WP2 - Requirements, Use case definition and Architecture Blueprint

D2.2 Social barriers and enablers, building business use case definition and requirements

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Abstract:

This report documents the social based requirements for the adoption of the PHOENIX solution and subsequently, defines the project business use case. Within this context, this task examines the societal and individual behavioural factors that shape consumers' intention to acquire a smart device or upgrade their building into a more connected and smarter one. The approach for eliciting the enabling and hindering factors is based on a social-psychological model, following the Theory of Planned Behaviour by Ajzen. The intention, norms and control of consumers' behaviour are measured by means of a cross-sectorial survey, thus highlighting the different factors that may enable or block the upgrade of existing buildings. Based on an analysis of the survey outcomes as well as the input from the *business, market and regulatory requirements*, as identified in D2.1., a business use case for the PHOENIX innovations is presented.

Keywords:

Social, barriers, enablers, requirements, business use case

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V0.1	15/01/2021	Table of Content and work allocation	MERITCH
V0.2	20/02/2021	Feedback from partners and survey results	All task partners
V0.3	05/03/2021	Analysis of survey results	MERITCH
V0.4	17/03/2021	Social barriers and enablers	KaMa, VERD
V0.7	26/03/2021	Business use case definition	SUITE 5, UBITECH
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EXECUTIVE SUMMARY

The present document is a deliverable of the project *Adapt-&-Play Enhanced Cost-Effectiveness and user-friendliness Innovations with high replicability to upgrade smartness of existing buildings with legacy equipment* (PHOENIX), funded by the European Union's Horizon 2020 Programme under Grant Agreement 893079.

The scope of this document is to define the project's business use case, following the elicitation of the social barriers and enablers, and by extent the social-based requirements for the adoption of smart building technology and services in existing buildings with legacy equipment.

Initially, the present report outlines the conceptual framework followed for extracting the social enabling and hindering factors to the adoption of smart building technology and systems. Thereafter, the choice of the methodology used is justified and analyzed based on the literature, and further extended to accommodate all specific aspects relevant to the scope and objectives of this task. The model deployed encompasses a wide range of behavioral aspects, which were used as variables in designing a cross-sectorial survey addressed to EU citizens, in order to capture their perceptions and intention towards engaging with the smart building technology concept and upgrading old building stock equipped with legacy systems to a smarter one.

To that end, survey questionnaires were distributed to EU citizens, both to building occupants of the PHOENIX pilot sites, in Greece, Ireland, Spain and Sweden, and to consumers in selected European countries with a relatively old building stock, thus presenting opportunities for energy saving measures: Belgium, Denmark, France, Germany, Italy and the Netherlands.

The survey results were analyzed for the effect of socio-demographics variables on consumers' perceptions towards smart building technology. Subsequently, the social enabling and hindering factors to the adoption of smart building systems and services were identified, measured, classified and translated into social-based requirements.

Finally, the project business use case was defined comprising an analysis of the current state, the proposed solution by PHOENIX, a preliminary business approach and risk analysis, and the PHOENIX business value analysis. The outcome of the present report will serve as a basis for the WP8 activities of the PHOENIX project, on Business Planning, Exploitation and Communication.

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1. INTRODUCTION

1.1 Scope and objectives of the deliverable

Smart building technology provides a new perspective of the role energy plays in the daily lives of consumers. Despite its benefits, however, it has yet to be realized at scale. The development of smart buildings is subject to an interplay of factors like policies, regulations, market, and society. Within the concept of the PHOENIX project and following the analysis of Task 2.1 on the market and regulatory landscape, this document addresses the societal aspects of smart building technology and services' adoption pertinent to social values, beliefs, capacity and practices of consumers, in order to capture the critical social enablers and barriers which are going to set the basis for the definition of the PHOENIX business use case.

To that end, this report investigates, measures, identifies and analyzes the current social enablers and barriers that may favor or hinder the integration of the PHOENIX solution in existing buildings with legacy equipment. More specifically, this deliverable includes a comprehensive study (survey) of consumers' socio-economic perceptions on smart building devices and systems. Based on the scope and objective of this deliverable, two questionnaire surveys were designed and conducted, according to the Theory of Planned Behavior by Ajzen [1], which were addressed to:

- building occupants of the PHOENIX pilot sites, and
- consumers in selected EU countries with a large share of old building stock, thus, having a lot of potential for prospective energy saving measures.

More specifically, the survey in selected EU countries was deployed to increase the precision and reliability of the results through a more representative sample, fully covering the scope and objectives of this task and ensuring a reliable prioritization and ranking of the important barriers and enablers pertinent to the adoption of smart building technology.

A comparative analysis through descriptive statistics techniques was conducted by measuring and analyzing all variables, cross-tabulated and tested against demographic characteristics. Through this process, statistically important differentiating factors within subgroups were identified, such as the impact of age and income level, as well as dependencies between groups of variables, e.g. attitude and social norms. Through this analysis, the key barriers and enablers were measured and classified, serving the aforementioned scope and objective of the deliverable. The enabling and hindering factors constitute the foundation of the social-based requirements, which can translate into the PHOENIX specifications for the integration and upgrading of smartness in existing buildings currently having legacy equipment and systems.

Finally, building on the social based requirements as captured by the survey, and on the business scenarios and requirements as defined in D2.1, the PHOENIX business use case was defined for the provision of smart building energy services to further serve as input to the PHOENIX business exploitation activities.

1.2 Relation to other tasks and deliverables

This task is closely linked to Task 2.1: *Business market and regulatory requirements*, from which the business scenarios and use cases were used as input to define the PHOENIX business use case. Further, the present deliverable is related to WP3, WP4, WP5 and WP6, in terms of social requirements and specifications considered for the development and integration of the PHOENIX smartness hub with ICT tools and services. Finally, WP8, which constitutes the *Business Planning, Exploitation and Communication* activities of the PHOENIX project, will build on the business use case description of this deliverable to develop the PHOENIX business model and identify profitable exploitable results under T8.3, as well as leverage the social requirements of D2.2 for its communication activities and awareness/training actions under T8.1.

1.3 Structure of the deliverable

Following the definition and scope of the deliverable in Section 1, D2.2 comprises the following sections:

Section 2: Conceptual and methodological framework of the survey. This section describes the methodology followed in order to gain insights into the EU society's perspective on smart building technology and services. Background information and the rationale of the proposed model are provided under this section, as a basis of the survey design which follows next.

Section 3: Survey design, results and findings. This section includes the survey specifications and design and the structured questionnaire administered to the targeted participants. The key outcomes of the surveys are also presented herein, together with the description and elaboration of the results.

Section 4: Enablers and barriers pertinent to the PHOENIX project. This section translates the survey outcomes into social barriers and enablers pertaining to the PHOENIX solutions and elaborates on the social-based requirements necessary for the definition of the project's business use case.

Section 5: Business use case definition. The last section of the deliverable core includes the description of the project's business use case, from problem definition to the business value of the PHOENIX project.

Section 5: Conclusions. This is a summary of the key outcomes of this deliverable and its main conclusions.

2 CONCEPTUAL AND METHODOLOGICAL FRAMEWORK OF THE SURVEY

2.1 Conceptual framework

As stated in the DoA, the aim of the document is to pulse the situation of the European society and focus on the different behavior-based factors that may enable or block the realization of smart buildings through the upgrade of their existing systems and equipment. The scope of this section is to provide an **overview of the methodology considered for the extraction of these social and individual behavioral barriers and enablers.**

At first, **the choice of methodology use** is justified and an identification of **some key critical behavior aspects** are elucidated through a review of literature pertinent to the subject that hinder or enable building occupants towards acquiring a smart device or upgrading a building towards a more connected and smarter one. Then, and in order to address the specificities of the PHOENIX project, a survey is conducted on the way to extract the specific needs and preferences of the occupants at the different demo sites.

In order to ensure that the survey performed in the context of the project is not biased on the project specific characteristics, a broader cross-sectorial survey is conducted in order to clearly understand the different factors that may enable or block the realization of smart buildings. Following the survey, an analysis of the main results is performed in order to finally extract the list of social/behavioral related requirements that have to be considered at the design of the PHOENIX solution. The different steps of the methodology are visually presented in the following figure:

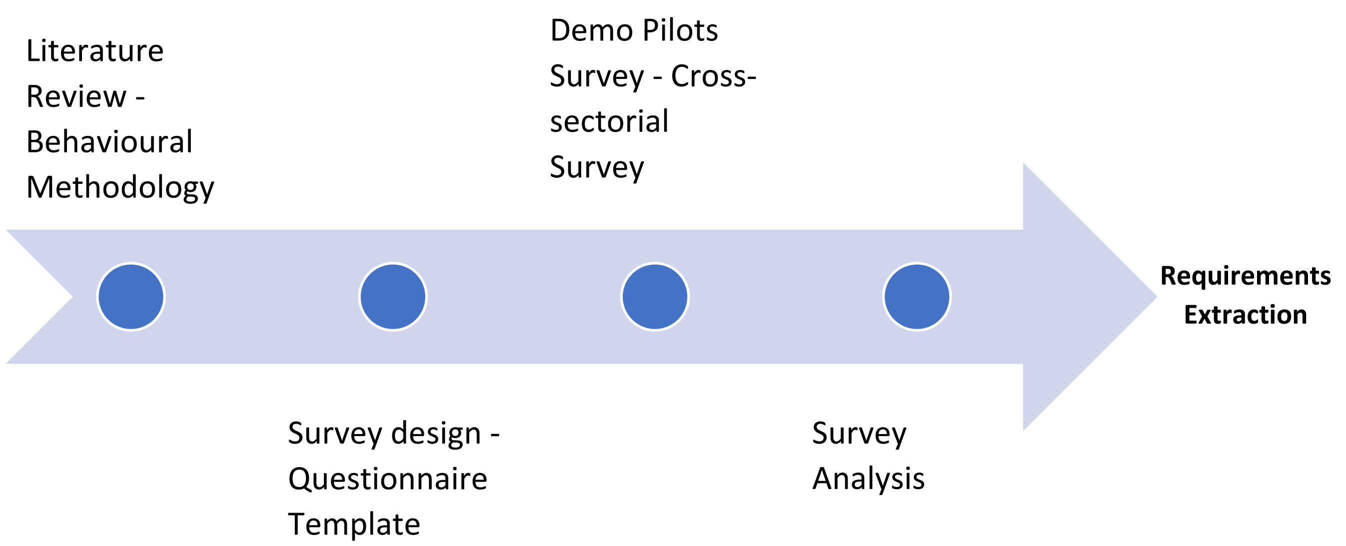

Figure 1. PHOENIX Social barriers and enablers extraction methodology

In the following sections, the details of the different steps of the methodology are provided. Further, we present the results of the literature, specifying the details of the **Theory of Planned Behavior of Ajzen** as well, which is adopted in the project to help understand how the behavior of people can be interlinked with the adoption and realization of the smart buildings concept.

2.2 Methodology to obtain the social barriers and enablers

The essence of smart building lies on embedding Information and Communication Technologies (ICTs) in appliances, which impart information to users and offer them the potential to automate commands and routines, thus increasing functionality and manageability. Regardless of the smart building configuration, the aim is to facilitate daily operations.

Despite its significant benefits, however, the smart building concept has much room left to be realized at scale. In this respect, an important set of challenges to be dealt with is found in social barriers to the adoption of smart technology. Such barriers have already been identified in different studies and include concerns regarding, amongst others, privacy and technology cost [2].

Consumers' acknowledgement of potential smart building benefits, on the other hand, such as convenience and monetary savings, can be important drivers. Within this context, social barriers and enablers are inextricably linked to end-users' perceptions and attitude towards smart technology. Thus, in order to elucidate them, a social-psychological survey is deemed appropriate. As stipulated in the DoA, the suitable approach to gain insights into social-psychological factors that influence consumers' decision-making process, is the **Theory of Planned Behavior by Ajzen**, which measures the norms, attitude and control perceptions of people towards adopting a specific behavior. The theory is further analyzed in the following section.

2.2.1 Theory of Planned Behavior

The Theory of Planned Behavior (TPB) is an extended model of the Theory of Reasoned Action (TRA) developed in 1975 by Fishbein and Ajzen, both postulating that the most important driver of human behavior is intention. Intention, in turn, is described as an individual's motivation to exert an effort towards performing a specific behavior [1, 3]. According to the TRA, behaviors are performed under the influence of volitional control, i.e. people will make a reasoned choice amongst possible alternatives if they believe they can perform a specific behavior at their own will. TRA has been widely used to study behavioral intentions in the area of consumer behavior [4, 5, 6], amongst others. TPB has further extended this model to account for other parameters that might affect individuals' intention towards adopting a behavior. Specifically, TPB postulates that **intention** is a function of three conceptually independent variables:

i) **attitude**, i.e., the degree to which a person evaluates a specific behavior as favorable or unfavorable to them [1]. It is based on the individual's **behavioral beliefs** and reflects one's perceptions of what the consequences of a specific action will be and their level of significance. In general, an individual will tend to develop a positive attitude towards a behavior, when they positively appraise its outcomes, and in that case they are likely to adopt this specific behavior [1];

ii) **subjective norm**, i.e. the perceived pressure from the individual's social environment to perform or not a specific behavior. This norm represents how the preferences of significant others are perceived by an individual. Most importantly, however, this norm indicates the **individual's motivation to comply with the expectations of their significant others**, since their opinion constitutes a latent form of approval/disapproval [7]; and

iii) **perceived behavioral control**, i.e., the perceived ease or difficulty in performing a specific behavior [1]. Control reflects the perceived ability of an individual to act on their environment, and hence, when people feel they have control over a behavior, they are more likely to adopt it.

A schematic representation of Ajzen's Theory of Planned Behavior is shown in Figure 2.

