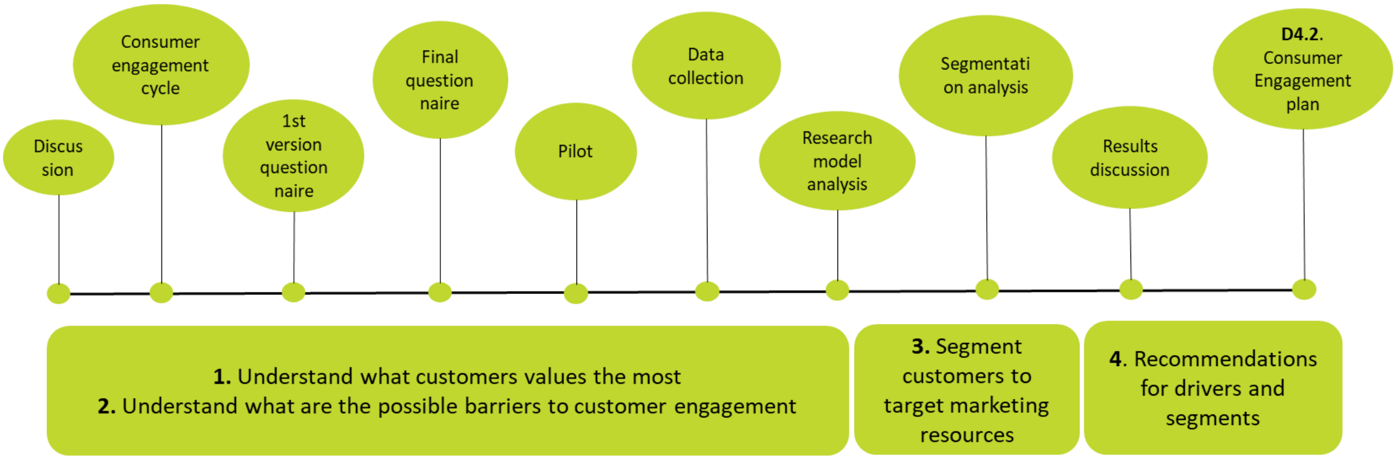

Figure 2. Steps for engagement plan

1.4 Relation to other tasks and deliverables

First, this deliverable relates to Task 2.1, as it focuses on citizen engagement and co-design, helping to ensure citizen participation in the pilots. Our work has the same foundation, as it studies and deepens the analysis of consumer engagement, complementing it with the consumer behavioural analysis. Our work also develops a more holistic model to understand consumer willingness to participate in local energy communities and the relevant drivers for that, as part of the new business models to be created, under objectives 5 and 6 of the project. For this, outputs of Task 2.2 – Stakeholders' analysis – were also used. By identifying the factors that influence consumer decisions regarding participation in local energy communities, this task's results will be of primary importance for WP7 and WP9, as the conclusions of this report will be useful for the successful implementation of the use cases and pilots. It will also provide comprehensive insights into future implementations and actions related to consumer engagement and participation in local energy communities as a second impetus.

2/ Consumer engagement

2.1 Consumer engagement cycle

Consumer engagement can be defined as the intensity of how an individual participates or connects with an entity's services, being composed of many elements, social, behavioural, emotional, etc. (Vivek et al., 2012). Therefore, it is difficult to understand what can be done to engage individuals who, by their very nature, may have many different cognitive, emotional, and social characteristics. Having this, the BRIDGE working group proposed a value chain to promote a better engagement (Vafeas et al., 2018) (see Figure 3) :

1. Involve the customer as a starting point to understand whom you are talking to;
2. Engage the customer through a clear and transparent process of benchmarking, personal incentives and segmentation.
3. Evolve the customer relationship by creating a feedback loop where end-user communication grows, supported by advanced feedback, information, and education.

Based on the abovementioned criteria, this task performed the following action for each point of the value chain:

1. Examine the consumer behavioural analysis to understand the consumers better and appraise what should be implemented to increase the engagement of individuals in the adoption of the necessary technologies for both use cases and pilots. Only by studying the consumer, it is possible to understand what they value the most. Task 4.1 conducted the consumer behavioural analysis with that purpose. Task 4.2 extended that analysis with the implications for the engagement process in the following sub-section. In Task 4.1, not only potential users were analysed (through behavioural intention), but also the current ones (through use behaviour). Therefore, it is possible to provide recommendations for the initial engagement of individuals and how that engagement can be sustained. Moreover, this task extends the consumer analysis for participation in local energy communities. Therefore, a clear identification of the key dimensions for citizens in this context will be achieved.

2. A segmentation analysis was performed in order to map and profile consumers better. Consumer segmentation provides information about consumer needs,

wants, and willingness. Several behavioural dimensions were used to segment citizens, providing vital information for the best way to approach them and, therefore, improving each group's engagement.

3. The last step is related to continuous communication and training and educating the consumer to evolve to give feedback and make recommendations to others. The assessment of this step can only be performed after the implantation of the solutions and the beginning of the consumer engagement process.

Figure 3. Engagement value chain

2.2 Understanding customers - consumer behavioural analysis implications

This section discusses the implications of consumer behavioural analysis for the engagement process. It is, therefore, the first step of the consumer engagement value chain. Task 4.1 conducted the consumer behavioural analysis regarding sustainable energy solutions. The adoption of these solutions is based on the TwinERGY use cases and pilots.

Technical, social and behavioural dimensions of individuals have a significant influence on the engagement in a project. As identified in previous projects, engagement is a process that can be constrained if there is a lack of communication, resources, trust, and clarity (Vafeas et al., 2018). Therefore, consumer engagement can be much more successful if all these dimensions are examined, as studied in Task 4.1. The following paragraphs describe the main implications of consumer behaviour analysis for the engagement process.

Before engagement

- Find individuals that already perform other pro-environmental behaviours, such as participation in local environmental organisations, petitions or even recycling – these are much more willing to engage in the proposed solutions.
- Provide information about practicality and reliability of the solutions, installation needs, available features, and environmental performance – the creation of workshops, association, collaboration with municipalities. Involvement of schools – start educating individuals and raise interest. Also, children can bring that vision and motivation to their homes through inculcation at school via environmental awareness projects in science classes. Many times, the level of engagement is related to the level of knowledge and awareness.
- Feeling of having the available resources and support is essential – create specific points of contact for support (e.g. associations, municipalities, agencies, stores, etc.);
- Promote the innovative side of the solutions.
- Promote the possible monetary, and energetic savings individuals may obtain.
- If possible, promoting and allowing the tribality or demonstration of solutions will increase the engagement of individuals in the solution.

During engagement

- Carefully provide information. Information cannot be overwhelming. Otherwise, it will have the contrary effect – users will perceive the technologies as challenging to use and therefore will reduce the use.
- Continue to promote the use of these solutions as an innovative activity.
- Promotion of a long-term view of the investment.

After these strategies are in place, the next step is to understand citizens' willingness to participate in local energy communities. Therefore, aligned with the acceptance and use of the necessarily sustainable energy solutions, the next section will develop the topic of participation in local energy communities as one of the project's main targets in building a new business model for energy markets.

2.3 Participation in local energy communities

The TwinERGY vision encompasses introducing a new demand response framework, enabling the appearance of new business models, where local energy communities have a fundamental role in energy markets, under objectives O5 and O6. Local energy communities are expected to significantly benefit from the TwinERGY solution by acting as demand response providers and introducing themselves into the energy market. If successfully implemented, the way the energy market runs can completely change, and communities can be empowered. Therefore, consumer engagement through participation in local energy communities is an appropriate and relevant step for successfully implementing the newly created business models. Nevertheless, the concept of a local energy community itself is still something new, and therefore its understanding is of utmost relevance.

Local energy communities are defined as a set of private and/or public energy utilities in which the end-users satisfy their energy needs by collaborating through the use of distributed energy generation (see Figure 4). This stratagem promotes the use of renewable energy and IoT, obtaining several monetary and environmental benefits (Ceglia et al., 2020). Also, it allows reducing the occurrence of load peaks, optimising load trends (Müller et al., 2015).

Figure 4. Representation of a local energy community

Local energy communities are of increasing interest in constructing strategies and policies, such as the EU Framework 2030 and the UN 2030 agenda for sustainable development (Moroni et al., 2019). In these communities, citizens may become prosumers by producing electricity through renewable sources, therefore having an active role as consumers/prosumers. This phenomenon is already a reality in some countries, such as Netherlands or Germany. However, the participation in local energy communities is much more than just installing a technology (Azarova et al., 2019), which is a usually studied perspective. By delving further into the topic, previous research has studied the participation in local energy communities from several perspectives, finding the relevance of factors such as attitudes/norms, visual perceptions, proximity to facilities/infrastructure, environmental harm, and costs (Aaen et al., 2016; Johansson & Laike, 2007). Therefore, consumer behaviour regarding participation in local energy communities is of great relevance, as understanding the factors that can influence citizens to participate in local energy communities will also help establish engagement recommendations.

Consumer empowerment

One key element of consumer engagement is consumer empowerment. Empowerment has been widely examined in studies regarding citizen participation (Zimmerman, 1995). Empowerment theory is described *as "the connection between a sense of personal competence, a desire for, and a willingness to take action in the public domain"* (Zimmerman & Rappaport, 1988, p. 746). This concept has been presented as a complex phenomenon and is therefore composed of four dimensions: competence, meaning, impact, and self-determination.

Competence represents the degree to which an individual has sufficient skills to perform an activity. Specifically, to the local energy community's context, for example, knowing how to use renewable energy installations. Meaning is defined as the individual judgment of the value of a certain activity. For example, if participating in a local energy community will bring value for the citizen, such as lower electricity bills, social benefits or higher flexibility of the energy system, the individual will be more willing to participate. Impact refers to the degree to which a certain activity is perceived as having an intended effect—for example, investing in renewable energy installations that will later contribute to the flexibility and sustainability of the energy system. Self-determination is defined as the perception of having responsibility for a particular outcome of a performed activity (Ryan & Deci, 1985). When participating in decision processes, the citizen may feel involved and responsible for creating a more sustainable energy community, therefore causing a sense of empowerment to that citizen. Hence, empowerment dimensions can be a strong driver for citizen engagement.

Pro-environmental behaviour

Local energy communities are based on many strategies for sustainable development. Therefore, an appropriate construct to explain participation in local energy communities should be pro-environmental behaviour (PEB). In fact, this factor was already referred to in the output of Task 2.2. (stakeholders' analysis): *"This massive consumer market is overall concerned with the environment and its consequences on the planet. It prefers an engagement with energy-savings and is often in the role of prosumer producing energy for their home and the local community".* Therefore, a pro-environmental factor should be present in this analysis. In terms of pro-environmental theories, we find the norm activation model (NAM) (Schwartz, 1977) and the value-belief-norm theory (VBN) (Stern et al., 1999). However, these theories are based on beliefs or personal norms and not actual environmental protection actions. In fact, these two frameworks try to explain pro-environmental antecedents and do not precisely understand what it is to have a pro-environmental behaviour itself. Therefore, many studies have tried to define PEB, suggesting its multiple dimensions, should be disaggregated according to its difficulty of performance, nature and/or magnitude of environmental impacts, etc. (Larson et al., 2015). Based on this, PEB can be conceptualised in some dimensions, such as social environmentalism, conservation lifestyle and environmental citizenship.

Social environmentalism is centred in social engagement and informing/ showing/teaching others the importance of conservation actions, such as local groups and environmental communities (Larson et al., 2015). This dimension is intrinsically related to public and social activities. Conservation lifestyle is one of the most common behaviours when someone is asked about how to help and protect the environment (Larson et al., 2015). Therefore, the comportments include recycling, saving water in the household, turning off lights when not in use, etc. Finally, environmental citizenship behaviour, which is less common, refers to the civic or political engagement in supporting policies towards environmental conservation. Therefore, PEB is a second-order construct formed by the above three concepts. The combination of Empowerment and PEB, which has not yet been tested in the literature, allows combining a more motivational/attitudinal perspective with a pro-environmental one, which may result in a more comprehensive understanding of the drivers for participation in local energy communities.

Gamification and comfort emerging from stakeholders' interviews

When discussing increasing the number and type of consumers engaged in demand response and energy markets, TwinERGY proposes user-friendly tools and interfaces, integrating gamification elements as a strategy towards that objective, also considered in

Module 8 of the project grant agreement. Also, the promise of improved comfort is a motivator for individuals to become energy citizens. Therefore, when examining the participation in local energy communities, it is essential to analyze the role of these two engagement strategies: gamification and comfort. Moreover, both variables arose from the conducted stakeholders' interviews. These interviews aimed to confirm and identify some other factors that could be relevant for the phenomenon under analysis. Therefore, the qualitative part proves the relevance of both comfort and gamification.

Regarding the first, several areas have examined the role of gamification in increasing the engagement of technologies (Lounis et al., 2013). In the case of sustainable energy solutions and tools needed to participate in local energy communities, gamifying the technologies is an emerging phenomenon, but with a significant impact on leading individuals to adopt more sustainable/green behaviours (Ke et al., 2019). Therefore, the presence of gamification is an increasing phenomenon in green technologies/systems and may play a key role in understanding the engagement in local energy markets. This finding was also confirmed in the interviews, e.g.:

- "I think this (gamification) may help a specific type of end-users to be more interested in it. Also, they potentially may support the continuous use of the solutions." – Stakeholder 1 (Expert on energy topic – from Italy)
- "I think making it like a game, so they can see on the laptop or their mobile phone that "ooh now I'm consuming less than something", it has to be something fun." – Stakeholder 2 (Expert on energy topic – from Italy)

In terms of comfort, studies in the area have examined comfort as a relevant co-benefit helping the decision to change to solutions that improve the energy performance of households (Ferreira & Almeida, 2015). Also, comfort considerations have been proven to be relevant regarding homeowners decisions of adopting heating systems (Michelsen & Madlener, 2013). Therefore, comfort can also be a key factor towards the participation in local energy markets, which was also confirmed in the stakeholder interviews:

- "From smart monitoring, I think most interesting things is to have better thermal comfort and or quality of elements like that." – Stakeholder 1 (Expert on energy topic – from Italy)
- "For instance, regulating, controlling the temperature of the house. This is one of the most important aspects that sometimes can improve the comfort and the silence also." – Stakeholder 3 (Consumer– from Germany)
- "I think the most important about it in order to keep us using it is how comfortable the user is." – Stakeholder 4 (Consumer – from Portugal)

The role of the use of sustainable energy solutions and wellbeing

One of the most quintessential elements of a local energy community is that citizens possess the necessary energy solutions to become active energy citizens. Therefore, the use of sustainable energy solutions, such as renewable energy installations, smart devices, electric vehicles, etc., is a determinant factor of the decision and capability to participate in these communities. Hence, when examining the participation in local energy communities, the use of sustainable energy solutions also needs to be analysed. Nevertheless, more than that, a citizen may only participate if they are satisfied when using those energy solutions and see an increase in their level of wellbeing. In fact, wellbeing is a strong component of the TwinERGY project, as assessing its levels is part of several of the project modules. In reality, a solution is only viable if, at the minimum, it does not negatively affect the users' wellbeing. Therefore, use and wellbeing should also be considered when studying the willingness to participate in a large project such as a local energy community.

3/ Research model

The integration of empowerment theory with pro-environmental behaviour and specific variables, namely gamification and comfort (given the importance of these variables for the project tasks), allows a complete model to understand the intention to participate in local energy communities. Empowerment theory has been used in several studies for public activities and engagement but is rarely studied in the energy topic. Thus, given the characteristics of local energy communities, using empowerment theory with pro-environmental behaviour makes it possible to better understand the inner motivations that may trigger citizens to participate in these communities. This research model also extends the study by adding the role of the use of sustainable energy solutions in both wellbeing and consequently on the participation itself. Therefore, we can first examine the relationship between the use of sustainable energy solutions and wellbeing and then assess its impact on participation in local energy communities. Figure 5 presents the research model, followed by the hypotheses.

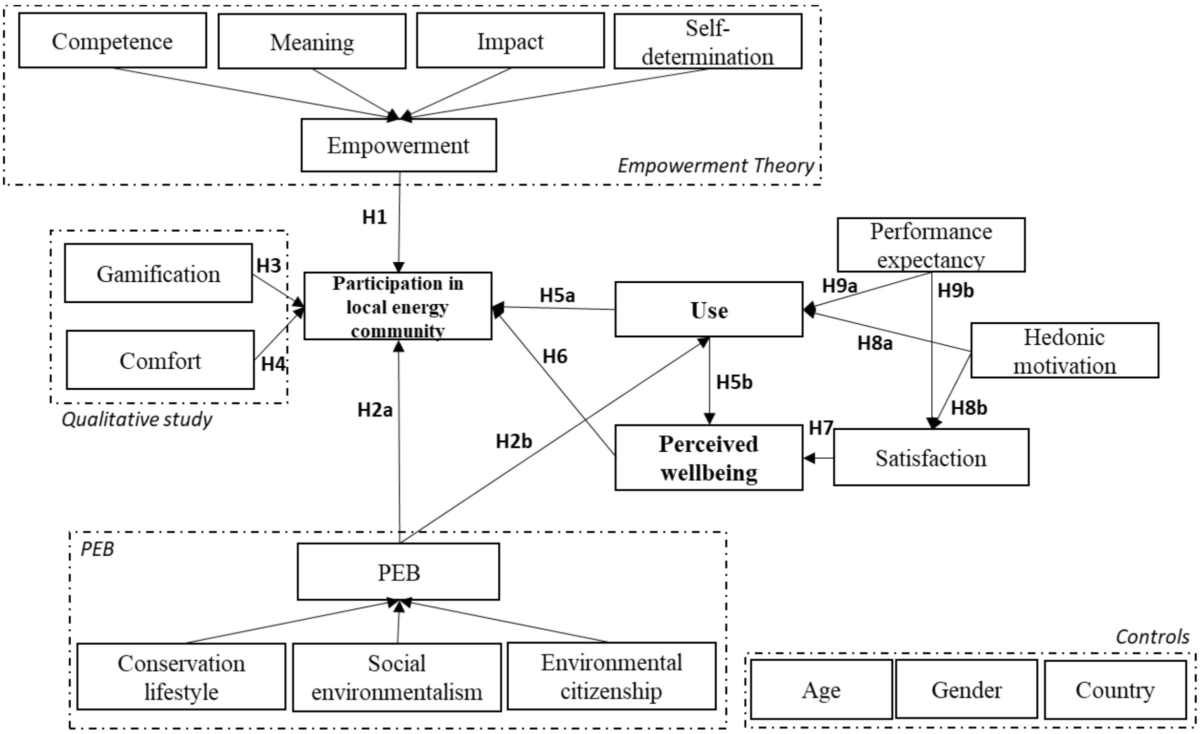

Figure 5. Research model

3.1 Hypotheses development

Empowerment theory has been widely used, especially for citizen activities, such as e-government participation (Naranjo-Zolotov et al., 2019), IoT public services participation (El-Haddadeh et al., 2019), proving to have a substantial impact on explaining citizen participation. When citizens perceive that participation in a certain activity may create feelings of competence, meaning, impact or self-determination, they feel empowered, resulting in a genuine interest in participating in the activity. Therefore, we hypothesise that:

H1: Empowerment will positively influence the intention to participate in local energy communities