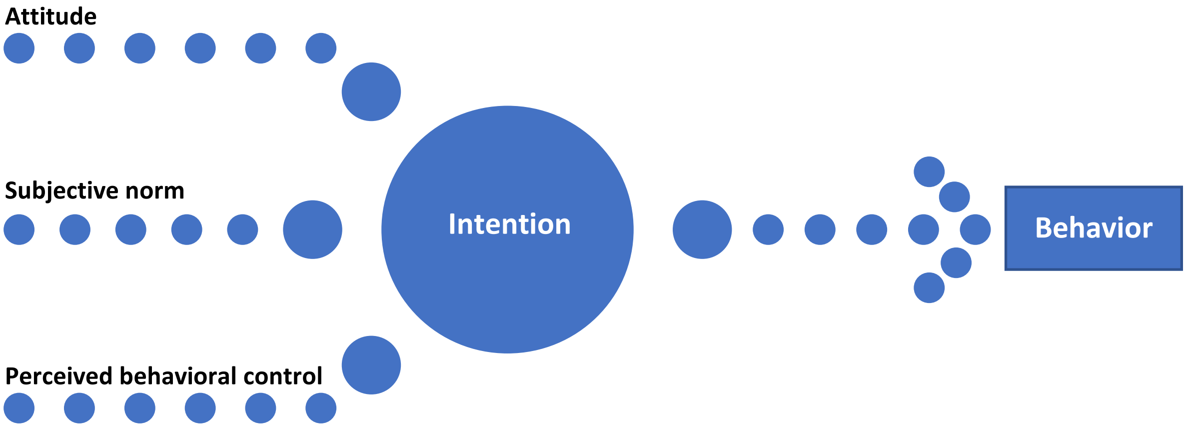

Figure 2. Ajzen's Theory of Planned Behavior model, Ajzen 1975

TPB allows to model the consumers' behavior through the above-mentioned variables, exhibiting strong explanatory capacity in a variety of situations and contexts, amongst which, the consumer adoption intention [8, 9]. Nevertheless, as in any theory, there is no "*one-size-fits-all*" application. The advantage of TPB in this case, is that it can become context-specific, by allowing the inclusion of additional parameters in order to capture the influence of other relevant and important intention determinants [10, 11]. The conceptual model in this task, combines the insights of TPB with insights from the theory of **behavioral economics,** which assumes that human behavior is also under the influence of non-rational determinants that might affect the decision-making process [12].

The PHOENIX concept is focused on new technologies and services that will introduce a higher level of smartness in buildings and as such, engenders a considerable level of consumers' behavior change. **Tendency or resistance to change**, is the inclination to change or not, respectively, the current lifestyle by adopting new behaviors, and this is a concept that has recently started receiving attention in research [13]. Within the scope of PHOENIX, we measure the tendency to change, as a non-rational variable contrary to the TPB default ones, which has been found to positively affect individuals' intention [6].

For the adoption of new technologies and innovative products and services, it is common to consider that traits such as social **innovativeness**, tend to influence individuals' intention positively [14, 15]. This means that people's behavior might be motivated by the self-assertive need to differentiate themselves from their environment [14]. Possession of innovative products can be considered a means to distinguish oneself and impress others, and hence it is also used as a variable to further extend the TPB for the scope of the PHOENIX project.

The extended TPB model is presented in Figure 3.

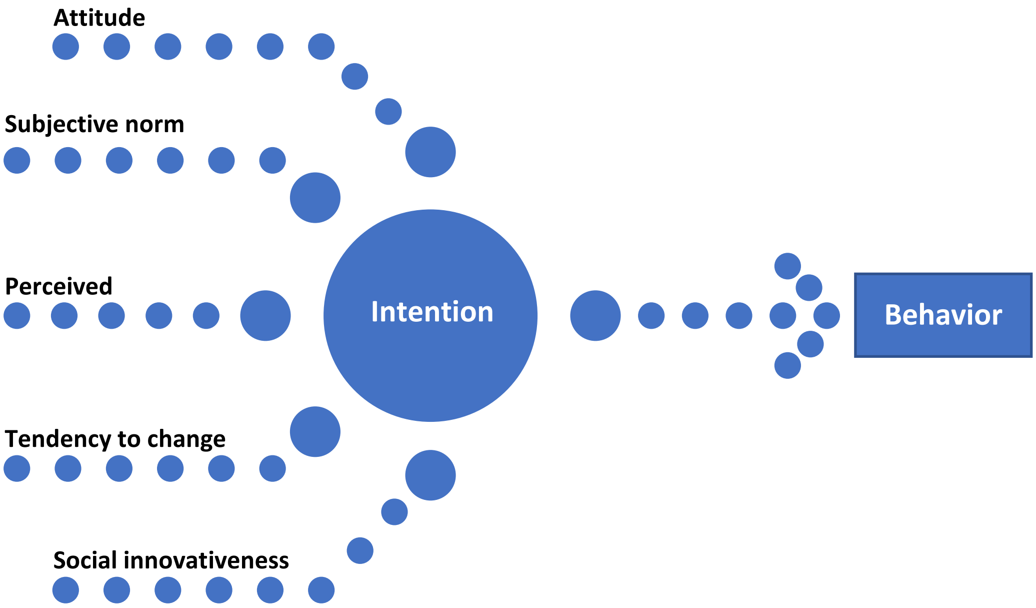

Figure 3. Extended Theory of Planned Behavior model.

Besides measuring consumers' intention, TPB is considered a very useful tool to elucidate the social barriers and enablers to the adoption of smart building technology, as it provides significant insight into what motivates and hinders engagement with it. Indicatively, for certain people, a strong endorsement from their significant others is likely to trigger a stronger intention to engage with smart technology, thereby is perceived as enabler. On the flipside, some people may refrain from using smart systems because they perceive them as difficult to handle. Behavioral choices are thereby explained in terms of perceived benefits and costs, which point to specific social barriers and enablers for the adoption of smart building technology. **Barriers** that have been commonly identified through a review of topical literature on the broader subject of smart technology (from smart homes to smart grids), include:

- High cost [2, 16, 17];
- Reliability concerns [2, 18];
- Privacy concerns [2, 19];
- Unawareness [2].

Enablers on the other hand, might include:

- Money savings [20, 21, 22];
- The influence of the social environment (norms) [6, 11, 23];
- Enhancing consumers' control [21];
- Environmental considerations [24];
- Time savings [25];
- Convenience [25].

The aforementioned enabling and hindering factors have been included as survey items/variables in the structured questionnaires distributed to EU participants, along with additional ones which were identified as important to be assessed within the scope of the PHOENIX project. Detailed listings of all the variables considered, are included in the following section, and further elaboration of the enablers and barriers from a social standpoint, is provided in Section 4.

3 SURVEY DESIGN, RESULTS AND FINDINGS

3.1 Survey design

Following the methodological approach described above, two surveys were developed: one corresponding to occupants from the PHOENIX pilot sites, and one public survey administered to consumers from six (6) different European countries. The public survey was conducted to generate a wider range of participants with different backgrounds and thus create variance across the measured parameters to complement the sample size of the pilots. Both surveys were based on the same questionnaire (presented in Section 3.2 and ANNEX I), yet they were administered through different platforms.

3.1.1 Pilot sites' survey

For the pilot sites' occupants, questionnaires were circulated to participants through the **EU Survey tool**, as decided by the consortium and already utilized for the scope of D2.1. The questionnaire was prepared in the English language, auto-translated through the EU Survey platform into the other pilot sites' local languages, i.e., Greek, Spanish and Swedish and was further fine-tuned by pilot sites' consortium partners. The EU Survey tool offers the possibility of advanced privacy, by allowing to create personalized survey access links for participants through the generation of tokens. Thus, connection details were not available in the received survey forms, respecting the occupants' anonymity. Further, the EU survey provides the opportunity to make the survey interactive by allowing dependent questions, which was a feature also utilized in our questionnaire.

Regarding results, the tool offers basic results' analysis which was used to visualize and get an overview of the participants responses. Further analysis was conducted with the use of the SPSS statistical software (Build 1.0.0.1447), in order to consolidate the pilot results with the public survey results and conduct further analysis.

3.1.2 Public survey

For the public survey, questionnaires were circulated through the **POLLFISH**[1] platform. POLLFISH was selected as a tool because it allows reaching out to a targeted audience in an anonymous way, using advanced targeting and distribution methods. The platform directly partners with app developers, who offer specific non-cash incentives to real consumers in exchange of completed surveys, so it was considered as a means to avoid contributions from "professional survey takers". POLLFISH also enables the creation of survey questionnaires narrowly targeting consumer populations by defining certain criteria (quotas), and applies AI fraud detection[2] to remove responses that fail quality standards.

Demographic criteria were used to target the audience of this survey: country, gender, employment status, education, and income level. As stated in the DoA, this task focuses on pulsing the situation of the European society towards acquiring a smart device or upgrading a building towards a more connected and smarter one. Hence, in order to reach a wider EU audience six (6) more countries were targeted. The countries were selected based on information from the EU Building Stock Observatory[3], which was established in 2016 as a part of the Clean energy for all Europeans package and provides information on buildings as a basis for

[1] https://www.pollfish.com/

[2] An algorithm that detects fraudulent responses, e.g. straight line responses etc.

[3] https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/eu-bso_en

relevant future policy making. Using transparent data from the observatory, **countries with a large share of old building stock** (built before 1980) were identified **across Europe**, because this indicates the buildings were constructed without considerable energy performance standards and thus, have a lot of potential for prospective energy saving measures. Specifically, the selected countries are: Denmark, Germany, Belgium, Italy, France and the Netherlands. Figure 4 depicts the respective shares of residential buildings built before 1980 in each of the selected countries. With respect to the rest of the demographic filters, the survey was administered to people of all incomes, different age groups, and of various educational levels, to ensure sample variance.

Figure 4. Percentage of residential buildings built before 1980

3.1.3 Sample

Within the context of Task 2.2, the objective of the survey is the prioritization and interrelations of the social enablers and barriers to the adoption of smart building technology. Hence, a sample with a good geographical spread across the EU is deemed appropriate, with variance in its demographic characteristics, thus ensuring that different perceptions across various societal groups are reflected. To that end, a critical sample size of 200 individuals was pursued. In order to achieve the critical sample size, 371 questionnaires were administered through the two platforms with quotas for specific demographics in the case of public survey, and eventually 242 valid responses were acquired, which exceeds the principal target.

It is worth mentioning that the above-mentioned sample size was selected to serve the scope of this survey, which is to discover and analyze trends and behaviors through interrelations of certain variables according to the Ajzen Theory of Planned Behavior, and not to conduct a specific poll in the framework of valuation statistics, which would be beyond the scope of this task. Furthermore, the critical sample size selected is adequate for conducting in depth between-group and in-group analysis.

The questionnaire structure of the survey is described in the following section.

3.2 Questionnaire structure

The questionnaire was designed in compliance with the TPB model, as extended to accommodate additional perceptions relevant to the adoption of new technologies, and comprises three main parts:

- **Part I**: A demographics section to understand if and how such variables are related to enablers/barriers for the adoption of smart home technology, shown in Table 1.

Table 1. Questionnaire - demographics section

Demographics and background information	Comments/Justification
Age	Age groups were classified to correspond to: early young adults between 16-25, late young adults between 26-35, middle adults between 36-50, old adults between 51-65 and older adults of over 65 years old. Age is usually negatively correlated with technology acceptance.
Gender	We included gender as a variable to see if there are differences in the perceptions of smart technology between men and women.
Country of residence	Pilot sites' countries, i.e. Greece, Ireland, Spain and Sweden, complemented with results from the six countries targeted through POLLFISH, i.e., Denmark, Germany, Belgium, Italy, France and the Netherlands.
Income level	All income levels from lower to higher were included to assess whether there is an effect on the intention to adopt smart building technology.
Education level	There is an assumption that people with more technical education, thus more exposed to technology, are more prone to accept new technological systems/services. On the flip side, technology has become more user friendly in the last few years, and we would like to examine if that trend has changed as a result.
Employment status	We administered the survey to people of different employment status, i.e. unemployed, employed, retired and students, to assess whether there is an effect on the intention to adopt smart technology.
Computer literacy level	Technology acceptance is assumed to vary with computer literacy, and thus participants were asked to classify their computer literacy level, i.e., beginner, basic knowledge, moderate and expert.
Housing tenure	Certain aspects, such as the cost of smart systems installation or the property value upgrade that comes with it, might be perceived differently by home-owners and private renters.
Type of building	In principle, a smart home may refer to any building type, i.e., detached, semi-detached or apartment building. This variable was used as background information.
Number of building occupants	This variable was used as background information and was also checked against respondents' perceptions for potential impact.

Demographics and background information	Comments/Justification
Residential situation	Participants were asked to declare whether they live alone, with family, partner or in co-housing, as background information.
Smart devices current use	Participants were asked to declare whether they currently use any smart home systems and thus whether they are familiar with the operations and functions under real life conditions. Information on the type of smart devices currently used, were also acquired through a dependent question.
Familiarity with smart home systems concept	The familiarity factor was used to assert whether participants who currently do not use smart systems are aware of the technology. A dependent question was also used to ask the type of smart devices those participants would like to use in the future.

- **Part II**: The main part of the questionnaire contained questions on behavioral beliefs (attitude), societal aspects (normative beliefs and social innovativeness), control beliefs and tendency to change. All questions under this part, were designed using a 5-point Likert scale[4] , in order to allow for quantitative analysis of the answers. Most of the questions were formulated in a positively worded manner (i.e., points 4 and 5 of the Likert scale to indicate agreement to perceiving smart technology positively), except for four questions which were negatively worded to avoid '*response set bias*'. Table 2 presents the context of questions included in the main part of the questionnaire.

Table 2. Questionnaire - perceptions section

Question group	Question context
Behavioral beliefs	Privacy as a barrier to engage with the smart building concept
	Saving money as an enabling factor to engage in the smart building concept
	Saving time as an enabling factor to engage in the smart building concept
	Saving energy as an enabling factor to engage in the smart building concept
	Convenience as an enabling factor to engage in the smart building concept
	Increase of property value as an enabling factor
	Smart device use perceived as a good idea
	Building equipment upgrade perceived as a good idea
	Energy control (lighting) perceived as a good idea
	Energy control (heating/cooling) perceived as a good idea
	Management of appliances through smart systems perceived as a good idea
	Smart equipment to improve quality of life perception
	Perceived usefulness of smart home services

[4] Respondent indicates degree of agreement or disagreement with a statement on a scale of 1 to 5: 1-Strongly disagree, 2-Disagree, 3-Neutral, 4-Agree, 5-Strongly agree

Question group	Question context
	Perceived concept of smart technology as difficult Perception of smart technology as unreliable Perception of smart technology as too expensive
Normative beliefs	Significant others encourage acquisition of smart device Significant others encourage building upgrade to a smart one
Social innovativeness	Desire to engage in smart building service to impress others Preference to present smart devices/services to others Perception of smart technology as a means to differentiate oneself
Control beliefs	Confidence in ability to operate smart equipment Confidence in ability to live in a smart building Possession of resources (financial) to upgrade existing equipment to smart ones Confidence in knowledge of smart building equipment use
Tendency	Inclination to change habits and use new smart products even if currently they are unknown to oneself

- **Part III**: A section containing multiple choice questions for timing participants' intention to adopt smart home systems. Respondents were invited to state when they intend to use smart devices (in less than 5 years; within the next 5-10 years; within the next 11-20 years, or never.

The EU Survey and POLLFISH templates are indicatively illustrated in the following pictures and the complete questionnaire is further presented in ANNEX I.

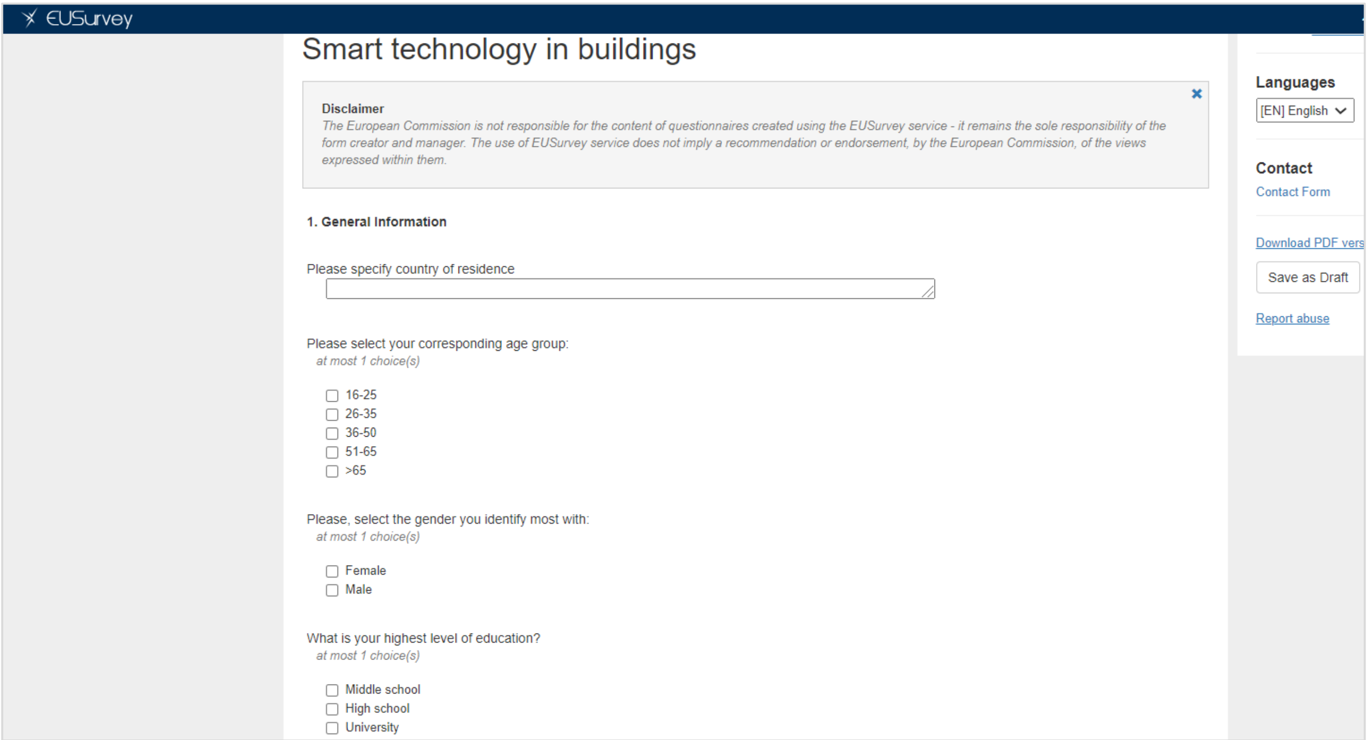

Figure 5. EU Survey questionnaire template

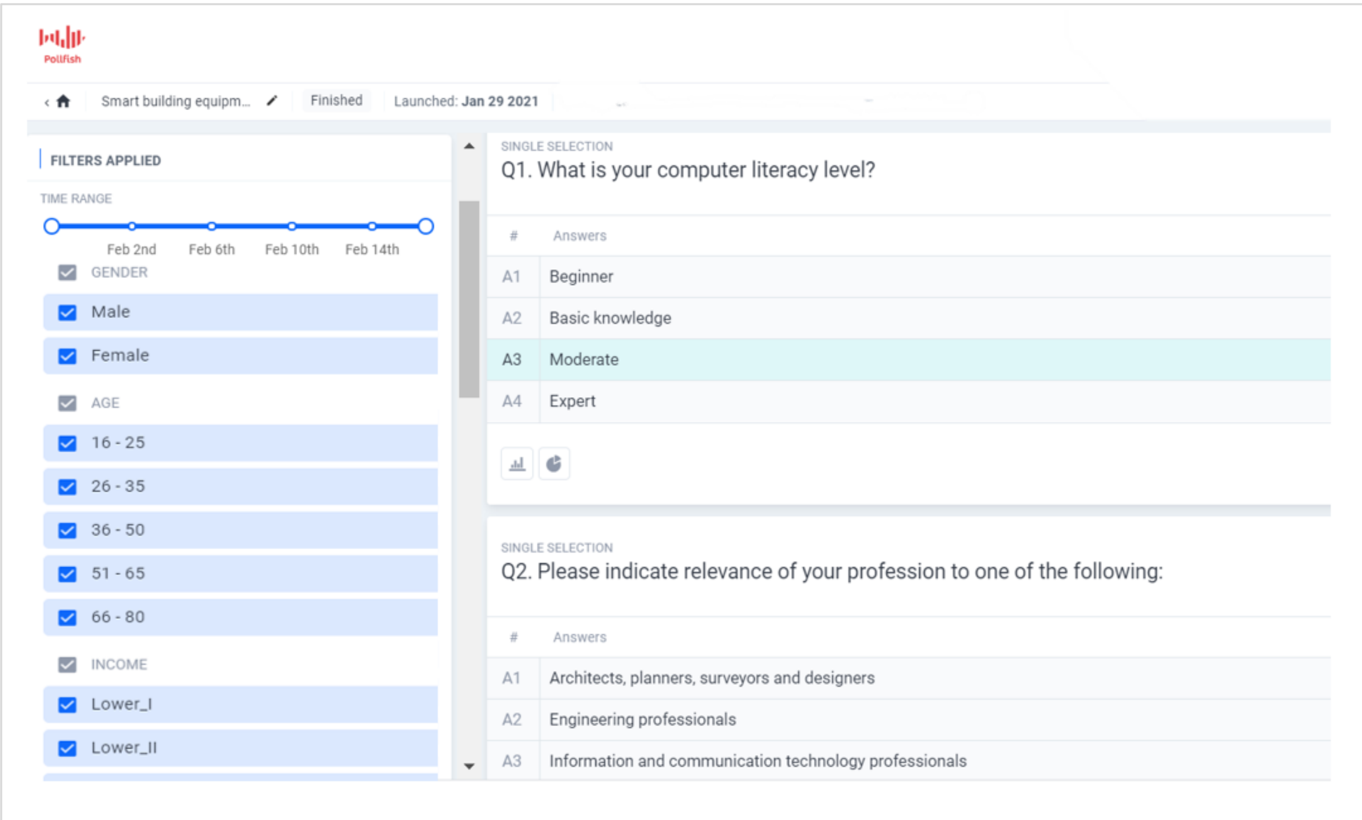

Figure 6. POLLFISH questionnaire template with filters applied on the left sidebar

3.3 Statistical analysis

For the analysis of the results IBM SPSS Statistics tool[5] (a template of which is presented in ANNEX II) and Microsoft Excel were used, and descriptive analysis was performed to deduce users' perceptions on smart home technology. Initial analysis performed on the two survey results (pilot sites' and public survey), revealed that both follow similar trends, with insignificant differences in some individual questions, which were not considered of particular importance or influence over the results. Hence, both surveys' responses were consolidated into a single database on SPSS. Statistical frequencies and cross-tabulation contingency tables were deployed to identify patterns and relate key variables to different groups of respondents. Nevertheless, the specific EU Survey results are also presented for reference in this deliverable, in the respective Annexes I-VI.

On the other hand, **significant differences** were identified between participants who currently **use smart systems and those who do not**. Thus, analysis was performed separately for the two groups of users and non-users. For the analysis, variables were first aggregated in the five (5) dimensions of the extended TPB model and reviewed for both groups. Following that, the responses of the two groups to each individual question were examined, and lastly, the effect of the socio-demographic variables was tested against the responses. Through this process, all potential patterns were identified and the effect of demographics on the perceptions of different societal groups was inferred.

3.4 Outcomes

The group characteristics of the survey respondents from the consolidated EU Survey and POLLFISH database, in terms of socio-demographics are depicted in Table 3.

Table 3. Sample characteristics[6]

Characteristics	Value	Count N	Table N%
Gender	Male	147	60.7%
	Female	95	39.3%
Age	16-25	83	34.3%
	26-35	67	27.7%
	36-50	46	19%
	51-65	34	14%
	>65	12	5%
Country	Belgium	27	11.2%
	Denmark	20	8.3%
	Germany	40	16.5%
	Greece	12	5%
	France	40	16.5%
	Ireland	4	1.6%
	Italy	40	16.5%
	Netherlands	40	16.5%
	Spain	7	2.9%
	Sweden	12	5%

[5] https://www.ibm.com/analytics/spss-statistics-software

[6] Any deviations in the sum of respondents is due to missing values (non-answered questions). We have proceeded with debugging for the missing response values on a case-by-case basis in the results' analysis, i.e. the percentages in such cases correspond to the valid percentage, excluding missing responses

Characteristics	Value	Count N	Table N%
Income level	Low	74	30.6%
	Middle	68	28.1%
	High	68	28.1%
	Prefer not to say	32	13.2%
Employment status	Employed	93	38.5%
	Unemployed	54	22.3%
	Retired	28	11.6%
	Students	35	14.5%
	Prefer not say	32	13.2%
Education level	Middle & High school	78	32.2%
	Vocational	46	19%
	University	67	27.7%
	Postgraduates	51	21.1%
Computer literacy level	Beginner	40	16.5%
	Basic knowledge	45	18.6%
	Moderate	106	43.8%
	Expert	51	21.1%
Professional affinity to the smart building concept	Architects, planners, etc	41	16.9%
	Engineering professionals	33	13.7%
	ICT Professionals	60	24.8%
	Other	106	43.2%
Housing tenure	Owned	153	63.2%
	Rent	89	36.8%
Building type	Detached	93	38.4%
	Semi-detached	48	19.8%
	Apartment	101	41.7%
Number of people in building	0-5	129	63.2
	6-10	18	8.8
	11-15	10	4.9
	16-20	14	6.9
	21-50	15	7.4
	51-100	18	8.8
Residential situation	Live alone	31	12.8%
	With family	110	45.5%
	With partner - no children	48	19.8%
	With partner & children	42	17.4%
	Co-housing	11	4.5%
Current use of smart systems	Users	154	63.6%
	Non-users	88	36.4%

At this point, it should be noted that some of the socio-demographics' breakdown achieved may be different from real life demographics. For instance, the gender breakdown is 60.7% (147) male and 39.3% (95) female. Also, a fair share of participants exhibited some sort of professional affinity to smart home technology, with 16.9% being architects, planners, surveyors and 24.8% being ICT professionals, as opposed to 43.2% having a different profession. Nevertheless, the idea here was to have an adequate number of participants from each group, which was fairly achieved. Further to that, socio-demographics were explored for their impact on consumers' perceptions and results did not appear to be gendered or differentiate with all variables. Rather, only certain demographic variables were found to have an effect on perceptions, such as income level or age. Other demographic variables had a case-specific effect applying only to certain perceptions, and others had no effect at all. The results acquired present strong explanatory capacity.

3.4.1 Respondents’ perceptions on smart technology

Initially, the sample was distinguished into two main groups: the respondents who currently do not use smart devices (88) and those who currently do (154). For aggregating the results, all questions were harmonized to positively worded statements that indicate respondents’ agreement or positive perception towards specific aspects of smart technology. That made it possible to group the questions into five main variables corresponding to the five beliefs of the extended TPB theory, as were depicted in Table 2. Overall, as expected, those who currently use smart systems and equipment are more positive in their beliefs than those who do not. Specifically, users appear to have a more positive attitude towards the smart building concept, they also tend to use new products even if they are currently unknown to them, they exhibit confidence in their ability to exert control over smart technology, and finally, to a lesser but still considerable extend, they value the social aspects of smart system use, such as feeling motivated by their significant others to engage with the smart technology concept (Figure 7 & Figure 8).