To complement the empowerment theory, we cannot forget the solid environmental component of this project. Therefore, PEB was used as a second-order construct. The role of PEB has been widely used to explain sustainable behaviours. So, more than just wanting to protect the environment, individuals who perform concrete pro-environmental behaviour are hypothesised to be much more eager to participate in local energy communities and use sustainable energy solutions, as they have already performed other types of behaviours for similar purposes. Hence, we hypothesise the following:

H2a: Pro-environmental behaviour will positively influence the intention to participate in local energy communities
H2b: Pro-environmental behaviour will positively influence the use of sustainable energy solutions

Also, gamification is hypothesised to impact the intention to participate in local energy communities positively. It is perceived as a successful strategy to increase engagement in projects that include complex technologies and tools by turning them into a more user-friendly gamified experience. Therefore:

H3: Gamification will positively influence the intention to participate in local energy communities

Furthermore, comfort has been identified as a great motivator towards sustainable behaviours. Studies suggest its importance regarding homeowners' decision of heating systems (Michelsen & Madlener, 2013) and energy improvements at the building level

(Ferreira & Almeida, 2015). Thus, people with lower levels of comfort are willing to make changes to increase it. Hence, we hypothesise that:

H4: Comfort will positively influence the intention to participate in local energy communities

The following hypotheses are related to the role of the use of sustainable energy solutions in both wellbeing and intention to participate in local energy communities. When studying the intention to participate in local energy communities, there is the need to include the use of energy solutions that make participation viable for the citizens. Therefore, we hypothesize that citizens with greater use of sustainable energy solutions, such as renewables, electric vehicles, etc., will be more willing to participate in local energy communities. Thus:

H5a: Use of sustainable energy solutions will positively influence the intention to participate in local energy communities

However, use itself may not be sufficiently explanatory for the participation in local energy communities, i.e., the intention to participate in these communities may be greater if the use of the solutions itself is satisfactory, and the citizen perceived an increase in their wellbeing. In fact, wellbeing is a vital component of the TwinERGY project, as the assessment of the levels of wellbeing is part of several modules of the project. Therefore, we hypothesize that the use of energy solutions will positively impact well-being and, consequently, greater well-being will lead to a greater intention to participate in local energy communities. We hypothesize the following:

H5b: Use of sustainable energy solutions will positively influence the perceived wellbeing
H6: Perceived wellbeing will positively influence the intention to participate in local energy communities

However, to have a more complete explanation of perceived wellbeing, not only may use influence wellbeing but mainly the satisfaction, i.e., if the citizen is satisfied with the use of the energy solution, an increase in wellbeing is expected. Therefore, two antecedents of wellbeing are identified: use behaviour and satisfaction with use. Finally, to have a more holistic explanation of both use and satisfaction, intrinsic (hedonic motivations) and extrinsic (performance expectancy) motivations are considered as positive antecedents of both use and satisfaction. Hedonic motivations correspond to the fun and enjoyment provided by the use of technology (Venkatesh et al., 2012). Performance expectancy is the user's perception that the use of sustainable energy solutions will improve its performance, especially in terms of energy performance (Venkatesh et al., 2012). Hence:

H7: Satisfaction with sustainable energy solutions will positively influence the perceived wellbeing

H8a: Hedonic motivations will positively influence the use of sustainable energy solutions
H8b: Hedonic motivations will positively influence the satisfaction with sustainable energy solutions

H9a: Performance expectancy will positively influence the use of sustainable energy solutions
H9b: Performance expectancy will positively influence the satisfaction with sustainable energy solutions

3.2 Control variables

The study of consumer behaviour is usually controlled by some variables, especially socio-demographic parameters (e.g. Erell et al., 2018; Davis, 2011; Mills & Schleich, 2009; Yang & Zhao, 2015). Age, gender, and country were used as control variables in the model. These attributes will preserve the impacts on explanatory variables.

4/ Quantitative study

4.1 Quantitative methodology

This task is composed of two primary analyses: the participation model and consumer segmentation. An online questionnaire was designed for both tasks, and data were collected in the five European countries under study (each country with an online questionnaire in their native language). Then, data were explored using some descriptive statistics.

Then, to test the research model, the partial least squares (PLS) technique was used. PLS-SEM is a variance-based technique, generically characterised by the following:

- It does not require that the data is normally distributed.
- It is used for exploratory research.
- It allows the use of both formative and reflective constructs.
- It allows complex models.

Based on the above information, this method was considered the best for the study since it fits the data, the research model has not been tested in the literature, the research model has reflective and formative constructs, and it is considered complex. SmartPLS 3.0 (Ringle et al., 2018) software was used to estimate the model, verify its validity and reliability, and analyse the model results. Figure 6 presents the methodology process of the quantitative approach for the participation research model.

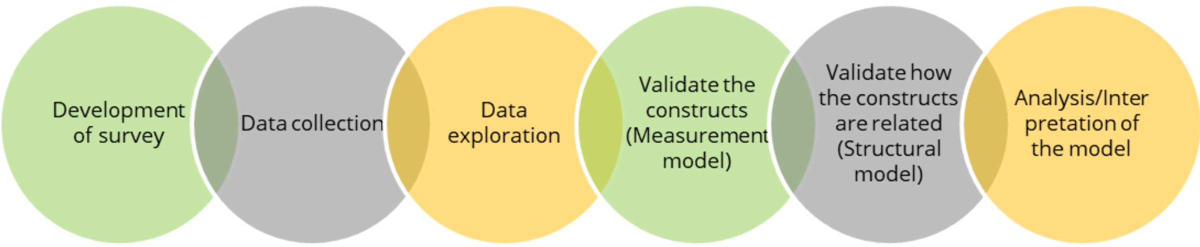

Figure 6. Quantitative study process methodology for research model

For the segmentation analysis, a factor and cluster analysis was performed. Factor analysis is a dimensional reduction technique used to explain the variability among correlated variables using fewer newly created latent dimensions, called factors. This

Twinergy has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957736

method allows finding dimensions that are not easy to directly measure and facilitates the analysis by reducing a vast set of correlated variables into a small set of underlying factors. Cluster analysis can also be seen as a reduction technique, but for observations, as it allows to create segments with similar characteristics/behaviours. For this analysis, both hierarchical and non-hierarchical methods were applied. Hierarchical methods to choose the number of clusters, and K-Means (non-hierarchical method) to create the groups. Figure 7 presents the methodology process of the quantitative approach for the segmentation analysis.

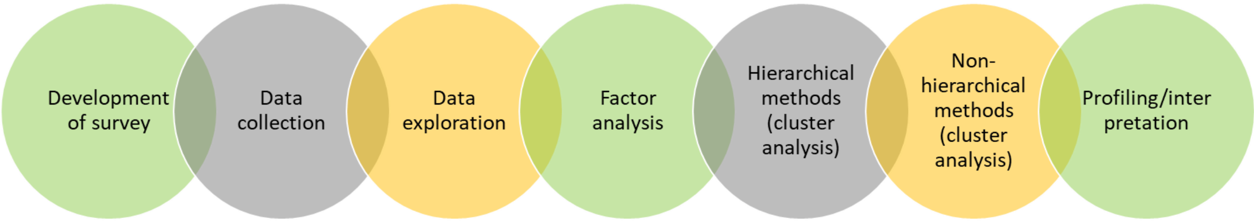

Figure 7. Quantitative study process methodology for segmentation

4.2 Survey

The questionnaire was built based on the variables identified in the literature. Most questionnaire questions have a seven-point numerical scale (1 – completely disagree; 7 – completely agree). The items of the constructs were adapted to the context of this study. Table 2 presents the survey items.

Table 1. Survey items

Variable	Item		Source
Hedonic motivation	HM1	Using sustainable energy solutions is fun	(Venkatesh et al., 2012)
	HM2	Using sustainable energy solutions is enjoyable	
	HM3	Using sustainable energy solutions is very entertaining	
Performance Expectancy	PE1	Using sustainable energy solutions improves my performance in managing energy consumption	(Bhattacherjee, 2001; Venkatesh et al., 2012)
	PE2	Using sustainable energy solutions increases my productivity in managing energy consumption	
	PE3	Using sustainable energy solutions enhances my effectiveness in managing energy consumption	
	PE4	Overall, sustainable energy solutions are useful in managing energy consumption	
Satisfaction	SAT1	How do you feel about your overall experience of sustainable energy solutions use: 1-Very dissatisfied 2 3 4 5 6 7-Very satisfied	(Bhattacherjee, 2001)
	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	
Conservation lifestyle	CL1	Recycled paper, plastic and metal	(Larson et al., 2015)
	CL2	Conserved water or energy in my home	
	CL3	Bought environmentally friendly and/or energy-efficient products	
Social environmentalism	SE1	Talked to others in my community about environmental issues	
	SE2	Worked with others to address an environmental problem or issue	

	SE3	Participated as an active member in a local environmental group	
Environmental citizenship	EN1	Voted to support a policy/regulation that affects the local environment	
	EN2	Signed a petition about an environmental issue	
	EN3	Donated money to support local environmental protection	
	EN4	Wrote a letter in response to an environmental issue	
Comfort	CS1	Evaluate your comfort sensation perceived in your house for each of the following: Visual comfort (with aspects such as view, illuminance, and reflection)	(Chan et al., 2017)
	CS2	Thermal comfort in heating season (air velocity, humidity, and temperature)	
	CS3	Thermal comfort in cooling season (air velocity, humidity, and temperature)	
	CS4	Acoustical comfort (control of unwanted noise, vibrations, and reverberations)	
	CS5	Air quality (smells, irritants, outdoor air, and ventilation)	
Gamification	GA1	How important are the following features to you? Rewards from a points collection system	(Hamari et al., 2018)
	GA2	Competition between neighbours	
	GA3	Competition between neighbourhoods	
	GA4	Achievements from more sustainable behaviour	
Competence	CP1	I have mastered the skills necessary for participating in a local energy community	(Naranjo-Zolotov et al., 2019)
	CP2	I am self-assured about my capabilities to participate in a local energy community	
	CP3	I am confident about my ability to participate in a local energy community	
Meaning	MN1	Participation in a local energy community is very important to me	
	MN2	Participation in a local energy community is meaningful to me	
	MN3	My local energy community participation activities are personally meaningful to me	
Impact	IP1	Based on the participation in a local energy community, my impact on what happens in the community is large	
	IP2	Based on my participation in a local energy community, I have significant influence over what happens in the community	
	IP3	Based on my participation in a local energy community, I have a great deal of control over what happens in the community	
Self Determination	SD1	I have significant autonomy in determining how I participate in a local energy community	
	SD2	I have considerable opportunity for independence and freedom in how I participate in a local energy community	
	SD3	I can decide on my own how to go about participating in a local energy community	
Use Behaviour	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	
Participation in a local energy community	EC1	I intend to become part of the local energy community in the following months	(Venkatesh et al., 2012)
	EC2	I predict I will become part of the local energy community in the following months	
	EC3	I plan to become part of the local energy community in the following months	
Perceived wellbeing	PW1	Overall, sustainable energy solutions... Have satisfied my overall household needs	(El Hedhli et al., 2013)
	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	

It was decided to conduct the questionnaire online due to its size and to facilitate distribution. The questionnaire was conceived in English and then validated by academic researchers and native language support partners of the project. 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 support partners of each country conducted the translations. A video was recorded and presented at the beginning of the questionnaire to help the respondents better understand a local energy communities' context and concept. This video was also created in the five languages spoken by the respondents, namely the audio, text in images and subtitles, guaranteeing the easy understanding of the video for respondents. Some versions were reworded from each language to English and vice versa to ensure that the questions were equivalent and the meaning was the same (Cha et al., 2007). This exercise was carried out in collaboration with Task 4.1. In terms of data collection, a Portuguese market research company (QMetrics) was subcontracted regarding the data collection process, ensuring that 400 respondents per country would be achieved. Also, in order to guarantee that the respondents had similar characteristics to the whole population of each country, quotas were set in terms of age and gender (two socio-demographic variables usually used in this type of study) (see Table 2 and Table 3), with no significant differences existing between the samples and country parameters. Again, this task was conducted in collaboration with Task 4.1.

Table 2. Age quotas[1]

Age	Germany	Greece[2]	Portugal[2]	Italy	UK
18-24	9%	9%	9%	8%	11%
25-49	37%	40%	39%	38%	42%
50-64	27%	25%	25%	27%	24%
>=65	26%	27%	28%	28%	23%

Table 3. Gender quotas[2]

Gender	Germany	Greece	Portugal	Italy	UK
Male	49%	49%	48%	48%	49%
Female	51%	51%	52%	52%	51%

Note 1: [1] http://appsso.eurostat.ec.europa.eu/nui/show.do?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).
Note 2: [2] The last class of Portugal and Greece were joined with the one above due to difficulties in data collection. We believe that there is no bias on the results due to that, as the majority target population for these types of solutions is not individuals older than 64

A pilot was also performed in order to understand if all items were perceptible and if there was the need to rewrite any of them. For this purpose, we gathered 200 responses. There was no need to change any questions, so the final questionnaires were launched over two weeks (end of July of 2021). The subcontracted company carried out this task.

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4.3 Sample size

Sample size definition is a crucial step. We assumed a random sampling methodology representative by country to calculate it. The formula of the sample size used was the one for an infinite population since the dimension of the target population is unknown.

$$n = \frac{Z^2 p * q}{d^2} = \frac{1.96^2 * 0.5 * 0.5}{0.05^2} = 385$$

where Z is the standard normal distribution for the (1-α/2) level, d is the precision, p is the prevalence, and q=(1-p).

Since it was assumed that there was no information regarding the prevalence of the characteristic (p), a pessimistic hypothesis, i.e., 0.5, was set. Prevalence stands for the proportion of the population that present the characteristics under study. In this case, it represents the proportion of the population responsible or co-responsible for decisions regarding energy solutions. Choosing the pessimistic hypothesis – the case of no information – would give us a sample size of a worst-case scenario – no information – and therefore, probably higher than what is actually needed. Thus, the sample size estimation required 400 survey responses per country. For the level of precision (d), 5% was used. The level of precision or margin of error should be carefully chosen. A lower margin of error indicates higher confidence levels in the results. Therefore, we believe that choosing 5% as the level of precision is satisfactory. Thus, 400 answers per country were collected.

4.4 Exploratory analysis

This section presents some descriptive statistics of the sample. The questionnaire was disseminated in the five European countries under study, and a total of 400 answers were collected per country. Table 4 presents the descriptive statistics of the whole sample.

Table 4. Descriptive statistics for the whole sample

Sample characteristics		Descriptive statistics
Gender	Male	49%
	Female	51%
Age (average)		50
Urban area		72%
Building Type	Terrace	13%
	Detached	22%
	Semi-detached	15%
	Flat	49%

	Other	1%
Employment	Student	5%
	Employed worker	46%
	Self-employed	11%
	Unemployed/Retired	37%
Homeowner		62%
Number of individuals living in the household (average)		3
Number of children (average)		1

As expected, the sample presents gender equality and an average age of 50 years old. In terms of area of living, most respondents live in urban areas and in a flat type of building. More than 50% of the respondents are house owners, as prevalent in many studies focused on the energy topic (e.g. Wilson, Crane, & Chryssochoidis, 2015; Musti, Kortum, & Kockelman, 2011). The average number of individuals living in the household is three, with an average of one child, which is in line with the EU statistics[3] in terms of household composition statistics. Table 5 presents the descriptive statistics per country to illustrate a more detailed understanding. Globally, they do not vary much from the total sample.

Table 5. Descriptive statistics per country

Sample characteristics		Germany	Greece	Italy	Portugal	UK
Urban area		62%	88%	69%	80%	63%
Building Type	Terrace	13%	12%	11%	5%	25%
	Detached	24%	22%	16%	24%	24%
	Semi-detached	11%	8%	9%	12%	34%
	Flat	50%	58%	64%	58%	16%
	Other	2%	1%	1%	1%	0%
Employment	Student	4%	6%	8%	6%	3%
	Employed worker	49%	43%	39%	51%	50%
	Self-employed	6%	15%	12%	14%	9%
	Unemployed/Retired	41%	37%	42%	29%	38%
Homeowner		35%	65%	74%	70%	68%
Number of individuals living in the household (average)		2	3	3	3	2
Number of children (average)		1	1	1	0	1

Note 3: [3] Source: EUROSTAT (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Household_composition_statistics)

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5/ Results

Partial least squares is a variance-based technique of structural equation modelling used to estimate the conceptual model. When using this technique, we should first analyse the measurement model, examining the relationship between the items/questions and the concepts/constructs they are measuring. Then, the structural model is analysed, examining the relationships between the constructs/concepts. (Hair et al., 2011) We present the model's results tested with all data from the five European countries in the following sections.

5.1 Measurement model

Several measures need to be examined to assess the measurement model. Table 6 shows the mean and standard deviation of the reflective constructs, as well as the composite reliability (CR) and the average variance extracted (AVE). All constructs should present a CR higher than 0.7 and an AVE higher than 0.5 to guarantee the reliability of scales and convergent validity (Hair, Ringle, & Sarstedt, 2011; Fornell & Larcker, 1981). Reliability of scales means that the instrument measuring the construct performs in consistent, predictable ways. The items assigned to each construct are reliable. Convergent validity is verified when all items of a construct effectively measure the construct. As observed, these measures are verified.

Table 6. Mean, standard deviation, CR and Fornell-Larcker table. The diagonal elements are the square-root of AVE

	Mean	STD	CR	CS	CP	CL	EN	GA	HM	IP	MN	EC	PW	PE	SAT	SD	SE	UB
CS	5.090	1.148	0.920	0.835														
CP	4.039	1.581	0.959	0.307	0.941													
CL	5.425	1.160	0.813	0.330	0.324	0.775												
EN	3.237	1.688	0.911	0.196	0.516	0.363	0.847											
GA	3.872	1.382	0.861	0.263	0.548	0.233	0.415	0.782										
HM	4.853	1.459	0.949	0.352	0.551	0.467	0.435	0.463	0.928									
IP	3.883	1.611	0.962	0.279	0.713	0.331	0.548	0.575	0.568	0.945								
MN	4.261	1.599	0.964	0.306	0.701	0.411	0.536	0.584	0.625	0.821	0.948							
EC	3.525	1.815	0.982	0.250	0.614	0.313	0.585	0.523	0.515	0.673	0.705	0.974						
PW	4.169	1.653	0.964	0.349	0.572	0.414	0.539	0.467	0.610	0.593	0.608	0.631	0.933					
PE	4.687	1.505	0.963	0.388	0.552	0.456	0.447	0.483	0.757	0.535	0.597	0.504	0.638	0.930				
SAT	4.661	1.376	0.967	0.358	0.514	0.455	0.419	0.442	0.675	0.502	0.545	0.481	0.615	0.704	0.939			
SD	4.434	1.484	0.928	0.329	0.553	0.337	0.378	0.372	0.462	0.617	0.560	0.477	0.453	0.435	0.418	0.901		
SE	3.627	1.621	0.917	0.260	0.594	0.484	0.790	0.496	0.519	0.622	0.615	0.623	0.600	0.525	0.492	0.430	0.887	
UB	3.824	1.703	0.967	0.359	0.579	0.442	0.532	0.442	0.537	0.546	0.560	0.586	0.711	0.602	0.587	0.454	0.581	0.953

Note: CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour

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The next step is to assess the discriminant validity. Discriminant validity is verified when a group of items intended to measure a construct does not measure, at the same time, another construct. For that, the Fornell-Larcker criterion, the cross-loadings and the Heterotrait-Monotrait Ratio (HTMT) were used. 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 is verified. To assess the second criterion, Table 7 represents the loadings and cross-loadings. As observed, all loadings are higher than the cross-loadings, satisfying the criterion (Chin, 1998). Finally, we need to assess the HTMT criterion. Table 8 presents this criterion, showing that the diagonal values are lower than 0.9, therefore establishing discriminant validity. Only between social environmentalism and environmental citizenship a value higher than 0.9 was found. In that case, we resorted to the interval of 95% confidence, which is 0.891 - 0.930 (the true value is within this interval with a 95% level of confidence). Since the interval does not contain the value 1, we can also establish discriminant validity for this set of variables.