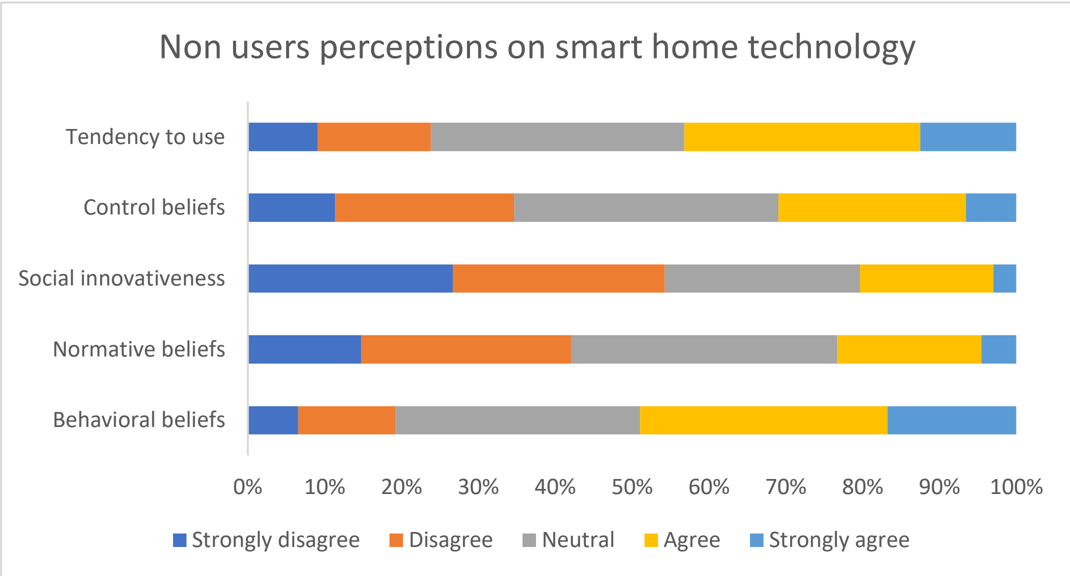

Figure 7. Non-users' aggregated perceptions on smart technology

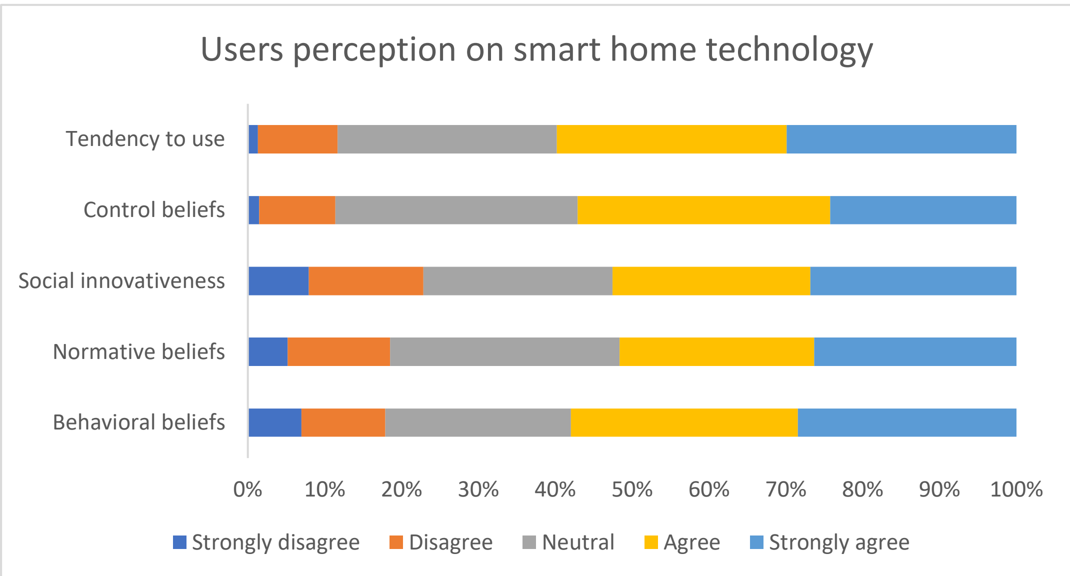

Figure 8. Users’ aggregated perceptions on smart home technology

A more in-depth analysis of the responses to the individual questions for each group of perceptions, i.e. behavioral, normative, innovativeness, control and tendency, is presented in the following sections.

3.4.1.1 Behavioral beliefs

Overall, most of the participants have a positive attitude (behavioral beliefs) towards the use of smart home systems, with almost 50% of non-users' and 60% of users' responses being favorable to behavioral aspects.

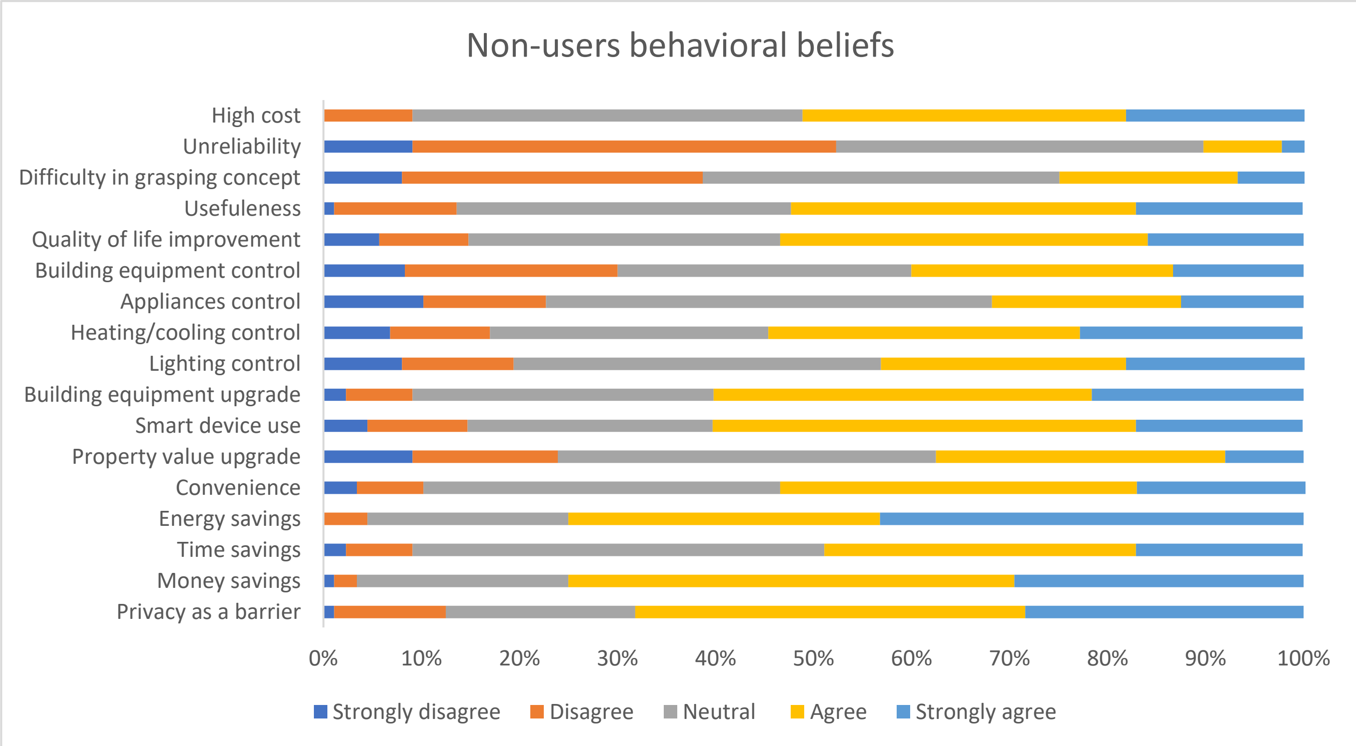

Figure 9. Non-users' responses on behavioral beliefs questions

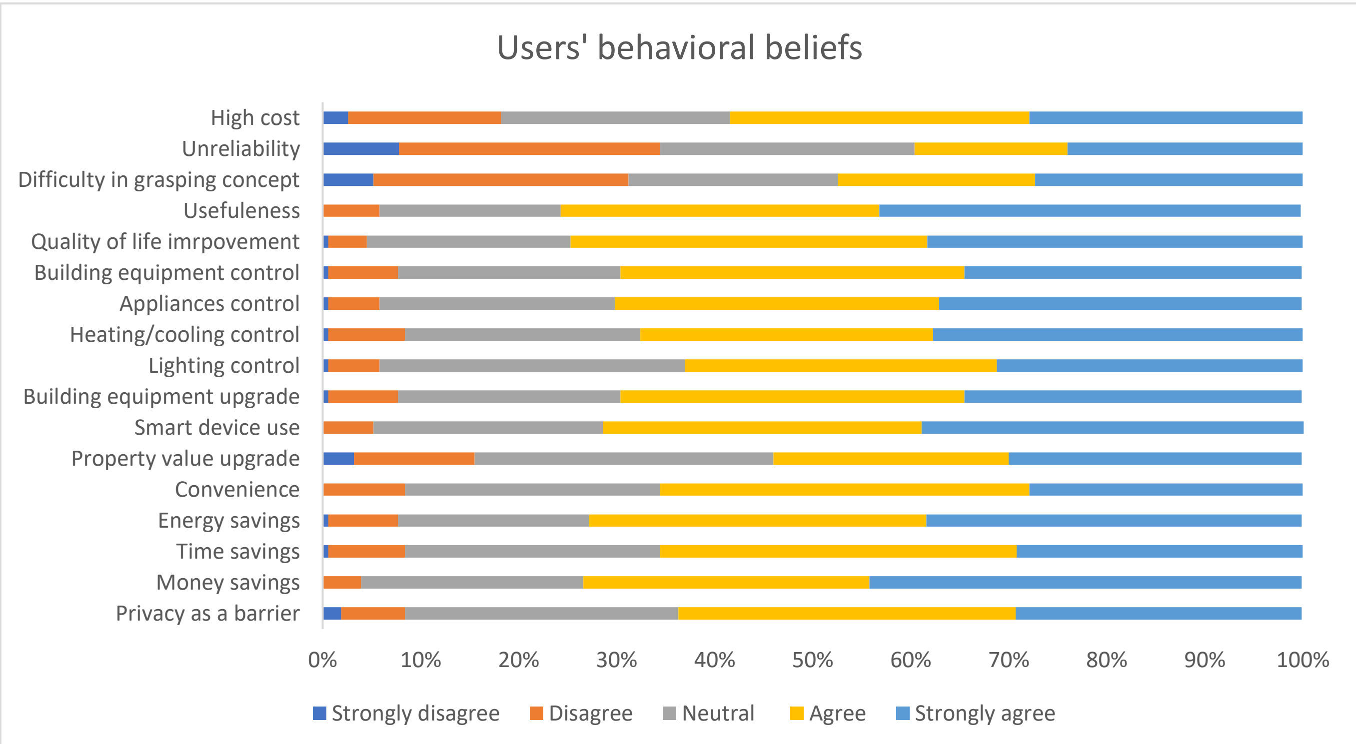

Figure 10. Users' responses on behavioral beliefs questions

Respondents mainly value money savings and energy savings as important factors in their decision-making process, with almost 75% of responses being positive in both groups (Figure 9 & Figure 10). 65.6% of users also evaluate time savings as an enabling factor, which likely stems from their experience with smart systems/technology.

It is worth noting that attitude is impacted by income level, since in both groups those with higher income perceived smart technology more positively than those with lower income (Figure 11). Low-income respondents do not value smart technology's benefits as highly, except for money and energy savings that come with smart home systems installation (detailed breakdown of behavioral beliefs by income is presented in Annex III, Figure 43 and Figure 44).

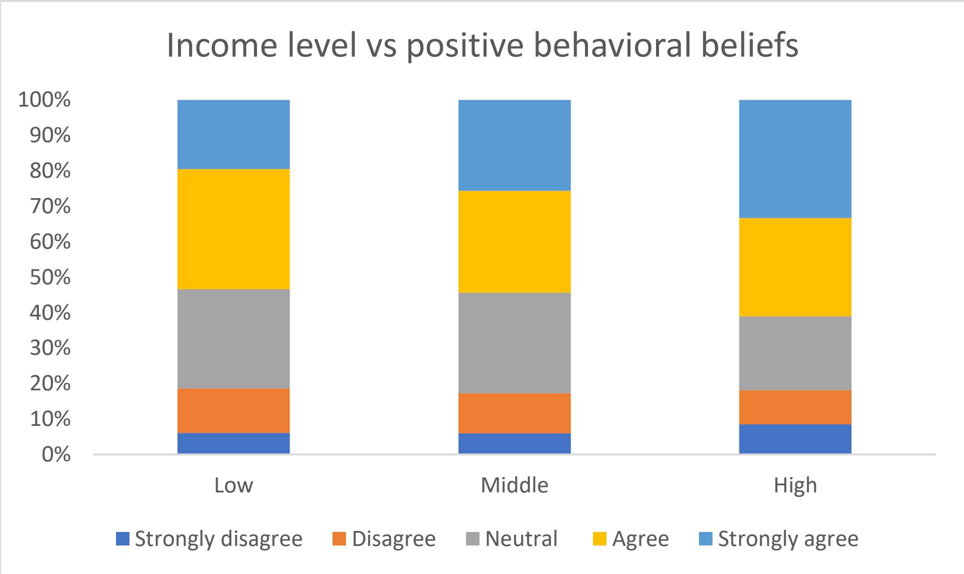

Figure 11. Income level versus positive behavioral beliefs for all respondents

Further, in the group of non-users, attitude seems to be impacted by age, with the dynamic group of the society aged between 16-50 being more positive than those over 50 (Figure 12). This group values, apart from money and energy savings, usefulness and time savings higher than those over the age of 50, which is reasonable considering that it represents the active work force of the society (detailed breakdown of behavioral beliefs by age is presented in Annex III, Figure 45 & Figure 46). Thereby benefits of the smart home systems adoption that might improve their daily lives, like saving time, are highly appreciated. In the users' group, positive attitude seems to be prevalent in all groups irrespective of age.

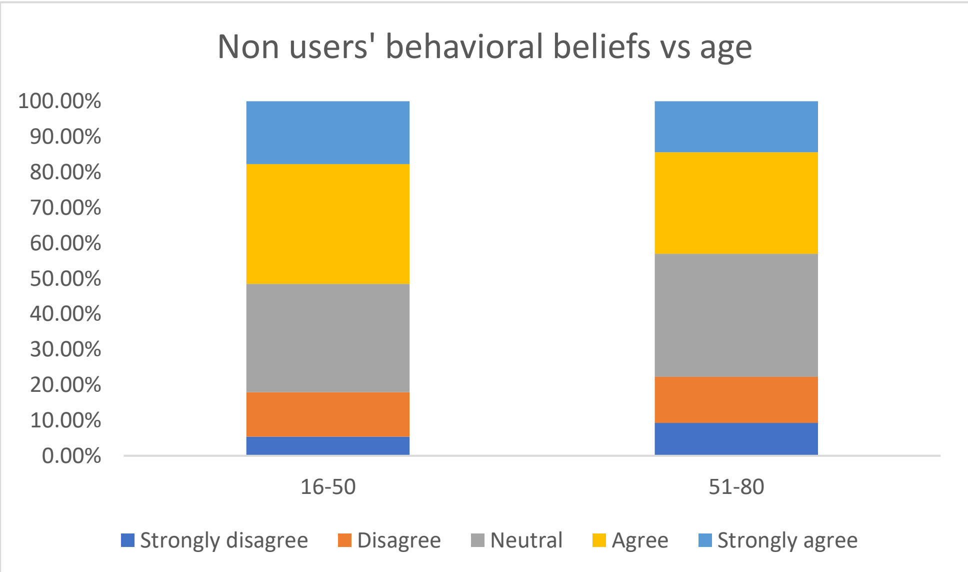

Figure 12. Age versus positive behavioral beliefs for non-user

Another socio-demographic variable that has an effect on attitude is education level, where overall vocational center graduates, post-graduates and to a lesser extent university graduates, seem to be more positively oriented towards the use of smart technology (Figure 13). This is reasonable, considering that they tend to be more technical or feel more familiar with the concept. Indeed, this seems to be further corroborated by the fact that from the group of non-users, those who declared familiarity with the smart building concept had also a more positive attitude towards it.