Table 7. Loadings and cross-loadings.

	CL	CP	CS	EC	EN	GA	HM	IP	MN	PE	PW	SAT	SD	SE	UB
CL1	**0.561**	0.036	0.228	0.029	0.037	-0.046	0.184	0.037	0.128	0.159	0.112	0.186	0.118	0.090	0.112
CL2	**0.802**	0.203	0.262	0.180	0.194	0.121	0.307	0.185	0.246	0.299	0.258	0.320	0.265	0.316	0.313
CL3	**0.918**	0.365	0.296	0.363	0.431	0.294	0.488	0.387	0.453	0.481	0.453	0.462	0.329	0.530	0.462
CP1	0.283	**0.921**	0.283	0.558	0.487	0.511	0.494	0.649	0.617	0.495	0.535	0.461	0.506	0.559	0.552
CP2	0.305	**0.959**	0.289	0.578	0.479	0.523	0.514	0.677	0.658	0.521	0.542	0.476	0.520	0.558	0.546
CP3	0.324	**0.943**	0.294	0.598	0.491	0.513	0.546	0.685	0.702	0.540	0.539	0.513	0.534	0.560	0.537
CS1	0.338	0.263	**0.793**	0.217	0.155	0.243	0.342	0.213	0.261	0.360	0.322	0.314	0.282	0.223	0.271
CS2	0.266	0.256	**0.868**	0.212	0.177	0.220	0.283	0.240	0.255	0.322	0.298	0.309	0.277	0.220	0.321
CS3	0.278	0.274	**0.867**	0.229	0.171	0.241	0.287	0.250	0.275	0.339	0.296	0.327	0.293	0.233	0.336
CS4	0.213	0.251	**0.814**	0.199	0.177	0.205	0.258	0.245	0.248	0.269	0.257	0.248	0.250	0.211	0.281
CS5	0.279	0.234	**0.833**	0.179	0.134	0.179	0.297	0.213	0.232	0.327	0.279	0.288	0.268	0.191	0.282
EC1	0.297	0.596	0.242	**0.974**	0.554	0.515	0.502	0.649	0.687	0.489	0.612	0.461	0.463	0.595	0.560
EC2	0.315	0.598	0.247	**0.972**	0.577	0.508	0.510	0.664	0.696	0.489	0.616	0.478	0.471	0.616	0.578
EC3	0.301	0.600	0.241	**0.975**	0.579	0.504	0.494	0.653	0.676	0.493	0.614	0.464	0.460	0.610	0.574
EN1	0.364	0.412	0.180	0.467	**0.831**	0.260	0.412	0.452	0.460	0.390	0.477	0.379	0.318	0.672	0.444
EN2	0.357	0.396	0.158	0.451	**0.843**	0.306	0.386	0.439	0.449	0.387	0.446	0.335	0.319	0.638	0.388
EN3	0.292	0.471	0.168	0.541	**0.873**	0.406	0.360	0.485	0.474	0.391	0.476	0.363	0.332	0.695	0.501
EN4	0.225	0.465	0.160	0.520	**0.843**	0.429	0.319	0.479	0.434	0.346	0.429	0.343	0.310	0.670	0.463
GA1	0.199	0.304	0.253	0.288	0.203	**0.657**	0.334	0.340	0.359	0.333	0.309	0.312	0.239	0.263	0.260
GA2	0.096	0.458	0.138	0.436	0.338	**0.879**	0.292	0.472	0.441	0.310	0.338	0.310	0.290	0.415	0.356
GA3	0.087	0.466	0.139	0.445	0.351	**0.886**	0.303	0.473	0.452	0.316	0.342	0.312	0.300	0.421	0.346
GA4	0.359	0.450	0.313	0.433	0.371	**0.676**	0.520	0.483	0.551	0.547	0.460	0.445	0.324	0.415	0.399
HM1	0.432	0.524	0.337	0.478	0.378	0.463	**0.937**	0.532	0.583	0.711	0.560	0.649	0.438	0.462	0.520
HM2	0.480	0.477	0.334	0.452	0.384	0.361	**0.932**	0.504	0.571	0.699	0.546	0.636	0.447	0.465	0.472
HM3	0.388	0.533	0.307	0.506	0.451	0.465	**0.915**	0.547	0.586	0.698	0.592	0.592	0.401	0.520	0.502
IP1	0.339	0.672	0.280	0.651	0.539	0.523	0.556	**0.935**	0.826	0.524	0.576	0.472	0.552	0.599	0.517
IP2	0.310	0.675	0.253	0.631	0.511	0.545	0.535	**0.962**	0.772	0.502	0.557	0.473	0.593	0.587	0.511
IP3	0.289	0.674	0.257	0.625	0.503	0.563	0.519	**0.939**	0.727	0.489	0.548	0.478	0.606	0.576	0.520
MN1	0.387	0.685	0.295	0.690	0.529	0.585	0.595	0.775	**0.958**	0.578	0.595	0.512	0.505	0.599	0.542
MN2	0.422	0.609	0.283	0.616	0.465	0.490	0.588	0.742	**0.933**	0.540	0.529	0.519	0.549	0.544	0.487
MN3	0.364	0.698	0.291	0.697	0.529	0.583	0.595	0.816	**0.954**	0.579	0.602	0.519	0.541	0.604	0.561
PE1	0.425	0.523	0.365	0.470	0.419	0.463	0.698	0.497	0.558	**0.937**	0.591	0.650	0.402	0.488	0.578
PE2	0.426	0.544	0.370	0.494	0.450	0.466	0.713	0.523	0.572	**0.950**	0.628	0.675	0.411	0.526	0.596
PE3	0.415	0.537	0.362	0.491	0.440	0.471	0.711	0.523	0.569	**0.957**	0.627	0.673	0.406	0.517	0.587
PE4	0.431	0.443	0.350	0.414	0.347	0.394	0.698	0.442	0.520	**0.875**	0.522	0.619	0.403	0.416	0.472
PW1	0.397	0.491	0.357	0.539	0.448	0.379	0.510	0.479	0.506	0.574	**0.894**	0.580	0.409	0.494	0.669
PW2	0.384	0.554	0.315	0.612	0.542	0.448	0.582	0.591	0.603	0.588	**0.942**	0.568	0.420	0.597	0.650
PW3	0.380	0.555	0.313	0.616	0.530	0.472	0.574	0.590	0.589	0.595	**0.949**	0.562	0.421	0.593	0.663

PW4	0.383	0.532	0.317	0.583	0.490	0.440	0.606	0.550	0.566	0.624	**0.945**	0.585	0.438	0.553	0.672
SAT1	0.445	0.514	0.365	0.473	0.409	0.421	0.670	0.492	0.549	0.708	0.616	**0.932**	0.417	0.484	0.588
SAT2	0.440	0.491	0.333	0.459	0.405	0.414	0.640	0.470	0.516	0.675	0.589	**0.954**	0.398	0.466	0.565
SAT3	0.399	0.464	0.315	0.430	0.368	0.409	0.611	0.452	0.482	0.627	0.553	**0.941**	0.384	0.443	0.526
SAT4	0.422	0.456	0.326	0.440	0.389	0.414	0.607	0.466	0.494	0.625	0.545	**0.927**	0.368	0.451	0.520
SD1	0.286	0.511	0.282	0.457	0.360	0.324	0.387	0.611	0.520	0.358	0.395	0.368	**0.904**	0.407	0.408
SD2	0.330	0.542	0.310	0.464	0.384	0.378	0.470	0.600	0.558	0.442	0.459	0.418	**0.932**	0.426	0.445
SD3	0.294	0.428	0.300	0.356	0.260	0.297	0.387	0.433	0.420	0.374	0.361	0.338	**0.864**	0.315	0.365
SE1	0.528	0.490	0.250	0.515	0.636	0.374	0.512	0.528	0.553	0.479	0.531	0.446	0.395	**0.869**	0.492
SE2	0.470	0.555	0.246	0.558	0.702	0.446	0.489	0.572	0.565	0.509	0.572	0.471	0.395	**0.933**	0.543
SE3	0.293	0.534	0.195	0.585	0.762	0.497	0.383	0.553	0.519	0.409	0.494	0.392	0.354	**0.858**	0.509
UB1	0.445	0.529	0.355	0.539	0.494	0.394	0.516	0.499	0.520	0.569	0.684	0.574	0.429	0.545	**0.938**
UB2	0.423	0.560	0.336	0.561	0.502	0.433	0.524	0.524	0.543	0.587	0.673	0.567	0.436	0.552	**0.966**
UB3	0.396	0.565	0.334	0.575	0.524	0.437	0.495	0.538	0.538	0.566	0.677	0.538	0.432	0.563	**0.955**

Note: CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour

Table 8. Heterotrait-Monotrait ratio (HTMT).

	CS	CP	CL	EN	GA	HM	IP	MN	EC	PW	PE	SAT	SD	SE	UB
CS															
CP	0.335														
CL	0.416	0.313													
EN	0.222	0.571	0.382												
GA	0.323	0.631	0.343	0.491											
HM	0.388	0.593	0.513	0.489	0.549										
IP	0.303	0.760	0.315	0.605	0.664	0.611									
MN	0.332	0.744	0.429	0.591	0.674	0.671	0.869								
EC	0.266	0.644	0.292	0.635	0.591	0.545	0.703	0.734							
PW	0.378	0.607	0.425	0.593	0.540	0.652	0.626	0.640	0.656						
PE	0.422	0.584	0.487	0.490	0.562	0.812	0.565	0.630	0.523	0.671					
SAT	0.385	0.542	0.496	0.459	0.513	0.718	0.529	0.573	0.498	0.645	0.738				
SD	0.370	0.602	0.381	0.424	0.443	0.510	0.667	0.607	0.509	0.491	0.475	0.452			
SE	0.295	0.660	0.528	0.910	0.592	0.584	0.689	0.680	0.680	0.662	0.579	0.541	0.486		
UB	0.388	0.614	0.458	0.584	0.508	0.574	0.578	0.590	0.610	0.749	0.633	0.615	0.492	0.641	

Note: CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour

Since we have two reflective-formative constructs (empowerment and pro-environmental behaviour), we needed to examine the formative part by availing of different measures. For that, we assessed the multicollinearity, statistical significance and relevance of the weights (Becker et al., 2012). We checked the variance inflation factor (VIF) to examine multicollinearity, which resulted in a value lower than 5 in both cases, indicating no collinearity issues (Hair et al., 2011). Regarding weights, all of them are statistically significant, as shown in Tables 9 and 10. The weights result from multiple regression with the Empowerment/PEB score as the dependent variable and the formative constructs as independent variables. Therefore, they are significantly different from zero.

*Table 9. Measurement model evaluation for second-order formative construct. Note: *p<0.10; **p<0.05; ***p<0.01*

		VIF	Weights
Empowerment	Competence	2.294	0.233***
	Impact	3.716	0.273***
	Meaning	3.359	0.545***
	Self-determination	1.691	0.047*

*Table 10. Measurement model evaluation for second-order formative construct. Note: *p<0.10; **p<0.05; ***p<0.01. PEB – Pro-environmental behaviour*

		VIF	Weights
PEB	Conservation lifestyle	1.308	0.186***
	Environmental citizenship	2.661	0.362***
	Social environmentalism	3.017	0.584***

In conclusion, we achieved a good measurement model. Summarising the measurement items, the reflective constructs, construct reliability, convergent validity, indicator reliability, and discriminative validity are confirmed. For the formative ones, no collinearity issues and the significance of weights were verified. The research model was tested using all data, but also individually for each country sample. This process was repeated for each model. The results are in Annexes A – E. Having all these validated, it is possible to estimate the structural model presented in the following sub-section.

5.2 Structural model

Table 11 presents the direct effects of each variable on the four independent variables. As observed, the model explains 61.3% of the variation in participation in local energy communities, 51.3% of the variation use behaviour, 56.1% of the variation of satisfaction and 60.5% of the variation in perceived wellbeing. We can then conclude that the model performs very well in explaining the four variables.

*Table 11. Direct effects over participation in LEC, use behaviour, satisfaction and perceived wellbeing. Note: *p<0.10; **p<0.05; ***p<0.01*

	Beta	R-Squared
Participation in LEC		**61.3%**
Comfort	-0.046***	
Empowerment	0.43***	
Gamification	0.047**	
PEB	0.184***	
Perceived wellbeing	0.184***	

Use	0.063**	
Use behaviour		**51.3%**
Hedonic motivations	0.114***	
PEB	0.403***	
Performance expectancy	0.322***	
Satisfaction		**56.1%**
Hedonic motivations	0.353***	
Performance expectancy	0.469***	
Perceived wellbeing		**60.5%**
Satisfaction	0.292***	
Use	0.532***	

From the table, we can identify the most critical factors for consumers to participate in local energy communities and use sustainable energy solutions as a driver for perceived well-being and satisfaction. The overall model supported all 13 established hypotheses, suggesting the relevance of all factors to explain participation, use, satisfaction, and wellbeing. After testing the model with the whole sample, the model was tested individually per country. The next section discusses the overall and individual results.

5.3 Results

Table 12 summarises the direct effects of the overall and individual models per country. As observed, holistically, the R-Squared measures are all high in all countries, with Italy and the UK showing a higher R-Squared value for participation in local energy communities (65.2%; 67.4%). In terms of wellbeing, Italy shows a higher R-Squared (71.5%). We will first discuss the results globally and then specifically for each country. These outcomes mean that the conceptualised model performs outstandingly in explaining all four independent variables and fulfils the tenets of its conception.

*Table 12. Direct effect (overall and per country). Note: *p<0.10; **p<0.05; ***p<0.01*

	Overall	Germany	Greece	Italy	Portugal	UK
Participation in LEC (R-Squared)	**61.3%**	**60.0%**	**60.1%**	**65.2%**	**55.3%**	**67.4%**
Comfort	-0.046***	-0.047	-0.096***	0.024	-0.067	-0.021
Empowerment	0.430***	0.469***	0.479***	0.555***	0.431***	0.332***
Gamification	0.047**	0.036	0.028	-0.057	0.047	0.093**
PEB	0.184***	0.207***	0.205***	0.111**	0.137**	0.226***
Perceived wellbeing	0.184***	0.127**	0.261***	0.051	0.210***	0.192***
Use	0.063**	0.059	-0.055	0.183**	0.073	0.095*
Use (R-Squared)	**51.3%**	**48.9%**	**42.8%**	**63.2%**	**45.6%**	**58.6%**
Hedonic motivations	0.114***	0.068	0.163***	0.096	-0.000	0.253***

PEB	0.403***	0.359***	0.485***	0.450***	0.401***	0.248***
Performance expectancy	0.322***	0.365***	0.123**	0.324***	0.378***	0.327***
Satisfaction (R-Squared)	**56.1%**	**61.3%**	**53.8%**	**58.7%**	**48.6%**	**58.8%**
Hedonic motivations	0.353***	0.557***	0.334***	0.272***	0.257***	0.218***
Performance expectancy	0.469***	0.274***	0.458***	0.524***	0.479***	0.565***
Perceived wellbeing (R-Squared)	**60.5%**	**60.0%**	**58.8%**	**71.5%**	**44.6%**	**57.9%**
Satisfaction	0.292***	0.352***	0.316***	0.280***	0.272***	0.229***
Use	0.532***	0.529***	0.533***	0.620***	0.471***	0.579***

Results transversal to all countries

We will examine each independent variable individually, starting with the two antecedents of perceived wellbeing – use and satisfaction. Regarding the **use of sustainable technologies**, we can see that it is greatly motivated by both performance expectancy and hedonic motivations and pro-environmental behaviour. Only for hedonic motivations, we did not find significance in all countries, just in Greece and UK. These results suggest the following:

- The confirmation of the tremendous impact of pro-environmental behaviour in the use of sustainable technologies. For all countries, individuals that already practised any kind of pro-environmental behaviour are the ones that use the most energy solutions.
- The confirmation of the importance of increasing the energy performance in terms of energy consumption for the users, as identified in Task 4.1.
- The confirmation that fun and enjoyment is not transversal to all countries. These can result from the fact that the users may not interact with the energy solutions daily, and/or the user experience is not dynamic or user friendly, and therefore the possibility of creating a fun and enjoyable experience is challenging.

Regarding **satisfaction with the experience of use of sustainable technologies**, we can see that it is significantly driven by both performance expectancy and hedonic motivations for all countries. Between the two, we can observe that performance expectancy has a greater impact on satisfaction than hedonic motivations (fun/enjoyment). This result suggests that users consider a more satisfactory use experience, especially when the solutions are able to fulfil their needs in terms of better energy performance and control of energy consumption, instead of when they provide an enjoyable interaction. Also, several studies suggest that it is essential to understand them clearly to have an enjoyable interaction with the energy solutions. This factor can be one of the reasons for Germany to be the only country where hedonic motivations have a more significant impact on satisfaction than the performance expectancy.

Examining **perceived wellbeing**, first, the model has an outstanding performance to explain the phenomena, with particular detail regarding Italy with 71.5% of variance explained. Both use and satisfaction are statistically significant to explain the wellbeing aspect. In all countries, use has a much higher impact on wellbeing compared to satisfaction. Therefore, this result suggests that the benefits that the use of sustainable technologies bring to the user are very relevant and even more important than creating a satisfactory use experience. Therefore, even if the experience of using the energy solutions was not so satisfactory, the benefits of use have much more weight. Thus, as the main conclusion, the use of sustainable energy solutions significantly and positively impacts the wellbeing of its users, increasing the quality of life and positively fulfilling the household needs.

Finally, regarding our key dependent variable – **participation in local energy communities**, we can conclude the following (see Figure 8):

- **Empowerment** is the most relevant factor in all countries.
- **Pro-environmental behaviour** and **perceived wellbeing** are the second and third most important factors in all countries.
- Regarding other variables, **comfort** is only statistically significant in Greece.
- **Gamification** is statistically significant in the UK.
- Finally, the **use** of sustainable technologies is only statistically significant in Italy and the UK.