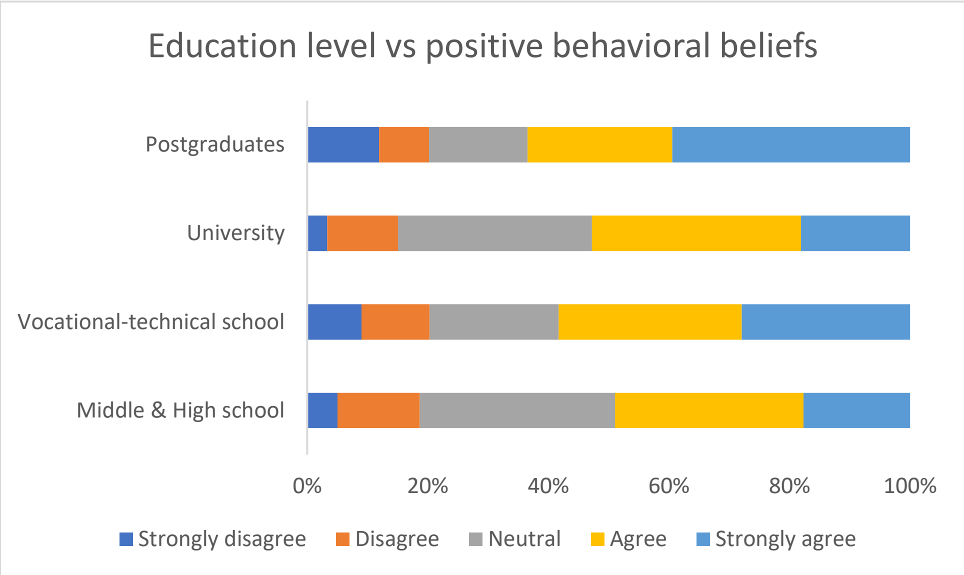

Figure 13. Behavioral beliefs versus education level for all respondents

With respect to negative perceptions of smart building technology, both groups of users and non-users (more than 60%), perceive privacy as an important barrier to adoption and also more than 50% of them believe that smart technology is too expensive. Users also tend to have more concerns about unreliability and complex concept than non-users, probably because they have more expectations for the systems' performance and ease of use. Nevertheless, at large less than 50% of the users agree on having difficulty or reliability concerns. Most non-users, on the other hand, disagree on smart technology being unreliable, or the concept too complicated, except for people who are at a beginner's stage of computer literacy level who are concerned about the concept complexity (Figure 14 & Figure 15).

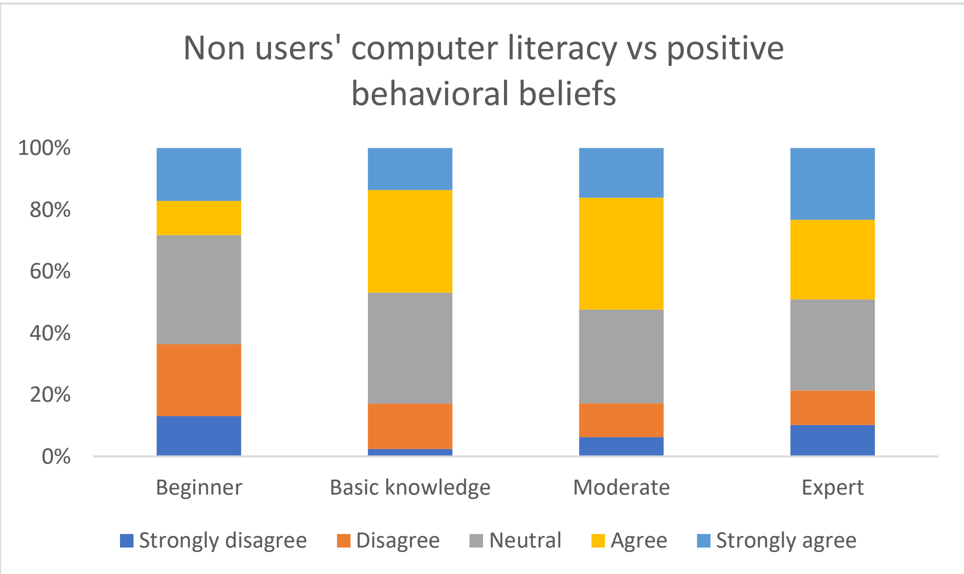

Figure 14. Behavioral beliefs of non-users versus computer literacy level

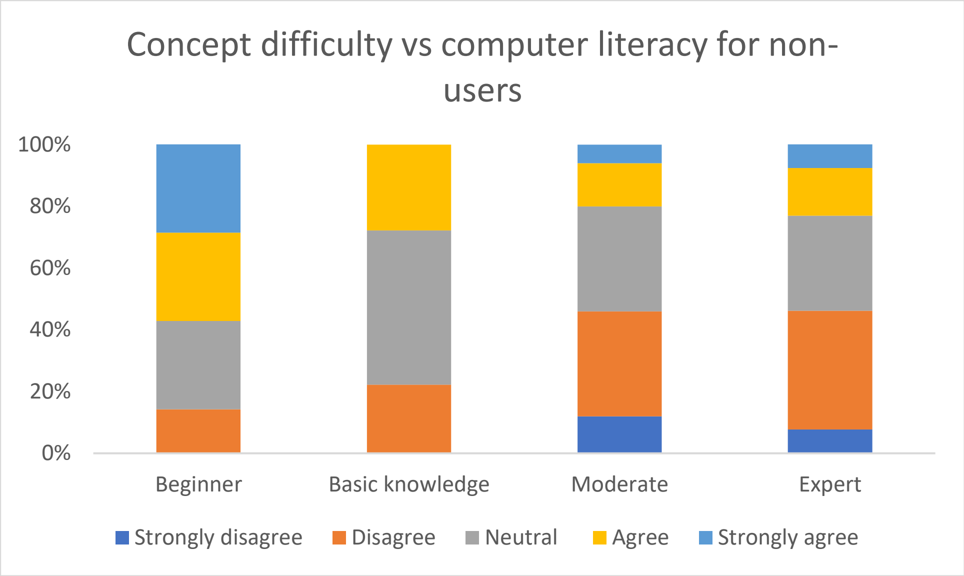

Figure 15. Concept difficulty perception of non-users versus computer literacy level

The results of the EU Survey respondents from the pilot sites, are also illustrated in Annex III, Figure 47, and reveal that there is a good agreement with the trends extracted from the survey overall.

3.4.1.2 Normative beliefs

Normative beliefs are not perceived highly by the non-users, with less than 30% of them feeling motivated to comply with the expectations of their significant others with respect to smart technology (Figure 16). Users, on the other hand, seem to take normative beliefs more into consideration, with close to 50% of them feeling the pressure to upgrade to smart buildings, and 54% to use smart devices (Figure 17).

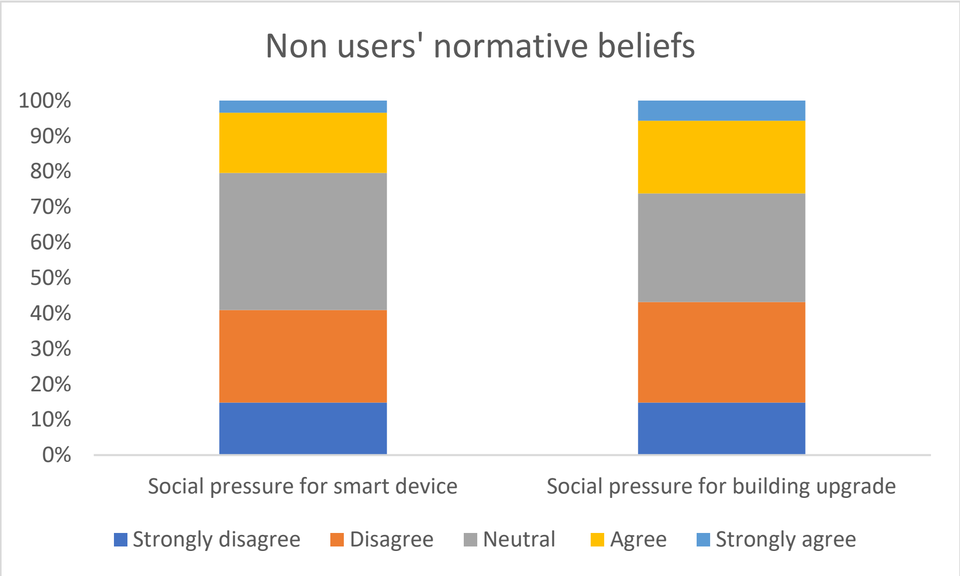

Figure 16. Non-users' responses on normative beliefs questions

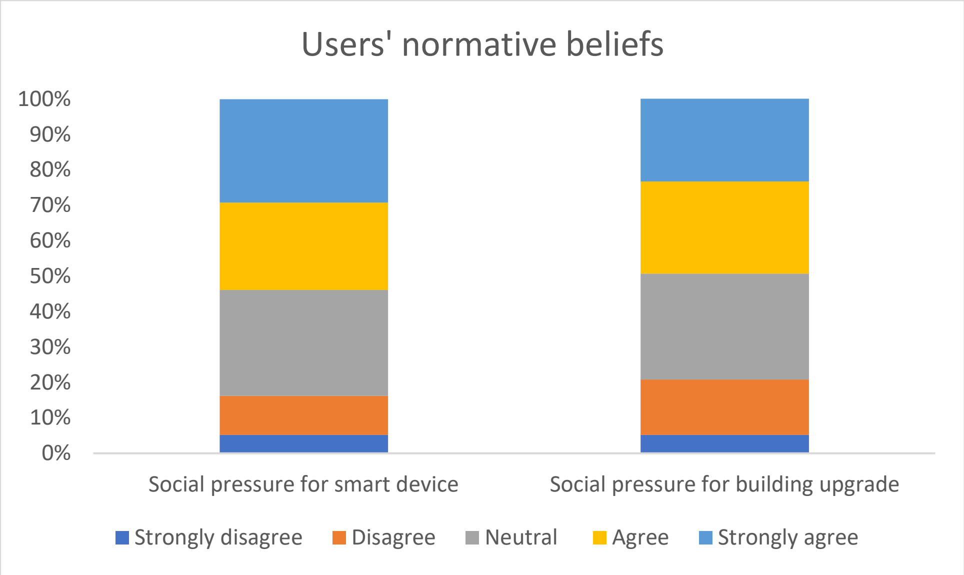

Figure 17. Users' responses on normative beliefs questions

Within the group of non-users, income seems to be positively affecting normative beliefs with those at higher income levels perceiving social pressure more as a motivation to engage with smart technology, either use a smart device or proceed to building upgrade (Figure 18). Education level also seems to be impacting how social pressure is perceived, with post-graduates being more amenable to the effect of their social environment.

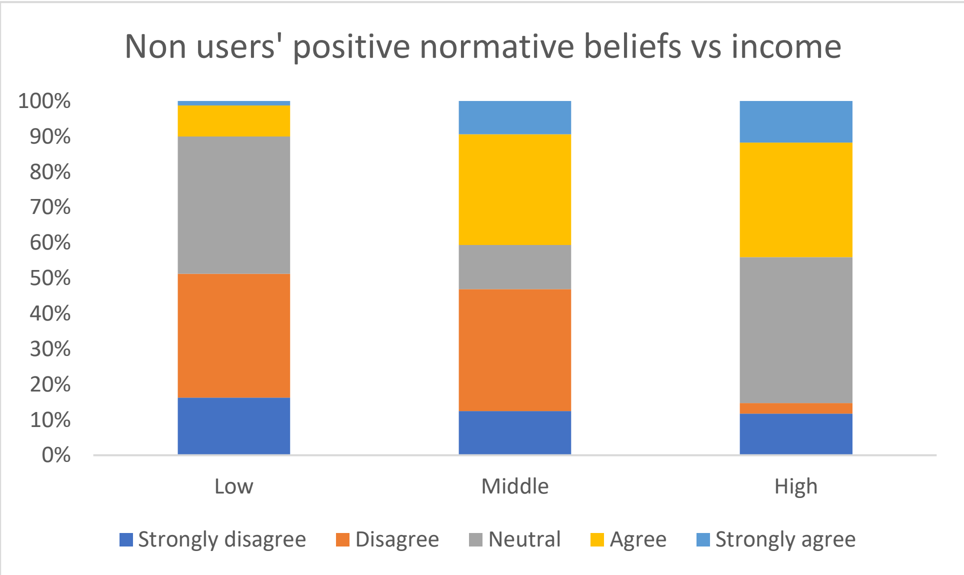

Figure 18. Normative beliefs on non-users versus income

Similarly to the non-users' case, normative beliefs of users are impacted by income level (Figure 19), but also by education level, with vocational center graduates and post-graduates being more amenable to the influence of their social environment when it comes to smart technology (Figure 20). Architects, planners, surveyors, designers and ICT professionals within this group, are also more positive to normative beliefs (Figure 21), which is expected, considering the high compatibility of their work with the concept and the higher exposure to smart technology.

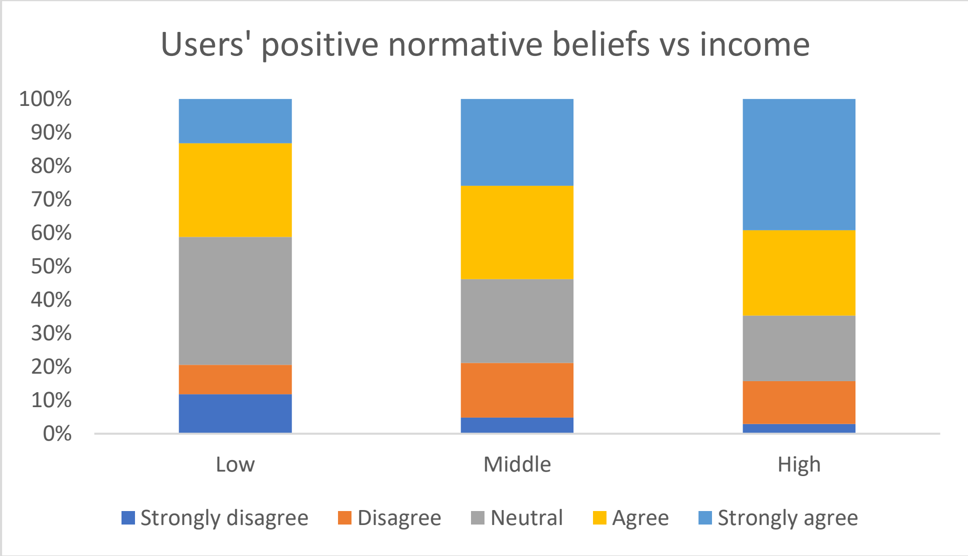

Figure 19. Normative beliefs of users versus income

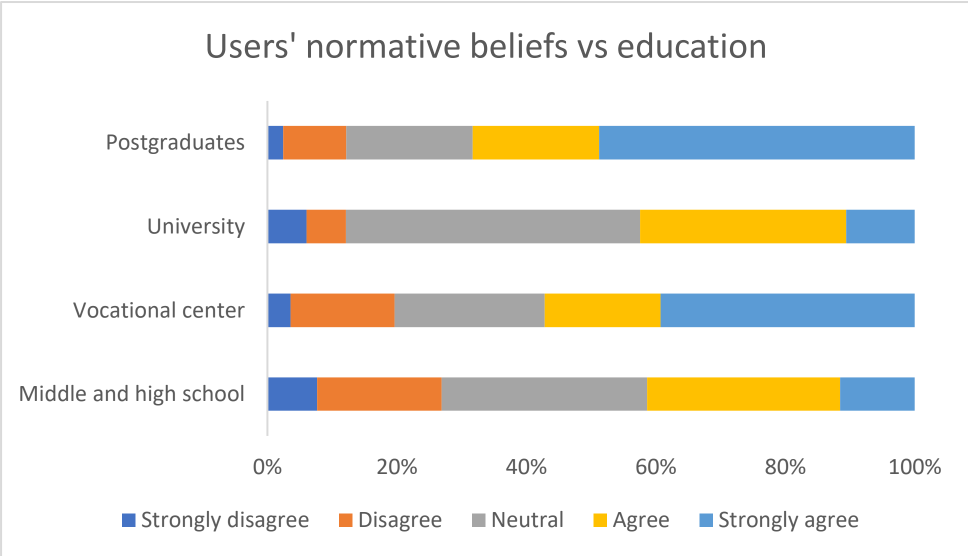

Figure 20. Normative beliefs of users versus education level

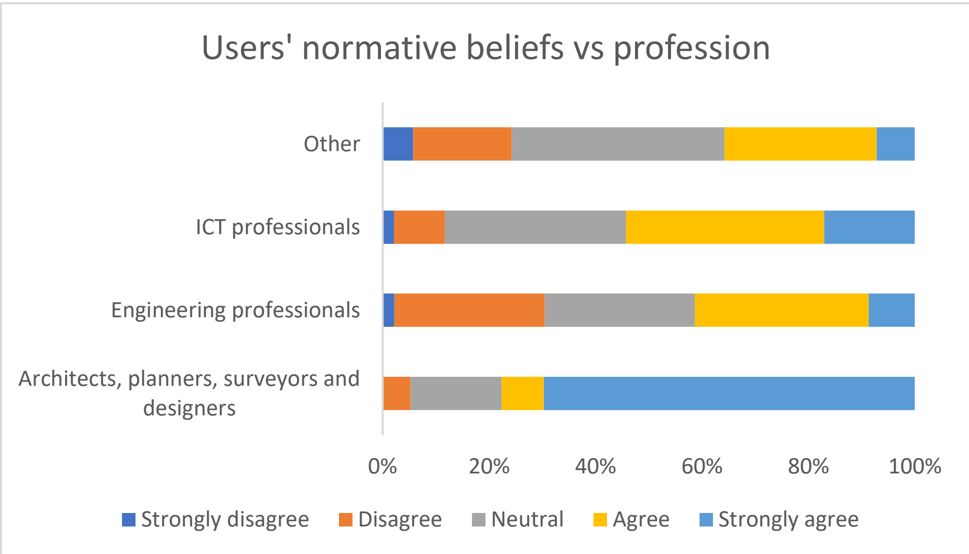

Figure 21. Normative beliefs of users versus professional affinity to the smart building concept

The EU Survey results alone, are also depicted in Annex IV, Figure 48, and show a good agreement with the non-users' group perceptions.

3.4.1.3 Social innovativeness

In the same spirit as normative beliefs, social innovativeness does not appear as an engaging factor for non-users, yet, in this case, irrespective of the age group and other demographic variables (Figure 22). Users on the other hand, seem to appreciate social impression and value with which they can present themselves to others when engaging with smart technology, and to a lesser but still significant extent, the ability to differentiate themselves from others (Figure 23).

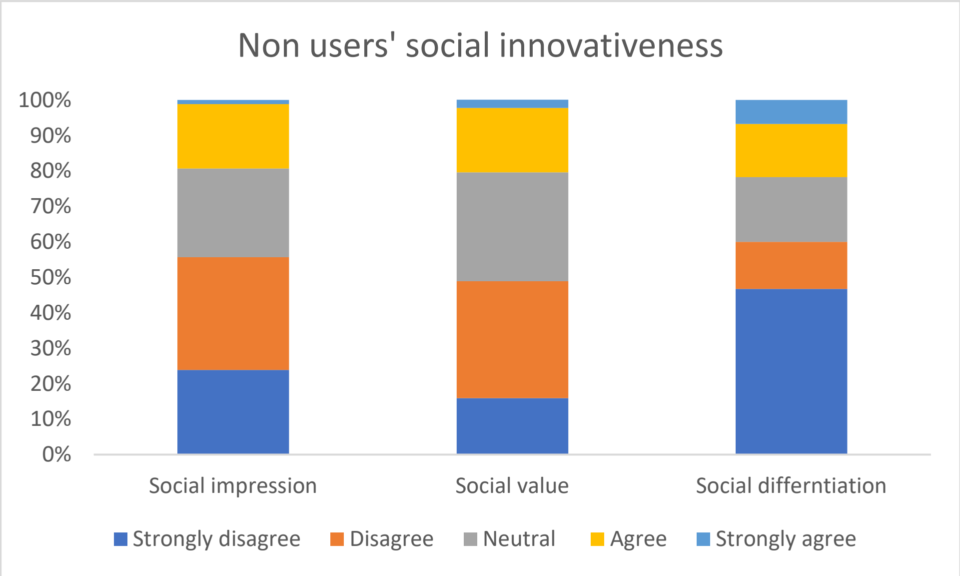

Figure 22. Non-users' responses on social innovativeness questions

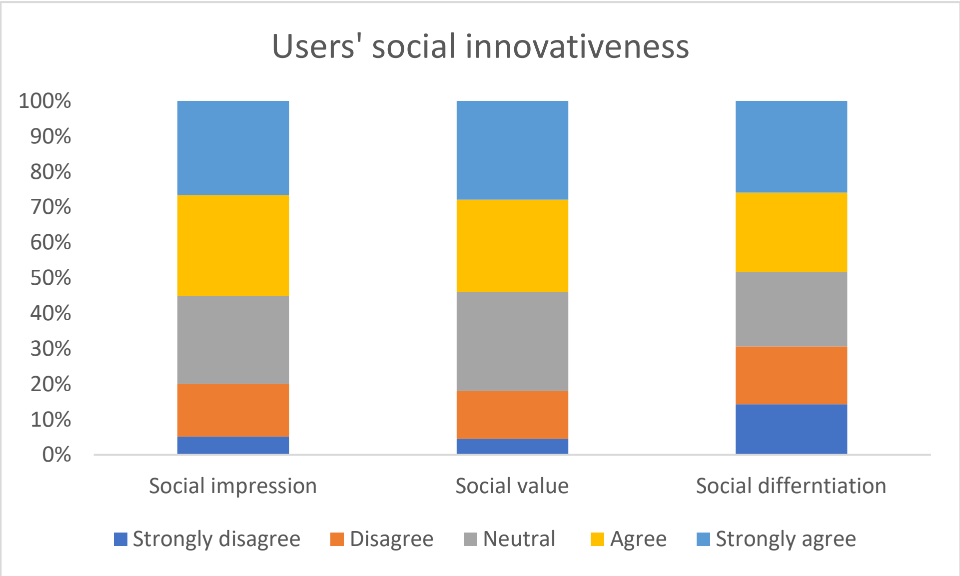

Figure 23. Users' responses on social innovativeness questions

The difference between the users and non-users in social aspects, could be either attributed to the fact that innovativeness is often considered a personality trait, thereby many of those who use smart devices feel the inherent need to demonstrate their innovativeness in their social environment [26], or it can be product specific and manifests itself upon use of smart technology [27]. Within the users' group, innovativeness seems to also correlate with income level, with those of higher income responding more positively to innovation aspects (Figure 24), likely seen as a means to demonstrate status within their social environment. Further, those with professional affinity and technically oriented education seem to also respond more positively.

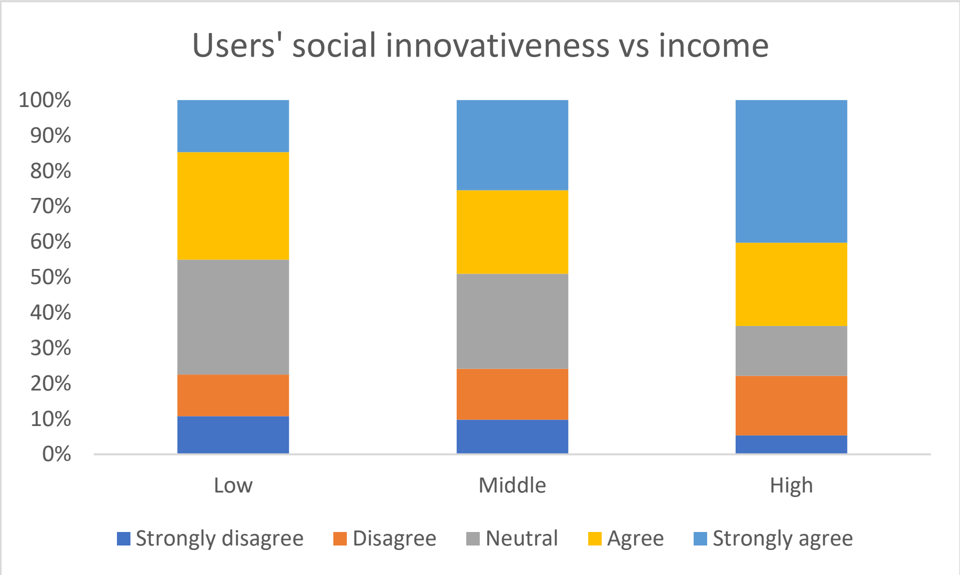

Figure 24. Social innovativeness of users versus income level

The EU Survey results alone, from the pilot sites occupants are illustrated in Annex V, Figure 49 and show a good agreement with the perceptions of non-users of the overall survey results.

3.4.1.4 Control beliefs

With respect to control beliefs, those who currently do not use smart technology are not as positive in their ability to control aspects of it (Figure 25). Users, as one would expect, feel they can exert more control on smart building systems (Figure 26).

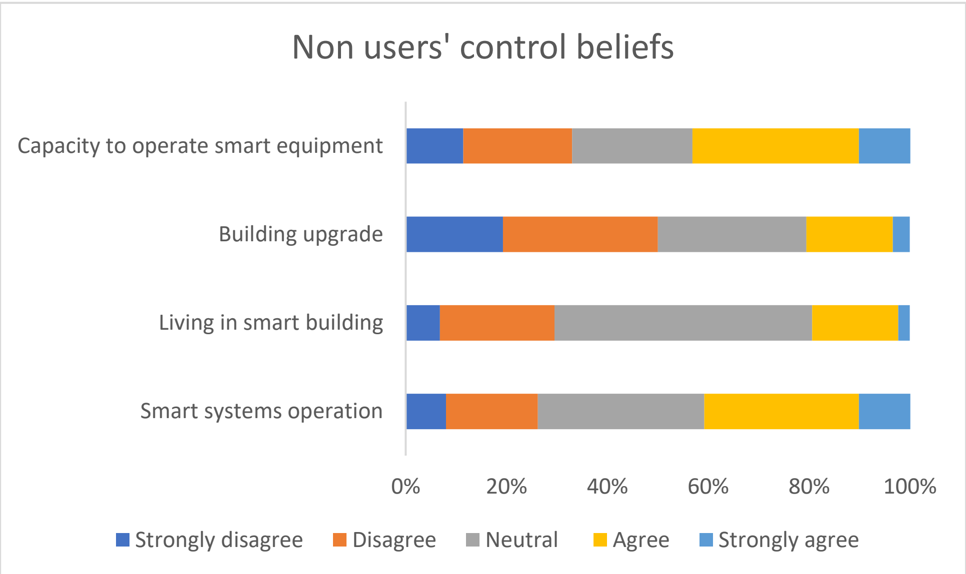

Figure 25. Non-users' responses to control beliefs questions

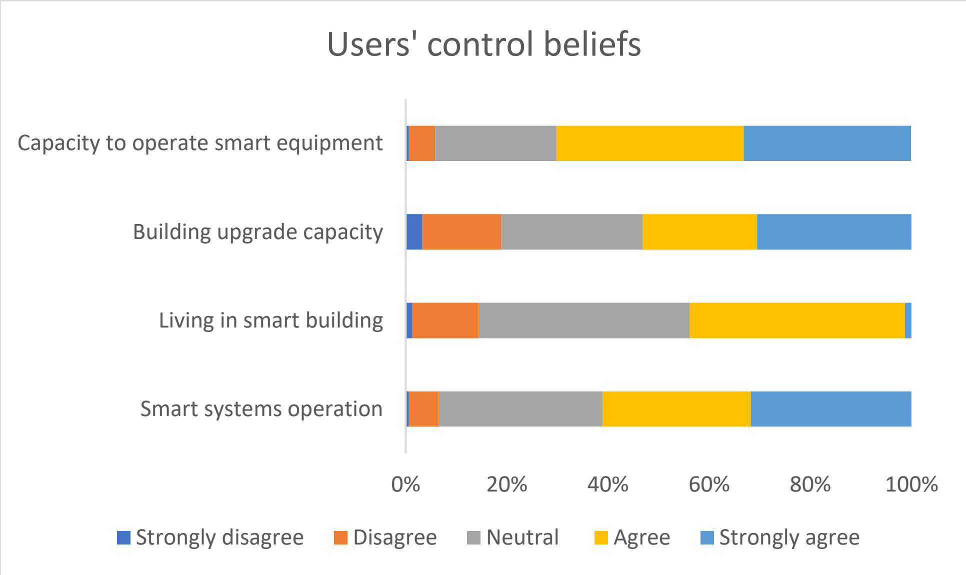

Figure 26. Users' responses to control beliefs questions.