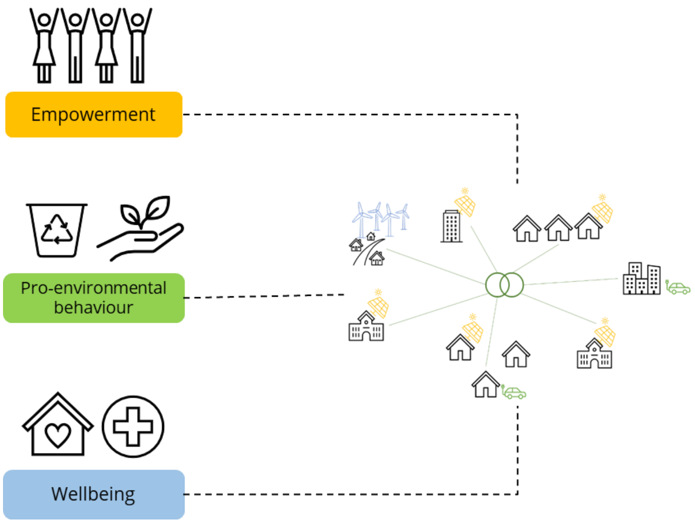

Figure 8. Most important factors for participation in local energy communities

When analysing **empowerment**, our findings suggest that if citizens perceive that participating in a local energy community will increase their feeling of empowerment, they will then be more willing to participate. Analysing each dimension of empowerment, we can conclude that, regarding competence, if the user has the skills and knowledge to participate in this type of community, the greater the intention. On examining the meaning factor, the results suggest that citizens will be more willing to participate if they perceive its participation has something of value and creates value for themselves and the community. Also, if citizens perceive that participating in local energy communities will have an impact and a positive outcome for the community, they will be more willing to participate. Finally, examining self-determination, the results suggest that when citizens perceive that they have a responsibility and a role in the community, they will also be more willing to participate. All this suggests that strategies to promote the participation/creation of local energy communities should consider these elements of citizen empowerment; for example, it is paramount to explain what a local energy community is, especially its impact and the role a single citizen can have in a whole community. This action will help create a sense of empowerment and thus increase the willingness of citizens to participate in these communities.

Regarding **pro-environmental behaviour**, results suggest that protecting the environment is a strong motivation for consumers to participate in local energy communities. It is of great importance to understand that PEB refers to real worries and practices the individual already performs, from recycling, discussing topics about environmental protection to participating in environmentalism groups. Therefore, these types of citizens are the ones most willing to participate in local energy communities.

When examining the impact of **perceived wellbeing** in the intention to participate in local energy communities, the findings indicate that the more the citizen perceives that using sustainable energy solutions increases their quality of life, the greater is the intention to use those technologies towards participation in a local energy community. These citizens are the ones that recognise the benefits of using these energy solutions. Therefore, how key energy solutions benefit the citizens' lives will undoubtedly impact the intention to participate. Hence, promoting quality of life through the use of sustainable energy solutions can be a great strategy that will not only impact use behaviour but also the intention to participate in local energy communities. The remaining variables will be discussed in the following sub-section.

Results per country

Table 13 presents the variables ordered, in descending order, by the impact they present in the intention to participate in local energy communities.

Table 13. Results per country (ordered by impact on participation in LEC)

Germany	Greece	Italy	Portugal	United Kingdom
Empowerment	Empowerment	Empowerment	Empowerment	Empowerment
Pro-environmental behaviour	Perceived wellbeing	Use	Perceived wellbeing	Pro-environmental behaviour
Perceived wellbeing	Pro-environmental behaviour	Pro-environmental behaviour	Pro-environmental behaviour	Perceived wellbeing
	Comfort			Use
				Gamification

As observed in Table 13, the most relevant variables for the intention to participate are similar for all countries (empowerment, pro-environmental behaviour, and perceived wellbeing). Examining the differences between countries, we can conclude the following:

- Greece is the only country where comfort has a statistically significant negative impact on the intention to participate. This finding means that households that perceive low comfort levels are more willing to participate in local energy communities. This aspect may imply that when facing lower levels of comfort, citizens may perceive participation as a way to improve their comfort. Greece has been previously studied, being a country with high levels of energy poverty (about 58% of the households), impacting aspects such as thermal comfort, humidity problems and even some difficulty managing energy bill payments (Papada & Kaliampakos, 2016). However, the possibility of participating in local energy communities would contribute to greater comfort, as well as better financial management in the energy sector. In this way, the need for improvement creates greater intentions to participate. Unlike other countries like the UK, Germany, or France, where more than 50% of the homeowners meet all comfort criteria, in Greece, the situation is different, since just 24% of the homeowners consider having all comfort criteria, with the need to improve this situation existing (Etienne Penissat, Alexis Spire, 2017). Even the neighbouring countries have better levels of house comfort (Italy – 29%, Portugal – 39%) (Etienne Penissat, Alexis Spire, 2017). Therefore, comfort has an impact on the intention to participate in local energy communities in Greece.

- Italy and the United Kingdom are the only countries where the use of sustainable energy solutions present a statistically significant impact. This finding suggests that when studying the participation in local energy communities, we should also understand the impact of the technologies that actually enable citizens to participate. In Italy and the UK, results indicate that the greater the use of these solutions, the greater the intention to participate in local energy communities.

- The United Kingdom is the only country where gamification has a statistically significant positive impact on the intention to participate in local energy communities. This element means that gamification in the energy sector is a relevant factor for UK citizens, which is not happening significantly in other countries. The UK has the lowest average age of its population (40 years), compared to the other countries under analysis (whose average population age varies between 45 and 50 years), which contributes to the fact that gamification is more present and a more impacting factor. This country has also recently developed mobile games and apps that seek to manage power demand and keep costs lower for consumers. Some companies (e.g., Northern PowerGrid) give prizes in a trial to show how a mobile game can encourage households to reduce their consumption. The apps have the ability to engage with customers in a way they can easily participate and have created a pool of people signing up as active flexibility providers (Networks, 2018). With all these incentives, UK citizens are more willing to use gamification in the energy sector and, in turn, to participate in local energy communities.

6/ Segmentation analysis

The purpose of segmentation is to find groups of citizens that behave in a particular fashion or have similar characteristics. In this specific case, profiling different types of consumers will add customisation to the engagement plan, identifying and classifying them according to the most relevant factors found in both the consumer behaviour analysis and participation in local energy communities' model.

The methodology will be the following:

- First, conduct a Factor analysis (FA). FA will allow the creation of new variables (called factors) that explain the correlation among the original variables. This schema can also be called a dimensional reduction technique since we will be able to create a smaller number of factors that contain a significant part of the information of the original variables.

- Then, a cluster analysis will be performed on the factors. Using factors to segment citizens instead of the original variables will facilitate the interpretation of the clusters. For this technique, we will first resort to hierarchical methods and then non-hierarchical methods (K-means).

- Finally, the achieved clusters will be characterised using variables such as gender, level of participation in local energy communities, use of sustainable energy solutions, and country.

6.1. Factor analysis

Factor analysis was used to capture the dimensions that translate the existing relationships between variables. FA is a widely used technique to understand latent dimensions responsible for the correlations between variables. This technique, therefore, helped to identify the overall dimensions that were applied to segment citizens.

Figure 9 presents the steps followed in conducting factor analysis. First, we needed to assess the suitability of data using the Kaiser-Mayer-Olkin (KMO) procedure. Second, the number of factors were extracted taking into consideration three criteria:

- Kaiser criterion: every factor with an eigenvalue higher than one should be retained.

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- Pearson criterion: all factors should be retained until 70-80% of the variance is explained.
- Scree plot criterion: all factors should be retained until the first big elbow in the plot is achieved.

Finally, the factors were rotated and interpreted based on factor loadings (i.e., correlations between factors and original variables.

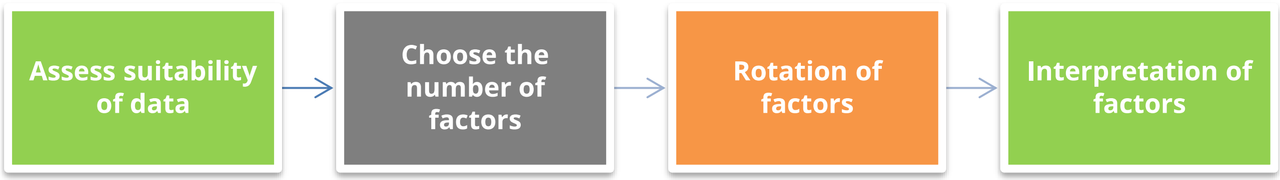

Figure 9. Factor analysis steps

The variables used to perform factor analysis were chosen based on the results of both consumer behaviour analysis and participation in the local energy communities' model. The statistically significant variables with greatest impact for the use of sustainable energy solutions and participation in local energy communities were chosen, namely gamification (GA), knowledge (K), social environmentalism (SE), environmental citizenship (EN), competence (CP), meaning (MN) and impact (IP). The variables are presented in Table 14.

Table 14. Variables used in Factor Analysis

Item	Question
GA1	Rewards from points collection system are important
GA2	Competition between neighbours is important
GA3	Competition between neighbourhoods is important
K1	I am familiar with sustainable energy solutions
K2	I am knowledgeable about energy topics and the environment
K3	I know how to select sustainable energy solutions
SE1	Talked to others in my community about environmental issues
SE2	Worked with others to address an environmental problem or issue
SE3	Participated as an active member in a local environmental group
EN1	Voted to support a policy/regulation that affects the local environment
EN2	Signed a petition about an environmental issue
EN3	Donated money to support local environmental protection
CP1	I have mastered the skills necessary for participating in a local energy community
CP2	I am self-assured about my capabilities to participate in a local energy community
CP3	I am confident about my ability to participate in a local energy community
MN1	Participation in a local energy community is very important to me
MN2	Participation in a local energy community is meaningful to me
MN3	My local energy community participation activities are personally meaningful to me
IP1	Based on the participation in a local energy community, my impact on what happens in the community is large
IP2	Based on my participation in a local energy community, I have significant influence over what happens in the community
IP3	Based on my participation in a local energy community, I have a great deal of control over what happens in the community

Factor analysis was performed over those variables, presenting a KMO of 0.933, proving the suitability of data to perform this analysis. Then, based on the Kaiser and Pearson criterion, four factors were chosen, presenting all eigenvalues higher than one and a cumulative percentage of variance explained of 75%. Neighbour solutions were tested (with three and five factors), but commonalities were very low, and the interpretability was difficult, respectively. Therefore, the final decision was to extract four factors, given the easy interpretability and good measures (RMSR = 0.04, meaning that the factors explain the correlation among variables well). After the four factors extraction, a Varimax rotation was performed to provide more interpretability, based on the factor loadings, represented in Table 15. Factors should be interpreted based on the variables that share a higher variance (factor loading > 0.5). These factors explain 75% of the initial variance of the variables (see Table 15).

When interpreting the factor loadings, factor 1 can be labelled as "**Feeling of empowerment**" as it includes almost all variables that describe the empowerment feeling, namely the feeling of having meaning, impact, or confidence in the capabilities to participate in local energy communities. Factor 2 can be labelled as "**Environmental activism**" since it includes variables related to the active participation in pro-environmental activities and active support of pro-environmental measures. Factor 3 can be named as "**Knowledge/Competence**". This factor includes variables related to the knowledge and familiarity with the energy area and the necessary skills to participate in a local energy community. Finally, factor 4 includes all variables related to gamification issues. Therefore, it is labelled as "**Gamification**".

Table 15. Factor loadings of the rotated factor solution

Rotated Factor Pattern

Questions	**Items**	Factor1 **Feeling of empowerment**	Factor2 **Environmental activism**	Factor3 **Knowledge/ Competence**	Factor4 **Gamification**
Based on the participation in a local energy community, my impact on what happens in the community is large	**IP1**	0.829	0.308	0.187	0.166
Participation in a local energy community is meaningful to me	**MN2**	0.817	0.257	0.181	0.100
My local energy community participation activities are personally meaningful to me	**MN3**	0.812	0.283	0.240	0.226
Based on my participation in a local energy community, I have significant influence over what happens in the	**IP2**	0.798	0.268	0.198	0.246
Participation in a local energy community is very important to me	**MN1**	0.797	0.291	0.226	0.220
Based on my participation in a local energy community, I have a great deal of control over what happens in the	**IP3**	0.744	0.262	0.198	0.308
I am confident about my ability to participate in a local energy community	**CP3**	0.603	0.219	0.513	0.249
I am self-assured about my capabilities to participate in a local energy community	**CP2**	0.564	0.204	0.521	0.307
Voted to support a policy/regulation that affects the local environment	**EN1**	0.248	0.803	0.156	-0.068

Signed a petition about an environmental issue	**EN2**	0.212	0.795	0.130	0.020
Donated money to support local environmental protection	**EN3**	0.188	0.755	0.164	0.252
Worked with others to address an environmental problem or issue	**SE2**	0.303	0.728	0.270	0.203
Participated as an active member in a local environmental group	**SE3**	0.241	0.719	0.158	0.383
Talked to others in my community about environmental issues	**SE1**	0.324	0.689	0.272	0.054
I know how to select sustainable energy solutions	**K3**	0.193	0.220	0.848	0.094
I am familiar with sustainable energy solutions	**K1**	0.217	0.264	0.822	0.020
I am knowledgeable about energy topics and the environment	**K2**	0.227	0.169	0.804	0.118
I have mastered the skills necessary for participating in a local energy community	**CP1**	0.498	0.231	0.514	0.337
Competition between neighbors is important	**GA2**	0.214	0.148	0.082	0.914
Competition between neighborhoods is important	**GA3**	0.222	0.162	0.074	0.909
Rewards from points collection system are important	**GA1**	0.239	0.034	0.138	0.499
Variance explained by each factor (total represent 75% of variance of initial data)		**5.45**	**4.17**	**3.37**	**2.76**

6.2. Cluster analysis

Cluster analysis is a method whose objective is to guarantee the homogeneity within groups of individuals and ensure the heterogeneity between those groups. The four factors were used to group the countries to perform this analysis. This step involved the use of both hierarchical and non-hierarchical methods. First, we ran the hierarchical methods to define the number of clusters. Hierarchical methods have the advantage of not needing to define the number of clusters a priori. The cluster solution, when using this method, depends on the used algorithm. We tried five algorithms: single, complete, centroid, average and wards. The wards algorithm was the best one based on an analysis of R-squared, and it was, therefore, the chosen method. Figure 10 presents a comparison between all hierarchical methods. After that, the dendrogram of wards method was analysed.

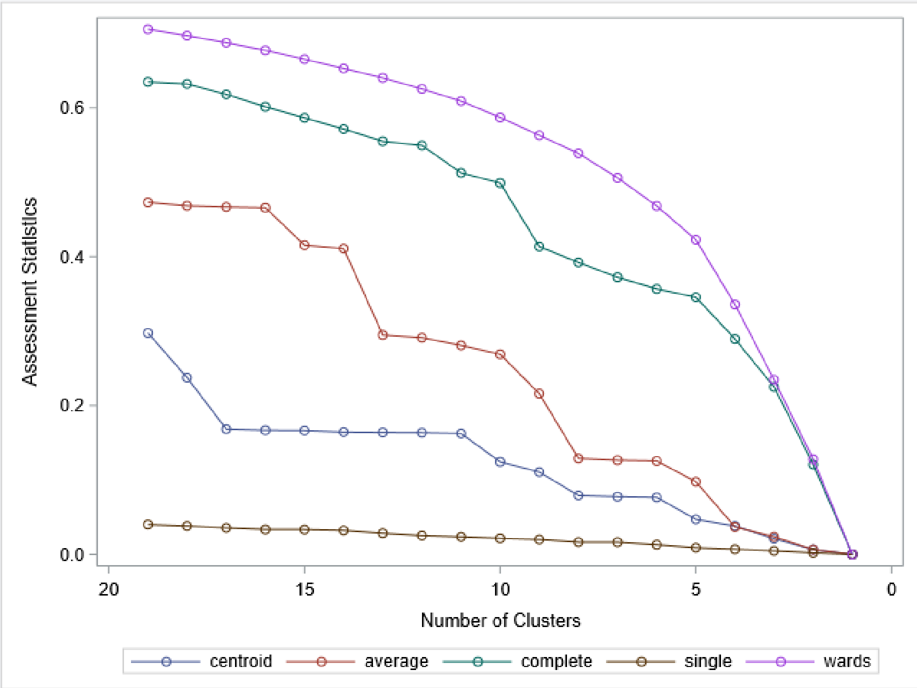

Figure 10. Comparison between hierarchical methods

Figure 11 presents the dendrogram. The horizontal axis represents the citizens, and the vertical axis measures the distance between clusters. We should stop joining clusters when that distance starts to be very significant. Based on the dendrogram, the five-clusters solution seemed appropriate.

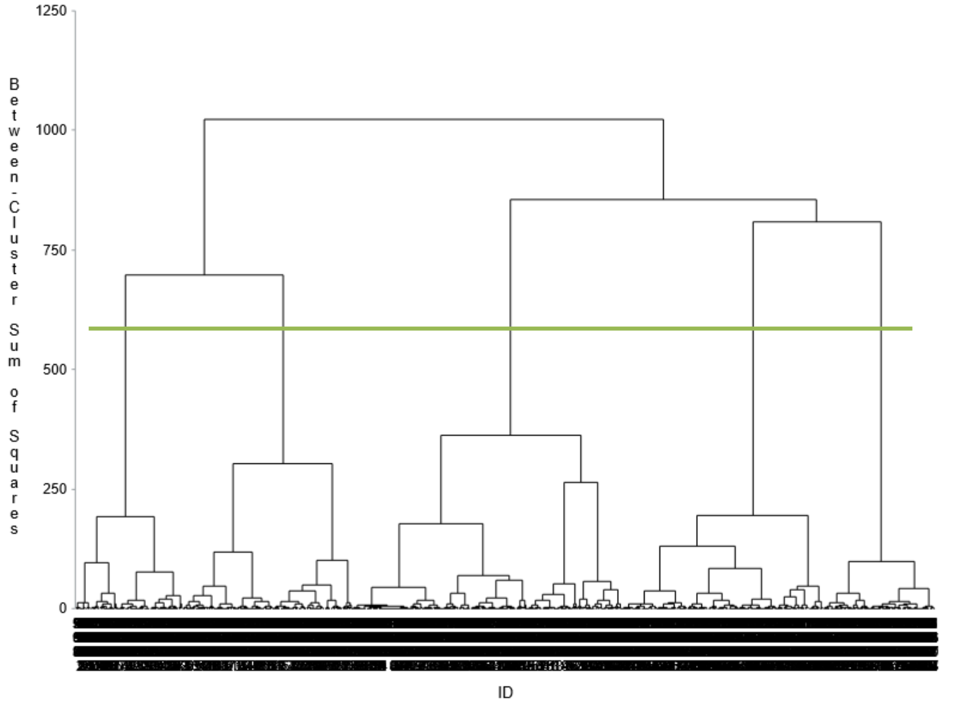

Figure 11. Dendrogram of Wards method

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The non-hierarchical method was analysed using as input the five clusters obtained from the wards method. The non-hierarchical method, namely K-means, is a well-known method that presents a better performance for clustering. K-means solution with five clusters present an R-squared of 55%, and all variables seemed to perform well in segmenting the citizens. Table 16 presents the cluster means for each factor. The results are discussed, along with further cluster analysis, in the next section.

Table 16. Cluster means

Cluster Means				
Cluster	**Feeling of empowerment**	**Environmental activism**	**Knowledge/ Competence**	**Gamification**
1	-0.40	-0.02	-1.40	-0.38
2	0.13	0.75	0.13	0.91
3	0.72	0.48	0.42	-1.03
4	0.69	-1.21	0.00	0.41
5	-1.31	-0.43	0.73	-0.35

7/ Profiling citizens

The final step of segmentation was to characterise the clusters (see Table 17). Since data are standardised, values below 0 mean "below the average", and above 0 means "above the average". Therefore, the clusters were labelled based on the cluster means. Cluster 1 presents all values below the average in all factors. Therefore, it was labelled "**Laggard citizens**". Cluster 2 is the opposite of cluster 1, as it includes all citizens that present high values in terms of empowerment, environmental activism, knowledge/competence and gamification, especially gamification and environmental activism. Therefore, we called this cluster "**Vanguard citizens**". Cluster 3 is characterised by citizens that present values above the average in all variables, except for gamification. It is mainly characterised by high feelings of empowerment and low values for gamification. It was therefore labelled as "**Conservative citizens**". Cluster 4 presents all citizens with the lowest values in terms of environmental activism and high levels in terms of empowerment and gamification. Therefore, it is labelled as "**Accommodated citizens**". Finally, cluster 5 includes all citizens with the highest levels of knowledge/competence but with the lowest in empowerment. We labelled this cluster as "**Passive citizens**".

Table 17. Cluster labels and means

	Cluster Means				
Cluster	**Feeling of empowerment**	**Environmental activism**	**Knowledge/ Competence**	**Gamification**	**Frequency**
Laggard	-0.40	-0.02	-1.40	-0.38	350
Vanguard	0.13	0.75	0.13	0.91	552
Conservative	0.72	0.48	0.42	-1.03	386
Accommodated	0.69	-1.21	0.00	0.41	364
Passive	-1.31	-0.43	0.73	-0.35	351

Finally, clusters should be characterized according to some key variables, such as the level of intention to participate in local energy communities, use behaviour and other socio-demographic variables (see Table 18).

Table 18. Cluster characterization (variables scale 1-7)

Cluster	Participation in local energy communities	Use of sustainable energy solutions	Age	Rural	Urban	Female	Male
Laggard	2.4	2.4	53	17%	18%	19%	16%
Vanguardist	4.8	4.8	47	27%	28%	26%	29%
Conservative	4.2	4.5	48	23%	18%	21%	18%
Accommodated	3.5	3.5	50	14%	20%	17%	20%
Passive	2	3.2	52	19%	17%	18%	18%
				100%	100%	100%	100%

Cluster 1 (Laggard) is the second with the lowest intention to participate in local energy communities. It also presents the lowest use of sustainable energy solutions, which was expected given the lower levels of empowerment, knowledge/competence, and even gamification.

Cluster 2 (Vanguard) is the cluster that includes citizens with the highest intention to participate in local energy communities and with the most significant use of sustainable energy solutions.

Cluster 3 (Conservative) is the second one with the highest intention to participate in local energy communities and the highest use of sustainable energy solutions. The main difference between clusters 2 and 3 is the value of gamification. Cluster 3 considers gamification features as unimportant, being the one with the lowest values on this factor.

Cluster 4 (Accommodated) is the third one in terms of intention to participate in local energy communities and use of sustainable energy solutions. Although the citizens in this cluster feel that participation in local energy communities can create a great sense of empowerment and have an average knowledge/competence in the area, they are the ones whose pro-environmental activities are the lowest. Therefore, the willingness to participate in local energy communities is also somewhat low.

Finally, **cluster 5 (Passive)** is the one with the lowest intention to participate in local energy communities and the second one with the lowest level of use of sustainable energy solutions. In this cluster, citizens are those with the lowest sense of empowerment and very low levels of environmental activism—nevertheless, they present levels of knowledge and competence significantly above the average. Therefore, they are clearly passive citizens who, although knowledgeable, are not practicing their competencies.

Regarding other variables, although age differences are not extremely evident, we can observe from Table 18 that the youngest have the greatest willingness to participate in local energy communities, and the highest use of sustainable energy solutions. Also, as expected, the level of interest in participating in local energy communities is in line with the level of the use of sustainable energy solutions, confirming a relationship between the two. The main differences were found between cluster 3 (conservative) and cluster 4 (accommodated) in terms of area. While 18% of the citizens in urban areas are considered conservative, this percentage increases to 23% when examining rural citizens. Also, 20% of urban citizens are considered accommodated, while only 14% of rural ones are in that cluster. Overall, rural areas are mainly characterized by both vanguard and conservative citizens, while urban areas are mainly characterized by vanguard and accommodated citizens. It is noteworthy that vanguardists are the majority in both areas. In terms of gender, no major differences are found regarding their distribution in the clusters.

Finally, it is also relevant to examine if there is any association between the clusters and the countries under analysis. Table 19 presents the percentage of citizens from each cluster divided by country.

Table 19. Cluster percentages per country

Clusters	Germany	Greece	Italy	Portugal	United Kingdom	Total
Laggard	25%	9%	15%	23%	27%	100%
Vanguardist	17%	22%	24%	19%	18%	100%
Conservative	22%	3%	29%	31%	14%	100%
Accommodated	19%	46%	12%	7%	16%	100%
Passive	17%	19%	17%	20%	27%	100%
Average	20%	20%	20%	20%	20%	100%

By analyzing the table results, we can conclude that the majority of the laggard cluster (1) belong to the UK, followed by Germany and Portugal. Also, UK citizens are the majority in the passive cluster (5). Regarding vanguardists (2), most citizens belong to Italy, followed by Greece. For the conservative one (3), Portugal is the most common country of such citizens, followed by Italy. Finally, there is ample evidence of Greek citizens in the accommodated cluster (4), representing almost half of the cluster. Overall, Germany has comparable percentages in all clusters.

Results suggest that implementations may vary from country to country, and recommendations for each cluster are further described. For example, Italy (and Portugal), show a prominence in vanguardist and conservative cluster, being precisely the ones with higher levels of use of sustainable energy solutions and intention to participate in local energy communities. On the other side, Greece has a strong presence in accommodated cluster. This suggests that individuals, although knowledgeable, do not practice much pro-environmental behaviours. Therefore, in this country, strategies that are more based on ease-of-use and on solutions that does not require much interaction with the user, should have greater success. United Kingdom shows a somewhat high prevalence in the laggards and passive cluster, showing some more difficulties in implementing the solutions. Nevertheless, although it is important to approach laggards and passive citizens, the main point is that a clear profile of citizens more willing to use sustainable energy solution and to participate in local energy communities was identified in all countries. Therefore, the transversal recommendation, to successfully implement the solutions, is to find individuals with the characteristics of vanguardists and/or conservatives: citizens that already perform other pro-environmental behaviours, that are interested in learning about the energy topic and are somewhat knowledgeable, and finally, look for a feeling of empowerment. This aim should be developed along the project implementation – citizens need to feel an increasing sense of meaning, impact and competence as they are participating in the pilots.

8/ Consumer engagement recommendations and plan

This section summarises all outcome implications and recommendations creating a consumer engagement plan, based on the analysis of the participation in local energy communities and segmentation analysis. To notice that the consumer engagement plan regarding consumer behaviour analysis was already analysed in section 2.2.

Regarding the participation model the following recommendations were set:

- The feeling of empowerment is the factor with the most significant impact on the intention to participate in local energy communities → Plan: The citizens need to feel that they are capable of being active energy citizens. For that, engagement actions should promote ease of use and demystify all these topics in a way that citizens may easily feel ready to be part of big projects, such as a local energy community or using energy solutions.

- Also, citizens need to feel that by participating in a local energy community, they have an important role in their community that allows them to have an impact → Plan: Promoting the impact of these communities and the increasing role a citizen can have in an energy market, that is usually governed by big industrial / commercial, entities is essential.

- Pro-environmental behaviour is the second factor with the most significant impact on the intention to participate in local energy communities. In fact, citizens who are already proactive in terms of pro-environmental behaviours are those more open to these types of projects → Plan: Finding individuals who already perform other pro-environmental behaviours, such as participation of local environmental organizations, petitions or even recycling, will facilitate the implementation of the solutions/pilots.

- Finally, participation is only possible through the use of some energy solutions → Plan: Promoting quality of life and wellbeing through the use of energy solutions will also have a positive impact on the intention to be part of a local energy community. Overall, the wellbeing of citizens should never be disregarded, so strategies that promote these solutions through the perspective of being an investment in the quality of life and increase of wellbeing will have a positive effect on the engagement of citizens.

Based on the segmentation results, it is possible to clearly identify the most likely citizens to engage on the proposed solutions, and therefore, target the efforts for each group of citizens. Therefore, it is possible to formulate the following plan:

- The cluster with the highest frequency is the vanguards, and it is also the one with higher levels of use and participation in local energy communities. The cluster with the second-highest frequency and second-highest levels of use and participation is the conservative one. Overall, these clusters are very similar, with the exception of the importance of gamification features in the solutions. Therefore, gamification seems to be an interesting point since it is one of the most robust characteristics of the cluster with higher frequency and interest in participation. However, it also shows that adding gaming features may not only have positive aspects, as there is a conservative group who still present a high level of interest in these communities but do not see much value in having game features → Plan: Gamification features should be carefully planned. If possible, an experiment study should be led to understand the features with greatest impact on citizens.

- The accommodated cluster shows that there is a need to promote these activities such as the use of sustainable energy solutions or the participation in local energy communities as something that does not require too much effort since this set of citizens is somewhat interested in participating but present the lower levels in terms of performing any other pro-environmental behaviour. Again, promoting the feeling of empowerment will have a significant impact on this group, as well as using gamification to simplify and better engage this type of citizen → Plan: Promotion of ease of use and empowerment feeling. Provide information about practicality and reliability of the solutions, installation needs, available features and environmental performance – the creation of workshops, association, collaboration with municipalities.

- Finally, the most complex set of citizens to engage in these types of projects are the laggard and passive ones. These clusters are very similar, except for the knowledge of the energy area. The laggard group is the most concerning one since it shows levels of knowledge far below the average, does not consider gamification features as relevant, and does not feel motivated by feelings of empowerment → Plan: For this group, strategies that involve increasing knowledge and energy literacy may help in their engagement. Once more, education and information provision prove their relevance for the engagement process.

- On the other side, passive citizens may also be challenging to engage since they consider themselves skilful and knowledgeable in the energy area but choose to have low intention to participate in local energy communities → Plan: In this case, financial incentives may be a good strategy since non-financial ones seem to be of low importance.

9/ Conclusion

Given the current environmental problems and therefore a substantial investment in projects and plans towards its mitigations and achievement of sustainability goals, TwinERGY stands out as a means to create more sustainable and sufficient communities, empowering individuals with technologies that will allow them to behave more sustainably, having a positive impact on well-being. Therefore, an analysis of consumer behaviour was needed for both use and participation in local energy communities. Only by understanding the citizen's behaviour it is possible to create an engagement plan. Hence, this report identified several engagement issues related to the consumer behavioural analysis, presented a model to identify the most relevant factors for citizens to participate in local energy communities, and conducted a segmentation analysis to better profile citizens and establish engagement recommendations. The report presents transversal results to all countries under analysis and describes the specificities found in each country, helping to formulate more customised and effective strategies. This task also followed the BRIDGE recommendations. Therefore, the first step was to understand the implications of the consumer behaviour analysis to the engagement process, and therefore better understand citizens and what they value the most. Then, a research model was built to identify the most relevant factors to the intention to participate in local energy communities. Empowerment, pro-environmental behaviour and wellbeing were identified as main factors. Finally, a segmentation analysis was conducted, in which four factors were first identified and then five clusters were created. Laggard, vanguard, conservative, accommodated, and passive groups of citizens were identified.

In conclusion, the participation model suggested the importance of empowering citizens, as well as the relevance of already practising other pro-environmental behaviours to be more willing to participate in a local energy community. Engagement and empowerment are strongly connected so that if citizens feel that by participating in a local energy community, a feeling of empowerment is created, then there is a clear positive intention to participate in such communities. Moreover, there is a clear relationship between sustainable energy solutions and participation, given that, in practice, citizens are only able to participate if they possess some sustainable energy solutions. Thus, the higher the wellbeing caused by those technologies, the higher the intention to be part of an energy community.

Finally, the segmentation analysis proved that both "vanguard" and "conservative" citizens are more interested in participating in local energy communities and using sustainable energy solutions. The "accommodated" group of citizens also shows somewhat high levels of intention to participate and use energy solutions. However, a sense of empowerment should be developed, and the promotion of ease of use since this type of citizen is not typically involved in pro-environmental actions. Finally, the most critical groups are the "laggard" and "passive" ones, whose strategies should be carefully planned, as in the first group education and training can be good strategies, but in the latter one, financial incentives may be a good driver, as the other factors have a low relevance. In conclusion, these results proved that the way we should engage citizens varies a lot, so understanding them through a behavioural analysis will always be relevant. All the above recommendations should then be used when implementing the use cases and pilots and as directives for future implementations.

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Annexes

Annex A - Measurement model Germany

Table 20. Mean, standard deviation, CR and Fornell-Larcker table. The diagonal elements are the square-root of AVE.

	Mean	STD	CR	CS	CP	CL	EN	GA	HM	IP	MN	EC	PW	PE	SAT	SD	SE	UB
CS	4.964	1.123	0.909	**0.817**														
CP	3.713	1.562	0.948	0.192	**0.926**													
CL	5.343	1.236	0.803	0.215	0.258	**0.767**												
EN	2.842	1.562	0.901	0.090	0.488	0.224	**0.833**											
GA	3.283	1.361	0.869	0.136	0.516	0.168	0.504	**0.792**										
HM	4.688	1.428	0.914	0.291	0.508	0.516	0.410	0.425	**0.884**									
IP	3.800	1.567	0.963	0.146	0.695	0.247	0.486	0.540	0.587	**0.947**								
MN	4.011	1.528	0.929	0.182	0.674	0.341	0.483	0.552	0.698	0.820	**0.902**							
EC	3.228	1.708	0.966	0.116	0.573	0.244	0.578	0.513	0.511	0.613	0.711	**0.951**						
PW	3.816	1.620	0.961	0.243	0.591	0.338	0.520	0.501	0.618	0.640	0.644	0.617	**0.928**					
PE	4.226	1.520	0.952	0.294	0.537	0.418	0.471	0.473	0.738	0.556	0.611	0.524	0.655	**0.913**				
SAT	4.633	1.405	0.964	0.268	0.473	0.478	0.414	0.430	0.760	0.546	0.609	0.526	0.632	0.687	**0.933**			
SD	4.779	1.407	0.922	0.325	0.360	0.226	0.173	0.223	0.402	0.410	0.464	0.303	0.363	0.336	0.364	**0.893**		
SE	3.452	1.488	0.886	0.147	0.558	0.379	0.796	0.565	0.502	0.570	0.567	0.606	0.579	0.563	0.503	0.248	**0.849**	
UB	3.595	1.657	0.955	0.207	0.585	0.378	0.512	0.482	0.536	0.518	0.548	0.563	0.715	0.629	0.532	0.323	0.579	**0.936**

Note: *CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour*

Table 21. Loadings and cross-loadings.

	CL	CP	CS	EC	EN	GA	HM	IP	MN	PE	PW	SAT	SD	SE	UB
CL1	**0.539**	-0.029	0.271	-0.029	-0.153	-0.135	0.190	-0.007	0.080	0.077	0.074	0.175	0.208	-0.039	0.030
CL2	**0.753**	0.128	0.234	0.059	0.034	0.027	0.312	0.086	0.146	0.195	0.133	0.277	0.182	0.169	0.220
CL3	**0.953**	0.280	0.169	0.293	0.281	0.210	0.528	0.283	0.378	0.456	0.379	0.495	0.208	0.420	0.393
CP1	0.248	**0.934**	0.185	0.491	0.441	0.434	0.413	0.594	0.561	0.492	0.530	0.382	0.303	0.512	0.559
CP2	0.223	**0.942**	0.165	0.516	0.450	0.494	0.433	0.646	0.597	0.491	0.565	0.402	0.333	0.519	0.552
CP3	0.245	**0.903**	0.181	0.575	0.462	0.500	0.554	0.682	0.701	0.507	0.545	0.517	0.360	0.518	0.518
CS1	0.179	0.145	**0.854**	0.128	0.066	0.143	0.238	0.095	0.163	0.238	0.186	0.219	0.263	0.118	0.133
CS2	0.177	0.159	**0.868**	0.081	0.059	0.092	0.246	0.104	0.155	0.249	0.205	0.220	0.296	0.075	0.200
CS3	0.196	0.190	**0.866**	0.100	0.068	0.113	0.259	0.120	0.170	0.280	0.207	0.258	0.302	0.134	0.186
CS4	0.127	0.148	**0.664**	0.041	0.124	0.083	0.218	0.185	0.120	0.176	0.199	0.185	0.240	0.152	0.151
CS5	0.188	0.152	**0.814**	0.089	0.089	0.105	0.240	0.148	0.129	0.243	0.221	0.213	0.238	0.147	0.201
EC1	0.204	0.524	0.117	**0.958**	0.528	0.487	0.459	0.577	0.671	0.481	0.587	0.492	0.300	0.548	0.522
EC2	0.266	0.543	0.105	**0.939**	0.549	0.485	0.533	0.589	0.704	0.506	0.582	0.514	0.285	0.570	0.525
EC3	0.225	0.565	0.110	**0.956**	0.572	0.492	0.464	0.582	0.653	0.506	0.591	0.494	0.280	0.611	0.560
EN1	0.351	0.417	0.140	0.481	**0.795**	0.405	0.481	0.426	0.479	0.503	0.492	0.473	0.234	0.694	0.471
EN2	0.247	0.341	0.065	0.420	**0.830**	0.346	0.332	0.391	0.385	0.338	0.391	0.323	0.138	0.608	0.364
EN3	0.138	0.423	0.035	0.543	**0.879**	0.442	0.308	0.402	0.388	0.394	0.449	0.319	0.121	0.700	0.450
EN4	-0.001	0.440	0.058	0.472	**0.826**	0.484	0.233	0.396	0.349	0.319	0.389	0.251	0.075	0.641	0.410