Within the group of non-users, particularly those above 65 old are rather negative about exerting control over smart technology (Figure 27). They mostly disagree on their capacity to use smart technology (further breakdown of control beliefs by age is presented in Annex VI, Figure 50). By income level, low income respondents believe they do not have the financial capacity to upgrade their home to a smart one (62.5%) (Figure 28 and further breakdown of control beliefs by income is presented in Annex VI, Figure 51). Computer literacy also seems to have an effect on control beliefs of non-users, since beginners have over 82% of their responses being negative (Figure 29). Specifically, 85.7% of them believe they do not have the knowledge or skills to use smart equipment, all of them have responded negatively on their capacity to upgrade their home and 71.4% are concerned about their ability to operate smart systems (detailed breakdown of control beliefs by computer literacy is presented in Annex VI, Figure 52).

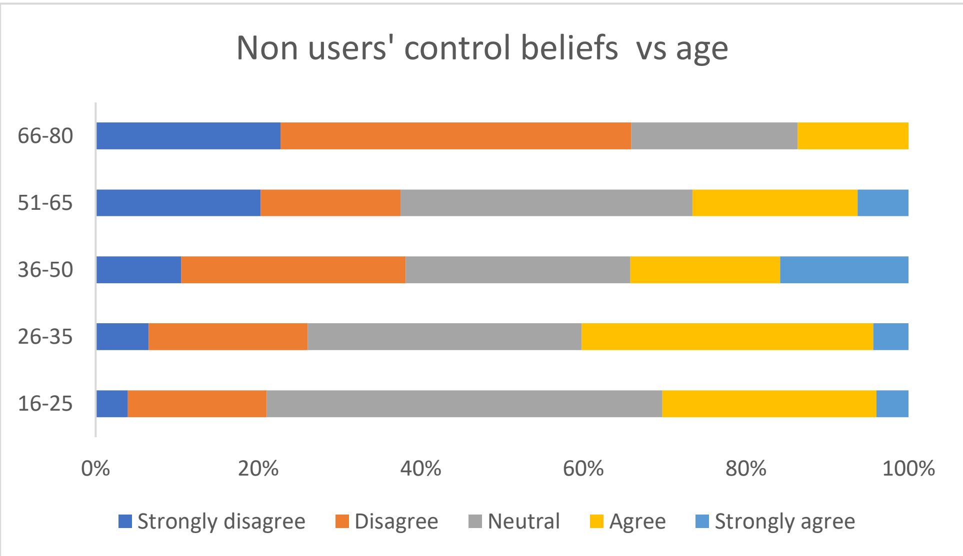

Figure 27. Control beliefs of non-users versus age

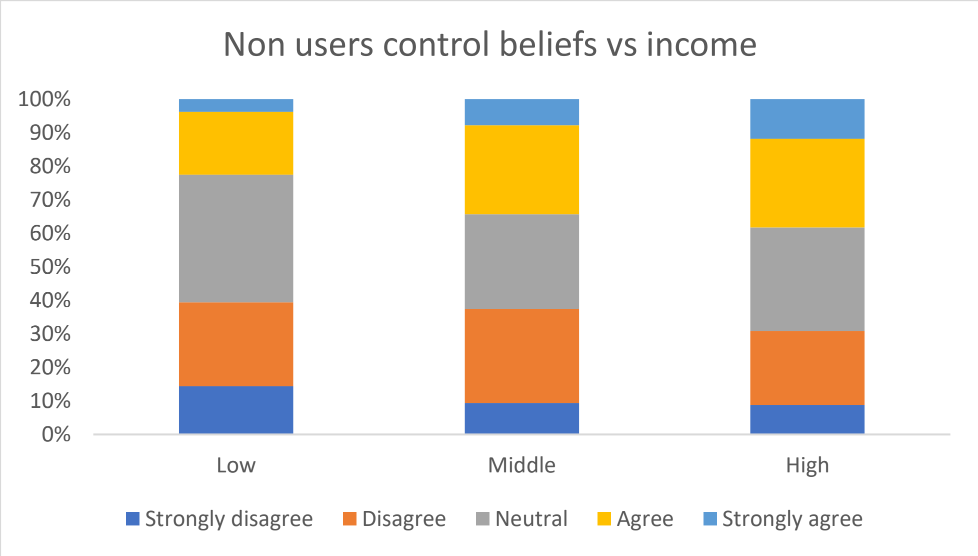

Figure 28.Control beliefs of non-users versus income level

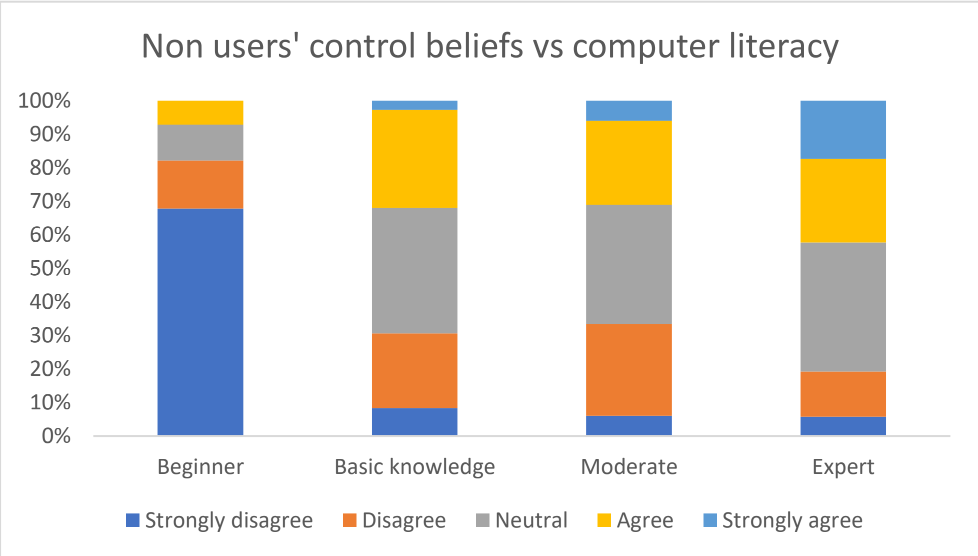

Figure 29. Control beliefs of non-users versus computer literacy level

On the other hand, within the users' group, an important distinction noticed, is that per tenure status, owners are more confident in their control than renters, with more than 60% of owners' responses being positive, as compared to 49% of renters (Figure 30). Renters are mostly neutral in their perceived control to live in a smart building, likely because probably they cannot make as many modifications in a space they do not own, while for owners options seem to be more present to upgrade their buildings.

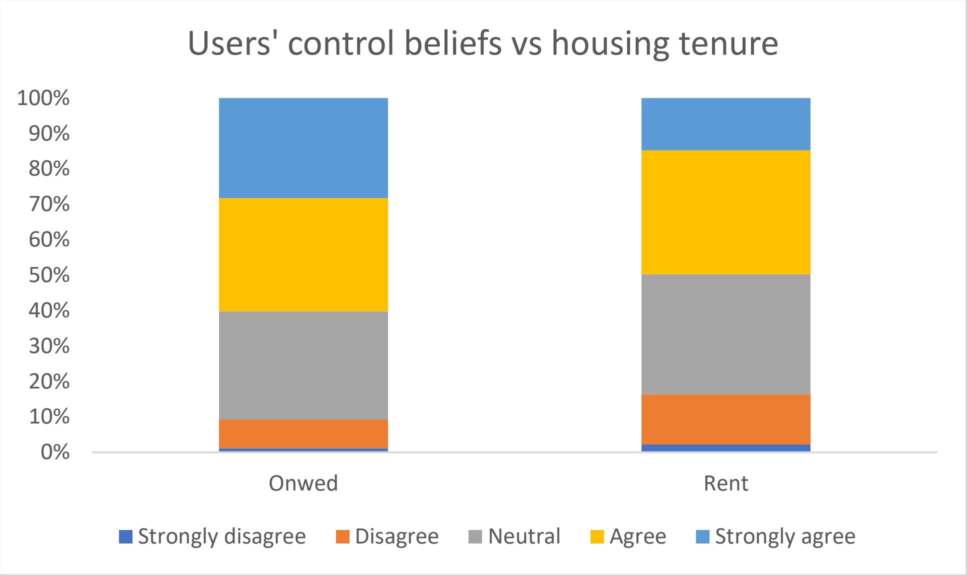

Figure 30.Control beliefs of users versus tenure status

The EU survey responses pertaining to the PHOENIX pilot sites are illustrated in Annex VI, Figure 53, exhibiting similar trends to the non-users' perceptions.

3.4.1.5 Tendency to change

With respect to tendency, 43.2% of non-users and 59.8% of users agree on being prone to using new products (Figure 31& Figure 32). Users, at large, irrespective of the other demographics, are naturally more inclined to try new products.

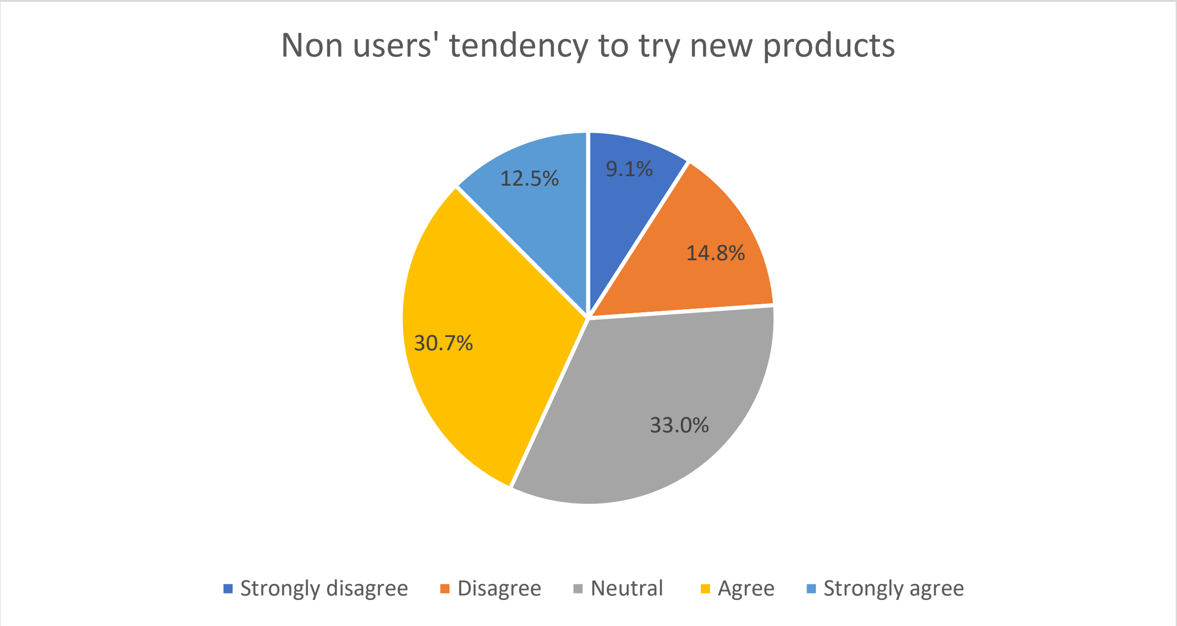

Figure 31. Non-users' tendency to use new products

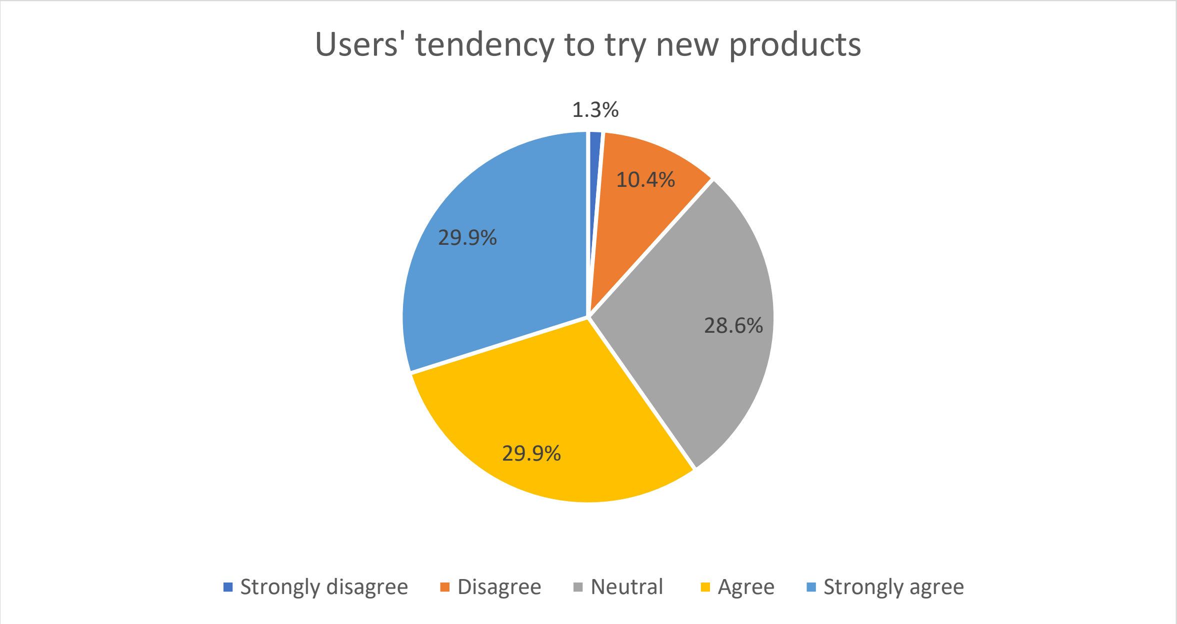

Figure 32. Users' tendency to use new products

In the non-users' group, there are differences in the responses by income level and age, which are illustrated in Figure 33 and Figure 34. By income level, 64.7% of the high-income group's and 56.25% of middle-income group's responses are positive, while those with low income have 40% of their responses negative. The dynamic society group aged 16-50 years old are also more positive towards using new products, the ages between 51-65 are balanced between neutral and positive and the over 65 years old are mostly neutral.