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GA1	0.054	0.203	0.146	0.263	0.196	**0.648**	0.267	0.276	0.316	0.242	0.224	0.202	0.163	0.235	0.221
GA2	0.053	0.458	0.054	0.439	0.452	**0.886**	0.256	0.432	0.404	0.361	0.411	0.317	0.094	0.498	0.421
GA3	0.046	0.464	0.031	0.422	0.447	**0.887**	0.257	0.432	0.412	0.353	0.389	0.303	0.103	0.492	0.398
GA4	0.339	0.441	0.212	0.456	0.434	**0.720**	0.538	0.519	0.575	0.496	0.502	0.489	0.338	0.495	0.433
HM1	0.472	0.481	0.305	0.461	0.355	0.387	**0.938**	0.541	0.636	0.679	0.593	0.725	0.388	0.436	0.513
HM2	0.520	0.362	0.281	0.369	0.266	0.278	**0.861**	0.441	0.568	0.627	0.484	0.687	0.378	0.360	0.381
HM3	0.377	0.502	0.182	0.525	0.467	0.461	**0.850**	0.572	0.647	0.649	0.558	0.600	0.298	0.536	0.524
IP1	0.211	0.654	0.136	0.604	0.466	0.510	0.567	**0.946**	0.800	0.518	0.617	0.522	0.396	0.560	0.501
IP2	0.255	0.647	0.142	0.579	0.464	0.490	0.561	**0.958**	0.785	0.531	0.608	0.532	0.399	0.541	0.487
IP3	0.235	0.674	0.136	0.558	0.449	0.534	0.539	**0.938**	0.745	0.531	0.595	0.498	0.368	0.516	0.484
MN1	0.292	0.679	0.157	0.708	0.500	0.575	0.610	0.767	**0.939**	0.572	0.622	0.537	0.385	0.582	0.563
MN2	0.382	0.433	0.185	0.495	0.293	0.346	0.657	0.643	**0.823**	0.500	0.470	0.571	0.489	0.358	0.359
MN3	0.269	0.682	0.159	0.698	0.488	0.546	0.637	0.800	**0.939**	0.578	0.634	0.553	0.403	0.567	0.538
PE1	0.395	0.532	0.301	0.487	0.454	0.469	0.666	0.518	0.576	**0.932**	0.624	0.635	0.321	0.523	0.616
PE2	0.380	0.511	0.260	0.488	0.448	0.452	0.672	0.498	0.545	**0.942**	0.613	0.621	0.292	0.543	0.603
PE3	0.364	0.507	0.242	0.493	0.483	0.452	0.664	0.522	0.558	**0.950**	0.620	0.629	0.284	0.558	0.599
PE4	0.389	0.405	0.270	0.443	0.325	0.349	0.697	0.493	0.553	**0.823**	0.532	0.626	0.336	0.427	0.470
PW1	0.330	0.527	0.262	0.549	0.429	0.394	0.528	0.522	0.545	0.609	**0.870**	0.604	0.381	0.451	0.654
PW2	0.317	0.538	0.213	0.589	0.512	0.472	0.590	0.619	0.610	0.597	**0.951**	0.593	0.325	0.577	0.653
PW3	0.299	0.580	0.214	0.583	0.501	0.514	0.574	0.635	0.620	0.594	**0.946**	0.553	0.296	0.566	0.661
PW4	0.306	0.548	0.213	0.569	0.483	0.479	0.600	0.599	0.613	0.630	**0.942**	0.593	0.347	0.551	0.683
SAT1	0.467	0.440	0.289	0.499	0.387	0.381	0.737	0.517	0.584	0.671	0.596	**0.934**	0.354	0.479	0.502
SAT2	0.452	0.448	0.249	0.498	0.389	0.415	0.719	0.511	0.576	0.653	0.615	**0.945**	0.371	0.471	0.530
SAT3	0.411	0.452	0.224	0.490	0.390	0.406	0.689	0.496	0.557	0.614	0.583	**0.944**	0.325	0.460	0.481
SAT4	0.450	0.424	0.236	0.475	0.377	0.405	0.689	0.513	0.555	0.621	0.562	**0.909**	0.306	0.466	0.468
SD1	0.183	0.296	0.291	0.232	0.100	0.144	0.333	0.337	0.372	0.274	0.281	0.310	**0.881**	0.148	0.206
SD2	0.230	0.394	0.301	0.337	0.230	0.266	0.420	0.455	0.507	0.352	0.393	0.379	**0.929**	0.301	0.355
SD3	0.183	0.240	0.278	0.212	0.094	0.159	0.296	0.260	0.318	0.253	0.270	0.260	**0.868**	0.180	0.282
SE1	0.507	0.425	0.189	0.453	0.572	0.416	0.536	0.470	0.512	0.507	0.475	0.498	0.304	**0.825**	0.491
SE2	0.346	0.550	0.154	0.546	0.663	0.499	0.464	0.539	0.526	0.545	0.550	0.474	0.237	**0.909**	0.532
SE3	0.114	0.441	0.031	0.544	0.793	0.524	0.279	0.439	0.404	0.380	0.445	0.308	0.091	**0.811**	0.449
UB1	0.373	0.509	0.229	0.496	0.474	0.421	0.517	0.475	0.522	0.561	0.666	0.518	0.289	0.527	**0.903**
UB2	0.373	0.554	0.186	0.531	0.465	0.453	0.515	0.481	0.508	0.610	0.670	0.504	0.322	0.539	**0.955**
UB3	0.315	0.580	0.170	0.554	0.498	0.478	0.475	0.501	0.510	0.595	0.671	0.473	0.297	0.559	**0.950**

Note: *CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour*

Table 22. Heterotrait-Monotrait ratio (HTMT).

	CS	**CP**	**CL**	**EN**	**GA**	**HM**	**IP**	**MN**	**EC**	**PW**	**PE**	**SAT**	**SD**	**SE**	**UB**
CS															
CP	0.215														
CL	0.334	0.215													
EN	0.114	0.549	0.285												
GA	0.160	0.577	0.241	0.586											
HM	0.336	0.567	0.524	0.476	0.504										
IP	0.175	0.744	0.186	0.541	0.606	0.652									
MN	0.206	0.731	0.315	0.543	0.633	0.808	0.894								
EC	0.118	0.611	0.184	0.640	0.576	0.567	0.648	0.768							
PW	0.272	0.634	0.284	0.576	0.557	0.685	0.678	0.698	0.652						
PE	0.320	0.578	0.357	0.521	0.532	0.827	0.594	0.673	0.557	0.698					
SAT	0.292	0.501	0.457	0.456	0.477	0.840	0.577	0.670	0.554	0.666	0.731				
SD	0.370	0.384	0.299	0.180	0.252	0.450	0.431	0.516	0.319	0.386	0.364	0.387			
SE	0.182	0.647	0.411	0.959	0.680	0.606	0.653	0.661	0.694	0.662	0.648	0.575	0.279		
UB	0.236	0.634	0.317	0.572	0.541	0.600	0.554	0.596	0.600	0.763	0.674	0.566	0.348	0.669	

Note: *CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour.*

*Table 23. Measurement model evaluation for second-order formative construct. Note: *p<0.10; **p<0.05; ***p<0.01*

		VIF	Weights
Empowerment	Competence	2.072	0.233***
	Impact	3.454	0.029
	Meaning	3.442	0.829***
	Self-determination	1.282	-0.062

*Table 24. Measurement model evaluation for second-order formative construct. Note: *p<0.10; **p<0.05; ***p<0.01. PEB – Pro-environmental behaviour*

		VIF	Weights
PEB	Conservation lifestyle	1.191	0.195***
	Environmental citizenship	2.783	0.367***
	Social environmentalism	3.087	0.595***

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Annex B - Measurement model Greece

Table 25. Mean, standard deviation, CR and Fornell-Larcker table. The diagonal elements are the square-root of AVE.

	Mean	STD	CR	CS	CP	CL	EN	GA	HM	IP	MN	EC	PW	PE	SAT	SD	SE	UB
CS	5.213	1.171	0.925	**0.843**														
CP	4.298	1.539	0.953	0.302	**0.934**													
CL	5.482	1.093	0.844	0.273	0.303	**0.805**												
EN	2.568	1.568	0.917	0.158	0.419	0.296	**0.857**											
GA	4.677	1.377	0.881	0.204	0.487	0.225	0.350	**0.809**										
HM	5.214	1.247	0.962	0.315	0.482	0.473	0.264	0.381	**0.946**									
IP	4.015	1.531	0.965	0.248	0.668	0.255	0.432	0.513	0.400	**0.950**								
MN	4.471	1.531	0.969	0.227	0.665	0.353	0.409	0.585	0.478	0.758	**0.955**							
EC	3.693	1.801	0.984	0.177	0.594	0.281	0.524	0.479	0.346	0.628	0.668	**0.977**						
PW	4.054	1.673	0.963	0.335	0.527	0.369	0.460	0.443	0.497	0.486	0.535	0.611	**0.931**					
PE	5.134	1.250	0.950	0.294	0.389	0.505	0.257	0.368	0.690	0.327	0.416	0.285	0.512	**0.909**				
SAT	4.828	1.310	0.980	0.347	0.453	0.505	0.375	0.427	0.649	0.367	0.473	0.388	0.624	0.690	**0.961**			
SD	4.498	1.330	0.893	0.305	0.517	0.284	0.327	0.310	0.348	0.603	0.470	0.428	0.421	0.348	0.337	**0.859**		
SE	3.438	1.700	0.946	0.302	0.553	0.471	0.725	0.413	0.369	0.549	0.539	0.607	0.609	0.369	0.458	0.404	**0.924**	
UB	3.807	1.670	0.970	0.353	0.496	0.453	0.448	0.334	0.450	0.417	0.438	0.476	0.719	0.441	0.572	0.391	0.564	**0.956**

Note: *CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour*

Table 26. Loadings and cross-loadings.

	CL	CP	CS	EC	EN	GA	HM	IP	MN	PE	PW	SAT	SD	SE	UB
CL1	**0.655**	0.120	0.211	0.102	0.062	0.048	0.300	0.046	0.156	0.318	0.142	0.317	0.134	0.176	0.190
CL2	**0.840**	0.214	0.222	0.181	0.206	0.094	0.409	0.145	0.226	0.446	0.253	0.382	0.268	0.352	0.333
CL3	**0.898**	0.332	0.237	0.324	0.349	0.309	0.420	0.328	0.396	0.445	0.413	0.489	0.256	0.507	0.484
CP1	0.238	**0.888**	0.288	0.496	0.383	0.431	0.414	0.555	0.579	0.325	0.466	0.383	0.467	0.504	0.432
CP2	0.295	**0.955**	0.280	0.579	0.392	0.464	0.454	0.651	0.629	0.350	0.492	0.423	0.476	0.520	0.466
CP3	0.312	**0.957**	0.280	0.585	0.399	0.467	0.481	0.659	0.654	0.412	0.518	0.459	0.504	0.526	0.489
CS1	0.319	0.254	**0.804**	0.149	0.089	0.183	0.331	0.194	0.215	0.294	0.301	0.332	0.246	0.251	0.266
CS2	0.222	0.234	**0.866**	0.160	0.177	0.189	0.241	0.196	0.172	0.231	0.288	0.301	0.238	0.293	0.317
CS3	0.220	0.256	**0.852**	0.126	0.122	0.196	0.294	0.231	0.172	0.300	0.278	0.332	0.266	0.248	0.323
CS4	0.169	0.286	**0.860**	0.172	0.149	0.160	0.224	0.237	0.223	0.189	0.261	0.230	0.275	0.250	0.278
CS5	0.228	0.239	**0.833**	0.128	0.120	0.133	0.248	0.183	0.165	0.243	0.286	0.281	0.262	0.224	0.313
EC1	0.262	0.576	0.193	**0.980**	0.496	0.471	0.343	0.613	0.662	0.272	0.591	0.376	0.410	0.580	0.458
EC2	0.264	0.580	0.163	**0.980**	0.528	0.473	0.334	0.615	0.656	0.275	0.605	0.381	0.419	0.601	0.467
EC3	0.297	0.585	0.163	**0.970**	0.512	0.458	0.336	0.613	0.639	0.288	0.594	0.379	0.426	0.598	0.469
EN1	0.167	0.401	0.146	0.468	**0.847**	0.313	0.182	0.379	0.323	0.154	0.406	0.261	0.263	0.629	0.376
EN2	0.345	0.344	0.132	0.433	**0.816**	0.271	0.228	0.368	0.359	0.241	0.334	0.344	0.339	0.609	0.336
EN3	0.302	0.337	0.119	0.445	**0.868**	0.306	0.260	0.353	0.377	0.255	0.417	0.337	0.258	0.623	0.415
EN4	0.201	0.354	0.145	0.450	**0.893**	0.309	0.234	0.380	0.344	0.229	0.418	0.342	0.262	0.623	0.403
GA1	0.273	0.254	0.298	0.273	0.130	**0.642**	0.324	0.303	0.365	0.349	0.296	0.350	0.214	0.256	0.238
GA2	0.126	0.462	0.123	0.467	0.373	**0.925**	0.272	0.485	0.537	0.230	0.384	0.319	0.292	0.393	0.290

GA3	0.141	0.473	0.122	0.471	0.383	**0.927**	0.281	0.485	0.538	0.239	0.399	0.328	0.286	0.398	0.296
GA4	0.283	0.341	0.202	0.282	0.158	**0.699**	0.442	0.349	0.435	0.502	0.360	0.466	0.195	0.254	0.263
HM1	0.450	0.455	0.322	0.300	0.193	0.361	**0.937**	0.373	0.449	0.653	0.443	0.590	0.325	0.312	0.409
HM2	0.471	0.446	0.303	0.342	0.262	0.355	**0.966**	0.384	0.466	0.675	0.481	0.635	0.340	0.368	0.422
HM3	0.421	0.468	0.271	0.338	0.291	0.366	**0.934**	0.377	0.442	0.631	0.485	0.616	0.323	0.366	0.446
IP1	0.235	0.648	0.227	0.617	0.419	0.513	0.381	**0.959**	0.735	0.318	0.451	0.340	0.547	0.530	0.361
IP2	0.247	0.635	0.230	0.586	0.410	0.478	0.385	**0.962**	0.738	0.328	0.465	0.350	0.565	0.531	0.405
IP3	0.246	0.619	0.249	0.586	0.400	0.469	0.373	**0.927**	0.685	0.284	0.470	0.356	0.606	0.504	0.424
MN1	0.339	0.638	0.220	0.643	0.397	0.564	0.475	0.709	**0.960**	0.382	0.520	0.468	0.460	0.506	0.406
MN2	0.339	0.614	0.188	0.598	0.387	0.560	0.445	0.692	**0.955**	0.404	0.474	0.441	0.415	0.507	0.388
MN3	0.332	0.652	0.239	0.672	0.389	0.553	0.449	0.768	**0.950**	0.405	0.536	0.445	0.471	0.532	0.460
PE1	0.445	0.311	0.241	0.206	0.198	0.305	0.583	0.259	0.348	**0.884**	0.383	0.550	0.292	0.277	0.350
PE2	0.470	0.403	0.292	0.294	0.279	0.344	0.644	0.332	0.418	**0.930**	0.540	0.670	0.338	0.387	0.467
PE3	0.489	0.402	0.286	0.307	0.277	0.367	0.664	0.340	0.409	**0.944**	0.532	0.684	0.343	0.398	0.460
PE4	0.431	0.282	0.243	0.213	0.161	0.317	0.614	0.242	0.324	**0.878**	0.378	0.591	0.283	0.255	0.302
PW1	0.361	0.474	0.360	0.505	0.393	0.400	0.459	0.396	0.448	0.479	**0.915**	0.600	0.367	0.528	0.694
PW2	0.311	0.512	0.296	0.607	0.473	0.428	0.457	0.510	0.538	0.439	**0.919**	0.555	0.392	0.592	0.639
PW3	0.349	0.507	0.301	0.619	0.454	0.438	0.467	0.489	0.529	0.457	**0.951**	0.569	0.410	0.601	0.673
PW4	0.355	0.469	0.291	0.540	0.393	0.381	0.466	0.413	0.474	0.531	**0.936**	0.600	0.397	0.544	0.670
SAT1	0.482	0.437	0.345	0.376	0.352	0.426	0.633	0.359	0.473	0.705	0.625	**0.943**	0.311	0.457	0.576
SAT2	0.514	0.455	0.322	0.394	0.361	0.416	0.641	0.358	0.473	0.675	0.622	**0.971**	0.324	0.450	0.557
SAT3	0.449	0.423	0.328	0.355	0.361	0.407	0.600	0.352	0.428	0.627	0.578	**0.968**	0.332	0.424	0.535
SAT4	0.493	0.423	0.336	0.363	0.366	0.393	0.619	0.341	0.440	0.642	0.569	**0.962**	0.327	0.426	0.527
SD1	0.251	0.522	0.248	0.486	0.342	0.318	0.279	0.679	0.498	0.274	0.418	0.312	**0.897**	0.415	0.404
SD2	0.241	0.436	0.267	0.324	0.290	0.242	0.348	0.468	0.381	0.316	0.348	0.294	**0.911**	0.335	0.316
SD3	0.248	0.332	0.294	0.226	0.167	0.217	0.286	0.309	0.278	0.336	0.292	0.254	**0.760**	0.255	0.254
SE1	0.496	0.510	0.284	0.551	0.588	0.385	0.401	0.511	0.508	0.385	0.584	0.454	0.379	**0.919**	0.527
SE2	0.464	0.502	0.281	0.566	0.663	0.391	0.348	0.509	0.515	0.363	0.582	0.441	0.389	**0.954**	0.529
SE3	0.343	0.522	0.270	0.566	0.758	0.368	0.273	0.503	0.471	0.273	0.521	0.373	0.352	**0.897**	0.505
UB1	0.471	0.459	0.353	0.454	0.417	0.288	0.454	0.376	0.405	0.433	0.703	0.565	0.386	0.538	**0.958**
UB2	0.427	0.448	0.327	0.426	0.398	0.308	0.432	0.371	0.417	0.438	0.663	0.544	0.352	0.503	**0.960**
UB3	0.403	0.514	0.332	0.484	0.467	0.359	0.406	0.447	0.436	0.397	0.695	0.531	0.383	0.574	**0.950**

Note: *CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour*

Table 27. Heterotrait-Monotrait Ratio (HTMT).

	CS	CP	CL	EN	GA	HM	IP	MN	EC	PW	PE	SAT	SD	SE	UB
CS															
CP	0.331														
CL	0.340	0.329													
EN	0.176	0.465	0.327												
GA	0.268	0.542	0.327	0.380											
HM	0.346	0.516	0.556	0.289	0.464										
IP	0.268	0.712	0.254	0.474	0.569	0.424									
MN	0.242	0.707	0.381	0.448	0.656	0.505	0.798								
EC	0.186	0.624	0.294	0.566	0.516	0.360	0.654	0.693							
PW	0.364	0.562	0.396	0.503	0.504	0.526	0.513	0.562	0.634						
PE	0.324	0.412	0.598	0.278	0.466	0.736	0.344	0.438	0.294	0.537					
SAT	0.374	0.475	0.574	0.406	0.506	0.677	0.383	0.490	0.397	0.649	0.720				
SD	0.363	0.569	0.352	0.363	0.360	0.399	0.637	0.504	0.445	0.462	0.406	0.371			
SE	0.331	0.602	0.517	0.810	0.464	0.397	0.591	0.578	0.643	0.654	0.393	0.485	0.447		
UB	0.383	0.527	0.492	0.488	0.380	0.475	0.439	0.459	0.493	0.756	0.462	0.593	0.423	0.603	

Note: *CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour*

*Table 28. Measurement model evaluation for second-order formative construct . Note: *p<0.10; **p<0.05; ***p<0.01*

		VIF	Weights
Empowerment	Competence	2.103	0.282***
	Impact	3.047	0.266**
	Meaning	2.637	0.58***
	Self-determination	1.634	0.048

*Table 29. Measurement model evaluation for second-order formative construct. Note: *p<0.10; **p<0.05; ***p<0.01. PEB – Pro-environmental behaviour*

		VIF	Weights
PEB	Conservation lifestyle	1.292	0.208***
	Environmental citizenship	2.12	0.235***
	Social environmentalism	2.485	0.702***

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Annex C - Measurement model Italy

Table 30. Mean, standard deviation, CR and Fornell-Larcker table. The diagonal elements are the square-root of AVE.

	Mean	STD	CR	CS	CP	CL	EN	GA	HM	IP	MN	EC	PW	PE	SAT	SD	SE	UB
CS	5.186	1.049	0.906	**0.812**														
CP	4.440	1.476	0.958	0.408	**0.94**													
CL	5.248	1.254	0.774	0.433	0.533	**0.752**												
EN	4.033	1.578	0.908	0.295	0.619	0.553	**0.844**											
GA	4.166	1.246	0.826	0.345	0.603	0.452	0.575	**0.742**										
HM	5.058	1.349	0.961	0.476	0.596	0.571	0.501	0.504	**0.944**									
IP	4.331	1.562	0.965	0.364	0.781	0.531	0.646	0.67	0.628	**0.95**								
MN	4.628	1.536	0.976	0.402	0.748	0.559	0.643	0.653	0.648	0.874	**0.965**							
EC	4.022	1.772	0.988	0.374	0.651	0.504	0.61	0.533	0.556	0.731	0.753	**0.982**						
PW	4.375	1.629	0.981	0.411	0.672	0.618	0.592	0.539	0.664	0.693	0.682	0.674	**0.963**					
PE	4.928	1.430	0.963	0.482	0.625	0.624	0.562	0.543	0.806	0.654	0.703	0.6	0.721	**0.931**				
SAT	4.824	1.409	0.959	0.451	0.607	0.615	0.508	0.554	0.698	0.591	0.612	0.545	0.712	0.747	**0.925**			
SD	4.440	1.477	0.951	0.373	0.76	0.477	0.631	0.634	0.572	0.812	0.753	0.67	0.672	0.597	0.531	**0.93**		
SE	4.094	1.579	0.92	0.312	0.659	0.629	0.831	0.581	0.525	0.69	0.688	0.644	0.641	0.613	0.57	0.628	**0.89**	
UB	4.201	1.684	0.977	0.414	0.683	0.617	0.622	0.529	0.632	0.662	0.642	0.679	0.82	0.712	0.69	0.625	0.667	**0.967**

Note: *CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour*

Table 31. Loadings and cross-loadings.

	CL	CP	CS	EC	EN	GA	HM	IP	MN	PE	PW	SAT	SD	SE	UB
CL1	**0.333**	0.067	0.276	-0.006	0.001	0.019	0.208	0.055	0.142	0.183	0.078	0.109	0.045	0.021	0.034
CL2	**0.877**	0.447	0.384	0.424	0.426	0.374	0.461	0.436	0.441	0.508	0.513	0.514	0.400	0.533	0.554
CL3	**0.903**	0.511	0.375	0.489	0.570	0.442	0.550	0.518	0.555	0.602	0.597	0.587	0.459	0.603	0.561
CP1	0.442	**0.914**	0.356	0.558	0.566	0.567	0.491	0.706	0.642	0.519	0.624	0.548	0.708	0.603	0.641
CP2	0.511	**0.964**	0.380	0.629	0.594	0.573	0.574	0.757	0.715	0.588	0.623	0.566	0.729	0.634	0.646
CP3	0.547	**0.942**	0.411	0.646	0.584	0.563	0.611	0.740	0.749	0.651	0.649	0.596	0.709	0.623	0.642
CS1	0.394	0.385	**0.754**	0.330	0.246	0.334	0.429	0.313	0.380	0.415	0.358	0.386	0.380	0.238	0.312
CS2	0.364	0.333	**0.859**	0.327	0.271	0.280	0.408	0.336	0.350	0.411	0.373	0.418	0.298	0.286	0.402
CS3	0.377	0.356	**0.844**	0.341	0.304	0.278	0.354	0.302	0.327	0.380	0.364	0.392	0.332	0.333	0.399
CS4	0.257	0.260	**0.783**	0.255	0.188	0.252	0.325	0.242	0.266	0.344	0.241	0.270	0.237	0.205	0.257
CS5	0.339	0.292	**0.814**	0.232	0.146	0.238	0.412	0.264	0.283	0.398	0.299	0.330	0.234	0.167	0.275
EC1	0.488	0.625	0.354	**0.981**	0.583	0.527	0.538	0.701	0.736	0.582	0.648	0.535	0.647	0.617	0.659
EC2	0.506	0.648	0.384	**0.981**	0.614	0.530	0.548	0.727	0.742	0.598	0.678	0.549	0.656	0.653	0.682
EC3	0.491	0.645	0.362	**0.983**	0.599	0.514	0.551	0.723	0.738	0.587	0.659	0.520	0.671	0.628	0.66
EN1	0.572	0.497	0.326	0.528	**0.815**	0.480	0.552	0.539	0.610	0.583	0.533	0.527	0.476	0.667	0.546
EN2	0.450	0.473	0.245	0.464	**0.853**	0.420	0.428	0.520	0.540	0.482	0.446	0.367	0.504	0.654	0.461
EN3	0.444	0.561	0.227	0.543	**0.860**	0.500	0.362	0.572	0.523	0.431	0.545	0.415	0.583	0.742	0.565
EN4	0.397	0.552	0.195	0.518	**0.848**	0.534	0.349	0.546	0.498	0.402	0.468	0.399	0.562	0.739	0.521
GA1	0.340	0.421	0.301	0.352	0.329	**0.728**	0.365	0.459	0.441	0.376	0.346	0.406	0.445	0.342	0.308
GA2	0.225	0.463	0.153	0.401	0.462	**0.839**	0.264	0.508	0.437	0.306	0.379	0.361	0.489	0.463	0.408
GA3	0.207	0.466	0.136	0.400	0.489	**0.842**	0.264	0.517	0.451	0.295	0.364	0.359	0.506	0.472	0.388
GA4	0.552	0.409	0.423	0.400	0.387	**0.511**	0.580	0.468	0.575	0.606	0.482	0.491	0.408	0.410	0.433
HM1	0.559	0.556	0.450	0.526	0.462	0.479	**0.943**	0.581	0.588	0.752	0.620	0.665	0.523	0.490	0.605
HM2	0.537	0.534	0.462	0.501	0.458	0.435	**0.941**	0.567	0.607	0.795	0.617	0.648	0.522	0.481	0.572
HM3	0.522	0.597	0.436	0.546	0.499	0.512	**0.948**	0.630	0.639	0.736	0.644	0.663	0.575	0.516	0.611
IP1	0.516	0.728	0.353	0.716	0.616	0.623	0.625	**0.937**	0.901	0.666	0.654	0.553	0.744	0.657	0.614

IP2	0.503	0.757	0.339	0.696	0.617	0.647	0.587	**0.966**	0.812	0.599	0.648	0.556	0.785	0.659	0.644
IP3	0.492	0.741	0.344	0.667	0.606	0.638	0.577	**0.946**	0.772	0.597	0.674	0.576	0.785	0.650	0.629
MN1	0.548	0.713	0.397	0.733	0.615	0.629	0.642	0.829	**0.971**	0.689	0.648	0.601	0.715	0.661	0.609
MN2	0.543	0.709	0.398	0.716	0.598	0.620	0.620	0.834	**0.971**	0.680	0.636	0.591	0.712	0.644	0.603
MN3	0.529	0.745	0.370	0.731	0.650	0.642	0.613	0.868	**0.954**	0.667	0.69	0.581	0.752	0.689	0.646
PE1	0.568	0.597	0.455	0.557	0.549	0.490	0.742	0.617	0.672	**0.932**	0.697	0.707	0.537	0.601	0.703
PE2	0.604	0.609	0.448	0.590	0.556	0.541	0.750	0.643	0.671	**0.949**	0.691	0.712	0.595	0.606	0.683
PE3	0.599	0.61	0.453	0.592	0.534	0.526	0.753	0.647	0.672	**0.953**	0.690	0.706	0.584	0.589	0.689
PE4	0.550	0.505	0.437	0.486	0.448	0.462	0.759	0.521	0.598	**0.889**	0.598	0.656	0.501	0.476	0.565
PW1	0.581	0.633	0.409	0.631	0.544	0.497	0.640	0.632	0.642	0.702	**0.949**	0.719	0.608	0.598	0.809
PW2	0.608	0.655	0.410	0.651	0.579	0.539	0.646	0.672	0.671	0.696	**0.972**	0.678	0.649	0.617	0.788
PW3	0.585	0.648	0.374	0.65	0.585	0.530	0.622	0.691	0.644	0.670	**0.954**	0.648	0.679	0.637	0.758
PW4	0.605	0.651	0.387	0.664	0.572	0.512	0.648	0.676	0.668	0.706	**0.975**	0.695	0.653	0.618	0.801
SAT1	0.560	0.614	0.456	0.539	0.503	0.512	0.714	0.606	0.644	0.764	0.719	**0.909**	0.552	0.560	0.686
SAT2	0.575	0.563	0.439	0.495	0.480	0.504	0.613	0.538	0.549	0.685	0.630	**0.945**	0.465	0.528	0.630
SAT3	0.562	0.540	0.367	0.492	0.455	0.512	0.615	0.520	0.532	0.644	0.635	**0.926**	0.469	0.524	0.614
SAT4	0.576	0.517	0.397	0.481	0.434	0.519	0.625	0.512	0.526	0.659	0.639	**0.919**	0.470	0.490	0.612
SD1	0.443	0.728	0.348	0.639	0.611	0.610	0.519	0.783	0.736	0.568	0.638	0.497	**0.948**	0.619	0.603
SD2	0.475	0.739	0.355	0.660	0.623	0.634	0.556	0.815	0.751	0.582	0.667	0.538	**0.950**	0.628	0.602
SD3	0.410	0.648	0.339	0.566	0.518	0.516	0.522	0.654	0.601	0.510	0.564	0.442	**0.891**	0.498	0.534
SE1	0.624	0.551	0.331	0.570	0.693	0.535	0.513	0.617	0.648	0.601	0.574	0.528	0.533	**0.871**	0.589
SE2	0.602	0.610	0.290	0.560	0.749	0.493	0.477	0.624	0.611	0.570	0.601	0.521	0.572	**0.934**	0.633
SE3	0.450	0.599	0.212	0.592	0.780	0.526	0.411	0.602	0.579	0.463	0.536	0.473	0.574	**0.865**	0.559
UB1	0.595	0.654	0.411	0.643	0.592	0.526	0.618	0.633	0.624	0.709	0.800	0.684	0.596	0.656	**0.964**
UB2	0.616	0.658	0.410	0.653	0.599	0.497	0.615	0.633	0.611	0.683	0.792	0.666	0.608	0.629	**0.975**
UB3	0.577	0.669	0.381	0.674	0.614	0.512	0.598	0.655	0.625	0.672	0.785	0.650	0.608	0.650	**0.961**

Note: *CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour*

Table 32. Heterotrait-Monotrait ratio (HTMT).

	CS	CP	CL	EN	GA	HM	IP	MN	EC	PW	PE	SAT	SD	SE	UB
CS															
CP	0.443														
CL	0.606	0.590													
EN	0.327	0.686	0.676												
GA	0.436	0.741	0.734	0.727											
HM	0.525	0.634	0.696	0.556	0.617										
IP	0.395	0.831	0.573	0.712	0.817	0.666									
MN	0.432	0.787	0.641	0.704	0.789	0.681	0.913								
EC	0.395	0.679	0.514	0.660	0.638	0.579	0.758	0.774							
PW	0.437	0.705	0.666	0.643	0.647	0.694	0.723	0.704	0.690						
PE	0.528	0.660	0.735	0.618	0.661	0.856	0.688	0.734	0.620	0.748					
SAT	0.486	0.643	0.689	0.558	0.677	0.738	0.623	0.638	0.564	0.740	0.786				
SD	0.407	0.817	0.521	0.702	0.780	0.615	0.865	0.794	0.703	0.707	0.636	0.565			
SE	0.347	0.732	0.737	0.958	0.737	0.581	0.762	0.753	0.699	0.697	0.672	0.628	0.699		
UB	0.442	0.720	0.650	0.679	0.636	0.663	0.693	0.665	0.698	0.845	0.741	0.720	0.661	0.728	

Note: *CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour. HTMT confidence interval for Impact and Meaning: 0.880-0.942; HTMT confidence interval for Social environmentalism and Environmental citizenship: 0.922 – 0.992.*

Twinergy has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957736

*Table 33. Measurement model evaluation for second-order formative construct. Note: *p<0.10; **p<0.05; ***p<0.01*

		VIF	Weights
Empowerment	Competence	3.009	0.115
	Impact	5.802	0.219**
	Meaning	4.465	0.558***
	Self-determination	3.351	0.179**

*Table 34. Measurement model evaluation for second-order formative construct. Note: *p<0.10; **p<0.05; ***p<0.01. PEB – Pro-environmental behaviour*

		VIF	Weights
PEB	Conservation lifestyle	1.662	0.342***
	Environmental citizenship	3.254	0.297***
	Social environmentalism	3.739	0.481***

Twinergy has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957736

Annex D - Measurement model Portugal

Table 35. Mean, standard deviation, CR and Fornell-Larcker table. The diagonal elements are the square-root of AVE.

	Mean	STD	CR	CS	CP	CL	EN	GA	HM	IP	MN	EC	PW	PE	SAT	SD	SE	UB
CS	5.157	1.236	0.929	**0.851**														
CP	4.221	1.583	0.969	0.311	**0.956**													
CL	5.681	1.060	0.841	0.366	0.301	**0.800**												
EN	3.887	1.474	0.877	0.259	0.503	0.507	**0.801**											
GA	3.771	1.259	0.842	0.320	0.517	0.255	0.493	**0.759**										
HM	5.328	1.231	0.949	0.337	0.482	0.426	0.434	0.348	**0.928**									
IP	4.019	1.587	0.955	0.350	0.687	0.388	0.596	0.571	0.461	**0.937**								
MN	4.407	1.595	0.979	0.398	0.691	0.425	0.565	0.571	0.497	0.827	**0.970**							
EC	3.676	1.823	0.983	0.286	0.537	0.300	0.553	0.494	0.425	0.634	0.660	**0.976**						
PW	4.825	1.435	0.943	0.412	0.500	0.406	0.498	0.451	0.566	0.544	0.511	0.567	**0.897**					
PE	5.052	1.297	0.958	0.409	0.523	0.419	0.437	0.352	0.656	0.461	0.472	0.407	0.636	**0.922**				
SAT	4.723	1.312	0.97	0.343	0.515	0.355	0.412	0.362	0.587	0.450	0.408	0.372	0.542	0.660	**0.944**			
SD	4.505	1.535	0.94	0.321	0.626	0.360	0.474	0.401	0.453	0.657	0.561	0.502	0.464	0.458	0.416	**0.916**		
SE	4.124	1.467	0.904	0.272	0.541	0.570	0.808	0.527	0.450	0.621	0.620	0.550	0.495	0.446	0.445	0.457	**0.871**	
UB	3.814	1.738	0.974	0.418	0.540	0.411	0.537	0.436	0.443	0.540	0.505	0.531	0.626	0.574	0.561	0.498	0.535	**0.963**

Note: *CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour*

Table 36. Loadings and cross-loadings.

	CL	CP	CS	EC	EN	GA	HM	IP	MN	PE	PW	SAT	SD	SE	UB
CL1	**0.723**	0.115	0.240	0.123	0.257	0.114	0.306	0.177	0.226	0.230	0.243	0.235	0.174	0.303	0.218
CL2	**0.785**	0.240	0.261	0.219	0.337	0.151	0.331	0.276	0.308	0.312	0.267	0.286	0.259	0.411	0.319
CL3	**0.884**	0.316	0.355	0.325	0.546	0.295	0.380	0.415	0.434	0.419	0.421	0.320	0.378	0.584	0.407
CP1	0.293	**0.933**	0.311	0.509	0.490	0.508	0.471	0.660	0.642	0.520	0.482	0.501	0.598	0.515	0.543
CP2	0.282	**0.969**	0.290	0.507	0.469	0.482	0.448	0.644	0.656	0.495	0.481	0.481	0.587	0.513	0.503
CP3	0.288	**0.964**	0.290	0.524	0.482	0.491	0.463	0.666	0.680	0.486	0.470	0.493	0.609	0.522	0.501
CS1	0.421	0.223	**0.725**	0.202	0.176	0.210	0.348	0.224	0.255	0.368	0.390	0.316	0.238	0.220	0.306
CS2	0.317	0.280	**0.899**	0.236	0.252	0.300	0.267	0.322	0.366	0.354	0.334	0.297	0.288	0.237	0.398
CS3	0.304	0.283	**0.908**	0.267	0.255	0.315	0.251	0.327	0.380	0.344	0.360	0.302	0.267	0.257	0.396
CS4	0.234	0.285	**0.869**	0.276	0.231	0.296	0.289	0.330	0.367	0.323	0.342	0.267	0.285	0.229	0.368
CS5	0.319	0.244	**0.841**	0.225	0.178	0.227	0.299	0.273	0.310	0.369	0.338	0.289	0.285	0.212	0.302
EC1	0.300	0.545	0.261	**0.969**	0.516	0.472	0.425	0.625	0.652	0.394	0.550	0.353	0.500	0.515	0.510
EC2	0.303	0.525	0.307	**0.978**	0.563	0.499	0.423	0.638	0.658	0.411	0.558	0.379	0.492	0.571	0.539
EC3	0.275	0.502	0.268	**0.980**	0.540	0.474	0.395	0.592	0.620	0.385	0.550	0.357	0.478	0.524	0.506
EN1	0.538	0.378	0.241	0.409	**0.809**	0.343	0.418	0.490	0.478	0.405	0.403	0.384	0.400	0.673	0.421
EN2	0.453	0.341	0.185	0.370	**0.782**	0.318	0.355	0.442	0.418	0.335	0.437	0.281	0.418	0.620	0.345
EN3	0.361	0.469	0.219	0.495	**0.838**	0.456	0.323	0.508	0.490	0.352	0.379	0.335	0.397	0.674	0.486
EN4	0.282	0.413	0.184	0.489	**0.773**	0.452	0.297	0.465	0.420	0.308	0.381	0.317	0.308	0.620	0.459
GA1	0.270	0.367	0.330	0.271	0.304	**0.628**	0.346	0.406	0.374	0.317	0.395	0.341	0.302	0.342	0.330
GA2	0.105	0.409	0.186	0.390	0.409	**0.858**	0.174	0.448	0.414	0.193	0.287	0.247	0.289	0.438	0.364

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GA3	0.065	0.408	0.208	0.424	0.392	**0.875**	0.204	0.435	0.432	0.211	0.287	0.260	0.292	0.413	0.337
GA4	0.373	0.385	0.283	0.387	0.377	**0.640**	0.370	0.446	0.505	0.375	0.430	0.278	0.342	0.398	0.299
HM1	0.355	0.500	0.300	0.431	0.444	0.391	**0.903**	0.475	0.475	0.612	0.557	0.579	0.464	0.463	0.459
HM2	0.425	0.418	0.307	0.362	0.359	0.262	**0.947**	0.392	0.439	0.611	0.501	0.525	0.389	0.379	0.374
HM3	0.409	0.416	0.332	0.383	0.398	0.305	**0.935**	0.408	0.466	0.600	0.511	0.523	0.399	0.402	0.392
IP1	0.419	0.632	0.356	0.622	0.565	0.505	0.482	**0.921**	0.853	0.459	0.537	0.423	0.570	0.589	0.499
IP2	0.334	0.657	0.305	0.571	0.544	0.536	0.417	**0.958**	0.760	0.426	0.499	0.406	0.624	0.563	0.494
IP3	0.332	0.642	0.322	0.587	0.564	0.565	0.392	**0.930**	0.704	0.408	0.490	0.434	0.653	0.593	0.524
MN1	0.422	0.682	0.394	0.648	0.550	0.558	0.477	0.798	**0.976**	0.461	0.506	0.401	0.536	0.611	0.496
MN2	0.428	0.662	0.389	0.624	0.533	0.546	0.496	0.785	**0.973**	0.462	0.482	0.403	0.532	0.594	0.464
MN3	0.385	0.665	0.376	0.646	0.559	0.556	0.473	0.823	**0.960**	0.448	0.499	0.383	0.565	0.598	0.509
PE1	0.392	0.496	0.354	0.402	0.430	0.337	0.612	0.433	0.437	**0.941**	0.598	0.636	0.434	0.431	0.567
PE2	0.376	0.524	0.414	0.402	0.429	0.332	0.595	0.466	0.460	**0.948**	0.609	0.645	0.424	0.444	0.560
PE3	0.363	0.501	0.392	0.377	0.402	0.343	0.601	0.435	0.448	**0.961**	0.619	0.634	0.414	0.415	0.545
PE4	0.429	0.397	0.350	0.310	0.344	0.281	0.625	0.357	0.391	**0.832**	0.513	0.504	0.424	0.344	0.431
PW1	0.336	0.410	0.399	0.497	0.407	0.351	0.425	0.419	0.375	0.526	**0.872**	0.470	0.400	0.390	0.578
PW2	0.388	0.508	0.351	0.514	0.487	0.439	0.546	0.538	0.530	0.578	**0.896**	0.497	0.422	0.503	0.524
PW3	0.389	0.474	0.359	0.538	0.511	0.458	0.509	0.530	0.501	0.603	**0.908**	0.488	0.398	0.515	0.574
PW4	0.343	0.400	0.368	0.481	0.377	0.367	0.552	0.463	0.426	0.574	**0.910**	0.487	0.447	0.364	0.566
SAT1	0.364	0.536	0.343	0.381	0.415	0.361	0.585	0.442	0.411	0.671	0.559	**0.943**	0.409	0.453	0.575
SAT2	0.346	0.477	0.292	0.351	0.411	0.309	0.561	0.415	0.378	0.649	0.517	**0.954**	0.400	0.419	0.537
SAT3	0.321	0.467	0.325	0.326	0.350	0.332	0.540	0.407	0.359	0.595	0.485	**0.947**	0.396	0.395	0.516
SAT4	0.305	0.457	0.335	0.343	0.376	0.365	0.524	0.433	0.390	0.567	0.476	**0.931**	0.360	0.409	0.482
SD1	0.303	0.621	0.272	0.514	0.475	0.392	0.391	0.671	0.545	0.400	0.382	0.359	**0.904**	0.466	0.478
SD2	0.357	0.583	0.303	0.452	0.448	0.373	0.450	0.599	0.522	0.466	0.462	0.430	**0.936**	0.433	0.474
SD3	0.330	0.504	0.309	0.403	0.370	0.330	0.403	0.521	0.469	0.392	0.437	0.351	**0.907**	0.346	0.411
SE1	0.574	0.436	0.244	0.452	0.638	0.392	0.436	0.488	0.518	0.407	0.466	0.359	0.395	**0.843**	0.399
SE2	0.571	0.498	0.242	0.444	0.719	0.454	0.440	0.566	0.561	0.431	0.462	0.444	0.396	**0.925**	0.496
SE3	0.352	0.476	0.224	0.539	0.747	0.525	0.304	0.564	0.538	0.329	0.369	0.357	0.403	**0.843**	0.497
UB1	0.421	0.504	0.423	0.469	0.487	0.410	0.439	0.484	0.453	0.574	0.617	0.557	0.475	0.485	**0.941**
UB2	0.386	0.530	0.392	0.513	0.523	0.430	0.417	0.528	0.497	0.539	0.593	0.538	0.480	0.529	**0.977**
UB3	0.382	0.523	0.394	0.551	0.540	0.418	0.424	0.546	0.507	0.545	0.598	0.525	0.484	0.531	**0.970**

Note: *CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour*

Table 37. Heterotrait-Monotrait ratio (HTMT).

	CS	CP	CL	EN	GA	HM	IP	MN	EC	PW	PE	SAT	SD	SE	UB
CS															
CP	0.334														
CL	0.448	0.333													
EN	0.300	0.568	0.617												
GA	0.404	0.618	0.343	0.627											
HM	0.376	0.512	0.516	0.500	0.434										
IP	0.379	0.730	0.435	0.683	0.692	0.494									
MN	0.423	0.719	0.477	0.635	0.674	0.525	0.869								
EC	0.302	0.557	0.327	0.618	0.573	0.446	0.665	0.678							
PW	0.456	0.534	0.471	0.577	0.560	0.614	0.588	0.541	0.598						
PE	0.450	0.551	0.486	0.498	0.433	0.709	0.490	0.494	0.422	0.683					
SAT	0.372	0.537	0.415	0.464	0.442	0.621	0.476	0.423	0.384	0.575	0.689				
SD	0.357	0.670	0.415	0.551	0.492	0.494	0.712	0.597	0.531	0.512	0.499	0.445			
SE	0.313	0.603	0.692	0.974	0.665	0.511	0.701	0.687	0.607	0.565	0.501	0.494	0.520		
UB	0.448	0.564	0.467	0.604	0.521	0.468	0.571	0.523	0.549	0.666	0.601	0.583	0.532	0.593	

Note: *CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour*

*Table 38. Measurement model evaluation for second-order formative construct. Note: *p<0.10; **p<0.05; ***p<0.01*

		VIF	Weights
Empowerment	Competence	2.32	0.088
	Impact	3.901	0.270**
	Meaning	3.488	0.576***
	Self-determination	1.963	0.173*

*Table 39. Measurement model evaluation for second-order formative construct. Note: *p<0.10; **p<0.05; ***p<0.01. PEB – Pro-environmental behaviour*

		VIF	Weights
PEB	Conservation lifestyle	1.495	0.082
	Environmental citizenship	2.906	0.521***
	Social environmentalism	3.198	0.474***

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Annex E - Measurement model United Kingdom

Table 40. Mean, standard deviation, CR and Fornell-Larcker table. The diagonal elements are the square-root of AVE.

	Mean	STD	CR	CS	CP	CL	EN	GA	HM	IP	MN	EC	PW	PE	SAT	SD	SE	UB
CS	4.934	1.132	0.928	**0.848**														
CP	3.529	1.548	0.957	0.267	**0.939**													
CL	5.074	1.328	0.781	0.348	0.313	**0.751**												
EN	2.982	1.756	0.932	0.189	0.576	0.419	**0.880**											
GA	3.350	1.242	0.834	0.241	0.587	0.226	0.533	**0.754**										
HM	3.951	1.580	0.965	0.320	0.584	0.449	0.588	0.542	**0.950**									
IP	3.254	1.615	0.957	0.226	0.688	0.299	0.609	0.644	0.634	**0.939**								
MN	3.766	1.662	0.975	0.263	0.678	0.431	0.621	0.569	0.705	0.796	**0.964**							
EC	3.009	1.796	0.987	0.249	0.645	0.311	0.680	0.609	0.633	0.695	0.685	**0.981**						
PW	3.771	1.673	0.962	0.327	0.543	0.371	0.542	0.530	0.656	0.593	0.650	0.673	**0.930**					
PE	4.085	1.665	0.970	0.416	0.556	0.433	0.527	0.475	0.779	0.564	0.665	0.575	0.639	**0.943**				
SAT	4.299	1.376	0.964	0.354	0.478	0.363	0.467	0.412	0.677	0.478	0.561	0.515	0.586	0.750	**0.932**			
SD	3.881	1.523	0.919	0.343	0.557	0.318	0.449	0.418	0.469	0.620	0.573	0.510	0.427	0.464	0.397	**0.890**		
SE	3.058	1.608	0.920	0.222	0.614	0.478	0.796	0.597	0.634	0.629	0.631	0.662	0.569	0.572	0.466	0.421	**0.890**	
UB	3.698	1.713	0.960	0.369	0.586	0.453	0.567	0.510	0.697	0.577	0.647	0.659	0.733	0.693	0.586	0.499	0.578	**0.943**

Note: *CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour*

Table 41. Loadings and cross-loadings.

	CL	CP	CS	EC	EN	GA	HM	IP	MN	PE	PW	SAT	SD	SE	UB
CL1	**0.452**	-0.071	0.187	-0.062	-0.055	-0.191	0.094	-0.079	0.064	0.140	0.053	0.117	0.056	-0.040	0.041
CL2	**0.755**	0.084	0.250	0.093	0.195	0.006	0.176	0.045	0.182	0.204	0.173	0.176	0.176	0.236	0.222
CL3	**0.957**	0.366	0.339	0.360	0.454	0.288	0.502	0.365	0.476	0.469	0.402	0.390	0.333	0.512	0.486
CP1	0.268	**0.916**	0.220	0.652	0.580	0.601	0.558	0.663	0.592	0.495	0.540	0.428	0.467	0.608	0.579
CP2	0.295	**0.958**	0.277	0.583	0.515	0.542	0.547	0.644	0.641	0.535	0.508	0.458	0.540	0.563	0.555
CP3	0.319	**0.941**	0.257	0.579	0.527	0.510	0.540	0.628	0.678	0.536	0.481	0.459	0.561	0.559	0.515
CS1	0.353	0.219	**0.851**	0.198	0.166	0.217	0.266	0.177	0.216	0.353	0.290	0.288	0.299	0.197	0.325
CS2	0.225	0.230	**0.845**	0.212	0.171	0.198	0.242	0.194	0.184	0.350	0.295	0.280	0.254	0.177	0.272
CS3	0.298	0.253	**0.869**	0.263	0.183	0.234	0.305	0.227	0.269	0.399	0.324	0.336	0.312	0.217	0.352
CS4	0.313	0.229	**0.838**	0.200	0.162	0.210	0.281	0.193	0.220	0.315	0.241	0.288	0.277	0.193	0.308
CS5	0.296	0.189	**0.839**	0.160	0.102	0.146	0.255	0.148	0.214	0.335	0.208	0.302	0.317	0.144	0.301
EC1	0.301	0.621	0.227	**0.979**	0.647	0.602	0.610	0.660	0.656	0.555	0.650	0.491	0.498	0.649	0.633
EC2	0.311	0.648	0.249	**0.982**	0.675	0.601	0.629	0.693	0.680	0.565	0.668	0.506	0.507	0.655	0.655
EC3	0.304	0.629	0.257	**0.983**	0.678	0.590	0.625	0.694	0.679	0.574	0.664	0.518	0.496	0.644	0.652
EN1	0.399	0.530	0.161	0.591	**0.895**	0.458	0.568	0.539	0.587	0.502	0.511	0.439	0.421	0.746	0.540
EN2	0.410	0.442	0.135	0.536	**0.871**	0.406	0.490	0.478	0.539	0.446	0.434	0.396	0.368	0.622	0.445
EN3	0.332	0.534	0.202	0.643	**0.885**	0.509	0.533	0.560	0.557	0.482	0.511	0.417	0.392	0.714	0.544
EN4	0.338	0.517	0.163	0.618	**0.870**	0.498	0.475	0.561	0.501	0.423	0.448	0.393	0.398	0.714	0.461
GA1	0.131	0.213	0.157	0.265	0.229	**0.490**	0.333	0.310	0.299	0.244	0.308	0.290	0.180	0.228	0.237
GA2	0.080	0.503	0.092	0.519	0.454	**0.892**	0.391	0.547	0.419	0.306	0.405	0.259	0.305	0.531	0.386

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GA3	0.075	0.503	0.104	0.521	0.454	**0.893**	0.395	0.530	0.418	0.313	0.418	0.256	0.323	0.534	0.377
GA4	0.411	0.479	0.396	0.475	0.419	**0.666**	0.522	0.511	0.563	0.559	0.460	0.467	0.421	0.435	0.507
HM1	0.427	0.537	0.288	0.568	0.570	0.496	**0.960**	0.565	0.655	0.740	0.620	0.647	0.422	0.581	0.664
HM2	0.492	0.565	0.341	0.601	0.563	0.496	**0.958**	0.596	0.690	0.770	0.613	0.666	0.465	0.598	0.678
HM3	0.357	0.564	0.282	0.637	0.543	0.555	**0.931**	0.650	0.664	0.709	0.637	0.613	0.449	0.630	0.642
IP1	0.375	0.658	0.279	0.640	0.586	0.560	0.642	**0.915**	0.823	0.571	0.580	0.467	0.563	0.594	0.580
IP2	0.262	0.630	0.184	0.659	0.562	0.616	0.572	**0.958**	0.730	0.510	0.557	0.436	0.577	0.590	0.518
IP3	0.204	0.648	0.173	0.660	0.565	0.638	0.571	**0.943**	0.687	0.505	0.532	0.442	0.605	0.586	0.527
MN1	0.426	0.642	0.242	0.666	0.614	0.539	0.671	0.762	**0.965**	0.619	0.639	0.514	0.537	0.620	0.616
MN2	0.439	0.638	0.264	0.633	0.577	0.534	0.677	0.739	**0.964**	0.657	0.607	0.542	0.549	0.589	0.622
MN3	0.384	0.681	0.254	0.680	0.604	0.573	0.692	0.800	**0.963**	0.649	0.634	0.566	0.570	0.615	0.634
PE1	0.436	0.533	0.412	0.558	0.508	0.456	0.741	0.535	0.626	**0.953**	0.612	0.707	0.439	0.550	0.673
PE2	0.408	0.544	0.380	0.571	0.532	0.476	0.774	0.567	0.650	**0.958**	0.639	0.731	0.439	0.579	0.688
PE3	0.374	0.538	0.384	0.560	0.504	0.477	0.751	0.561	0.641	**0.960**	0.631	0.721	0.443	0.553	0.667
PE4	0.420	0.480	0.396	0.478	0.442	0.377	0.670	0.458	0.591	**0.901**	0.523	0.670	0.430	0.470	0.580
PW1	0.367	0.406	0.346	0.512	0.400	0.376	0.520	0.434	0.516	0.571	**0.849**	0.530	0.377	0.417	0.637
PW2	0.349	0.534	0.289	0.682	0.535	0.535	0.627	0.602	0.657	0.599	**0.952**	0.538	0.403	0.582	0.690
PW3	0.328	0.527	0.289	0.661	0.528	0.525	0.632	0.588	0.623	0.601	**0.966**	0.555	0.402	0.551	0.683
PW4	0.344	0.543	0.300	0.638	0.545	0.522	0.652	0.567	0.614	0.608	**0.948**	0.559	0.408	0.555	0.717
SAT1	0.379	0.506	0.377	0.516	0.468	0.402	0.670	0.468	0.575	0.745	0.597	**0.932**	0.403	0.455	0.609
SAT2	0.348	0.466	0.339	0.497	0.449	0.398	0.648	0.450	0.537	0.723	0.566	**0.955**	0.388	0.433	0.577
SAT3	0.283	0.391	0.298	0.430	0.364	0.373	0.597	0.405	0.473	0.665	0.505	**0.921**	0.340	0.393	0.494
SAT4	0.336	0.409	0.300	0.470	0.455	0.361	0.602	0.457	0.497	0.657	0.509	**0.920**	0.345	0.453	0.493
SD1	0.242	0.485	0.317	0.453	0.419	0.382	0.400	0.605	0.495	0.383	0.372	0.337	**0.902**	0.397	0.419
SD2	0.331	0.555	0.314	0.523	0.453	0.425	0.466	0.622	0.597	0.460	0.446	0.385	**0.930**	0.407	0.514
SD3	0.273	0.433	0.285	0.368	0.308	0.292	0.378	0.396	0.415	0.393	0.305	0.337	**0.835**	0.309	0.386
SE1	0.534	0.529	0.225	0.533	0.641	0.473	0.599	0.512	0.587	0.532	0.478	0.396	0.355	**0.871**	0.502
SE2	0.453	0.569	0.226	0.618	0.704	0.550	0.581	0.568	0.577	0.549	0.548	0.449	0.391	**0.927**	0.541
SE3	0.296	0.541	0.144	0.614	0.779	0.568	0.516	0.596	0.523	0.448	0.493	0.397	0.379	**0.872**	0.501
UB1	0.454	0.526	0.348	0.620	0.519	0.433	0.633	0.515	0.585	0.631	0.684	0.551	0.452	0.531	**0.922**
UB2	0.423	0.581	0.331	0.640	0.562	0.501	0.680	0.568	0.641	0.673	0.706	0.576	0.472	0.576	**0.961**
UB3	0.405	0.549	0.367	0.606	0.524	0.508	0.657	0.551	0.604	0.655	0.684	0.529	0.489	0.529	**0.946**

Note: *CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour*

Table 42. Heterotrait-monotrait ratio (HTMT).

	CS	CP	CL	EN	GA	HM	IP	MN	EC	PW	PE	SAT	SD	SE	UB
CS															
CP	0.287														
CL	0.403	0.264													
EN	0.203	0.626	0.370												
GA	0.305	0.692	0.374	0.644											
HM	0.343	0.622	0.386	0.635	0.666										
IP	0.241	0.737	0.254	0.662	0.775	0.676									
MN	0.279	0.716	0.361	0.665	0.682	0.739	0.839								
EC	0.258	0.674	0.255	0.720	0.708	0.658	0.727	0.704							
PW	0.349	0.575	0.321	0.582	0.640	0.691	0.627	0.679	0.696						
PE	0.444	0.588	0.408	0.565	0.571	0.817	0.594	0.692	0.592	0.670					
SAT	0.378	0.505	0.342	0.503	0.513	0.712	0.507	0.584	0.532	0.617	0.784				
SD	0.388	0.613	0.299	0.498	0.511	0.514	0.675	0.617	0.545	0.464	0.507	0.435			
SE	0.247	0.682	0.446	0.896	0.729	0.702	0.697	0.691	0.716	0.624	0.626	0.511	0.479		
UB	0.399	0.626	0.379	0.614	0.613	0.739	0.617	0.681	0.687	0.779	0.729	0.617	0.547	0.640	

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Note: *CS - Comfort; CP - Competence; CL - Conservation lifestyle; EN - Environmental citizenship; GA - Gamification; HM - Hedonic motivations; IP - Impact; MN - Meaning; EC - Participation in local energy communities; PW - Perceived wellbeing; PE - Performance expectancy; SAT - Satisfaction; SD- Self-determination; SE - Social environmentalism; UB - Use Behaviour*

*Table 43. Measurement model evaluation for second-order formative construct. Note: *p<0.10; **p<0.05; ***p<0.01*

		VIF	Weights
Empowerment	Competence	2.16	0.316***
	Impact	3.293	0.391***
	Meaning	3.028	0.350***
	Self-determination	1.733	0.058

*Table 44. Measurement model evaluation for second-order formative construct. Note: *p<0.10; **p<0.05; ***p<0.01. PEB – Pro-environmental behaviour*

		VIF	Weights
PEB	Conservation lifestyle	1.303	0.131**
	Environmental citizenship	2.745	0.522***
	Social environmentalism	2.933	0.455***