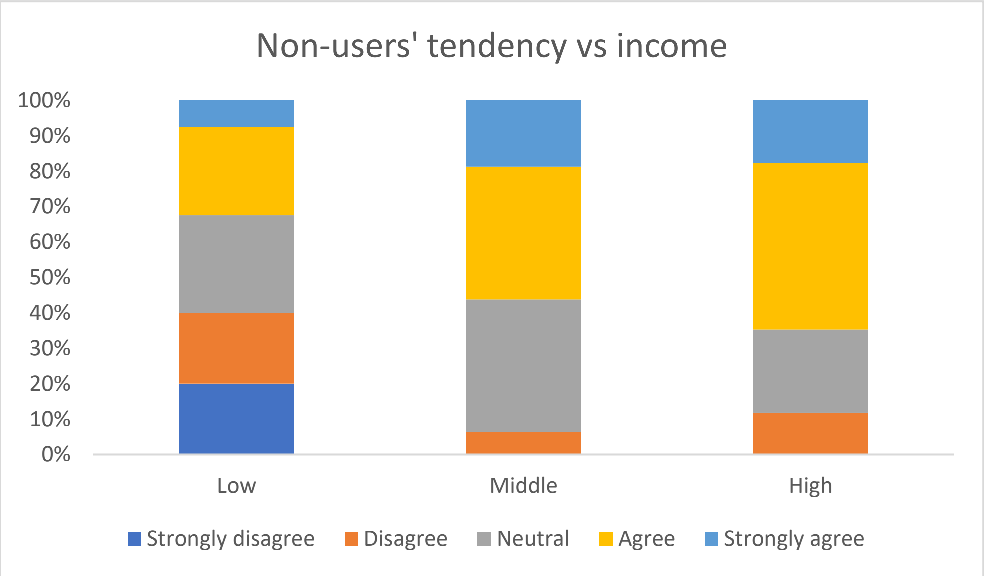

Figure 33. Non-users' tendency to try new products versus income level

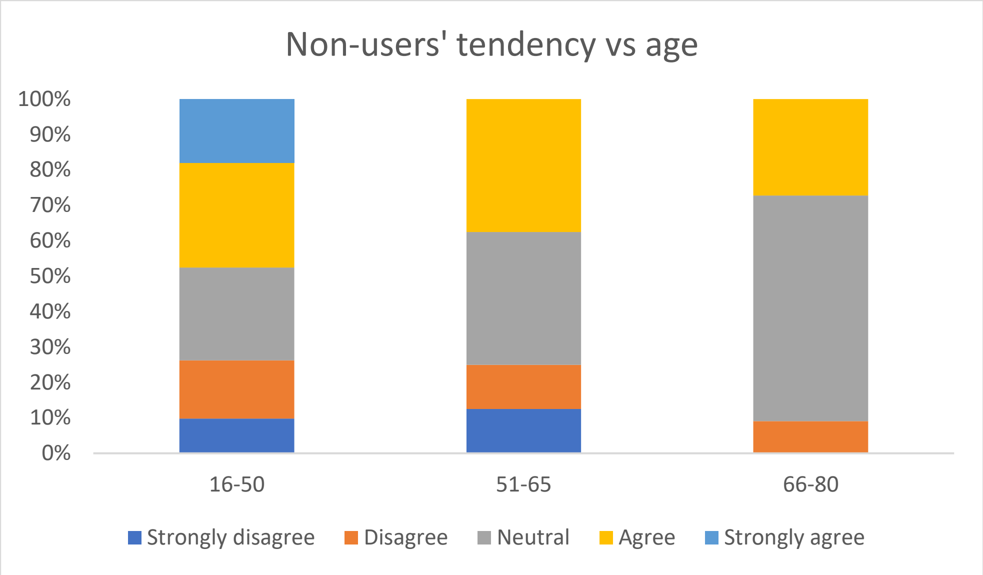

Figure 34. Non-users' tendency to try new products versus age

The EU Survey pilot occupants' responses alone, are illustrated in Annex VII, Figure 54 following the same trends as the non-users' responses.

3.4.2 Intention

Intention is shaped by the respondents' perceptions. Timing intention for those who currently do not use smart home technology has been checked against the demographic variables and some of them had an effect on the responses. In general, 40.7% of the respondents intend to engage with smart home technology in less than five years, 40.7% in 5 to 10 years from now, 12.8% in 11-20 years and 15.1% do not intend to use smart technology (Figure 35).

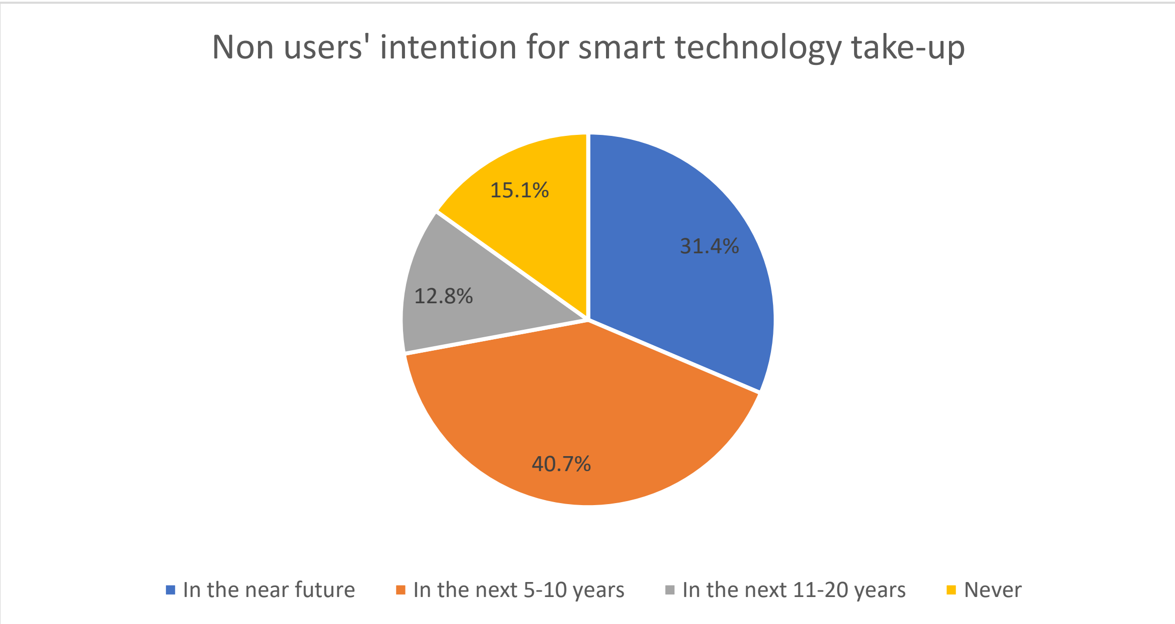

Figure 35. Non-users' intention to engage with smart home technology

By age, most groups of respondents indicated they intend to use smart building systems within the next 10 years and only a smaller share of them declared negative intention. The results reflect the generally positive behavioral beliefs of non-users, but also of their concerns over their current perceived ability to exert some sort of control over smart technology. Particularly most of the active working force group aged between 16-50 are planning on engaging with smart building technology in the next 5-10 years (Figure 36).

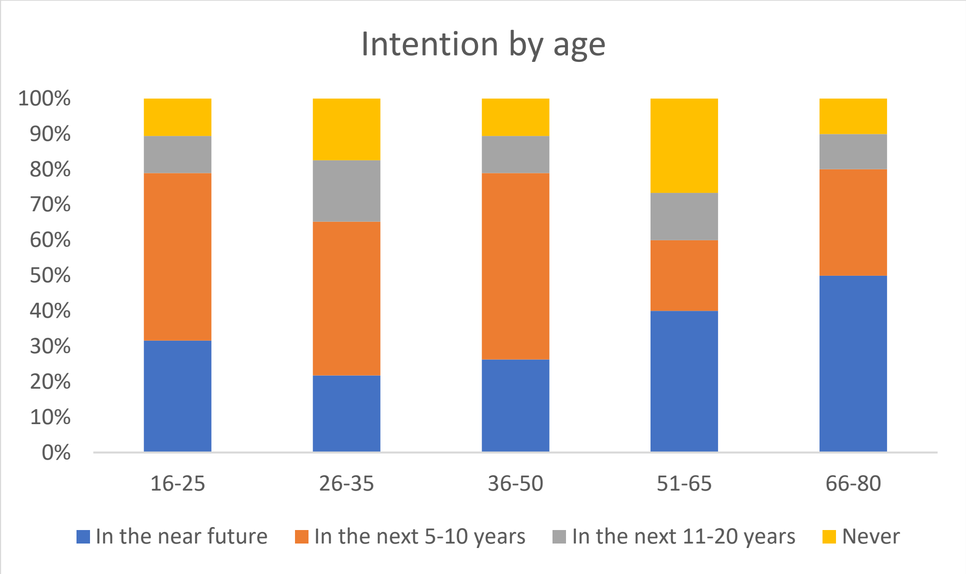

Figure 36. Non-users' intention by age groups

Further, housing tenure is an important consideration for those who are planning to adopt smart building technology. A large share of owners intend to adopt it in the near future, probably as it is easier for them to make the necessary modifications, as opposed to renters who are more limited in their options to upgrade a house or building they do not own. A large share of renters, however, plans to engage with smart technology in the next 5-10 years, probably related to their expectations of their housing tenure status or income level by that time (Figure 37).

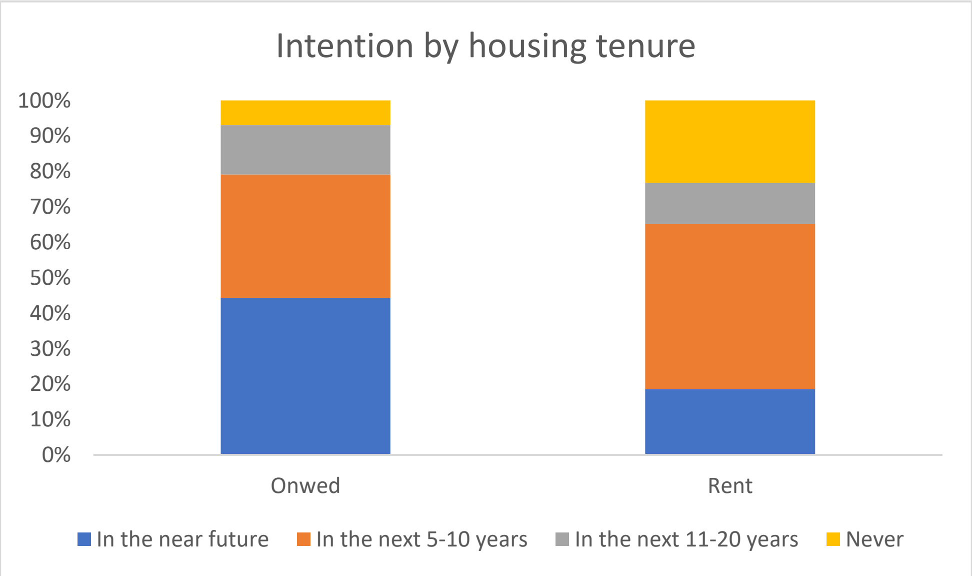

Figure 37. Non-users' intention by housing tenure status

With respect to income, only a share of low-income respondents stated they never intend to engage with smart technology, while the largest share of high-income respondents intends to engage with it in the near future. This is expected since those with higher incomes were more positively oriented in their smart technology beliefs. Most of middle- and low-income respondents intend to engage with the smart building concept in the coming 5-10 years, likely linked to their expectations of their future income status (Figure 38).

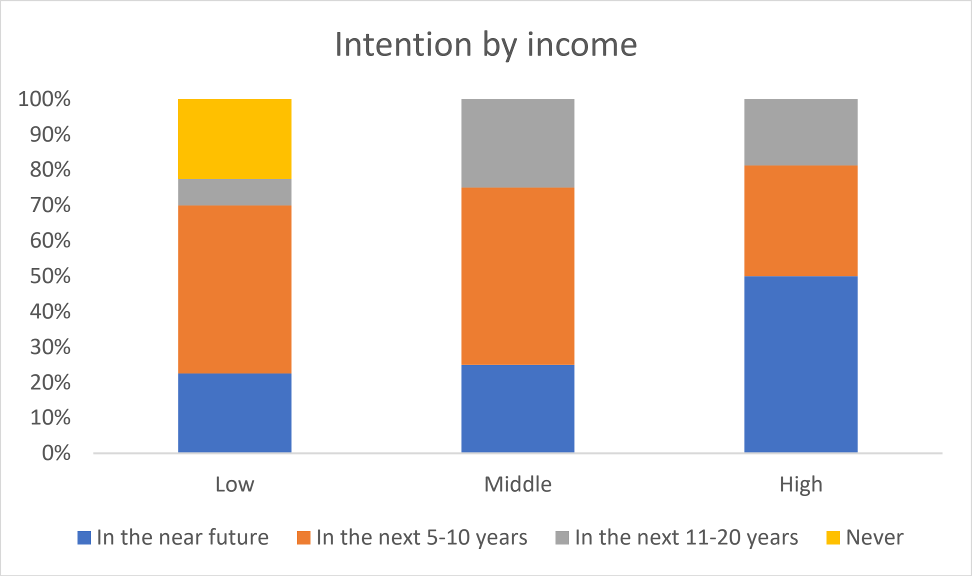

Figure 38. Non-users' intention by income level

3.4.3 Type of smart building technology and services

Within the scope of this deliverable, respondents who currently do not use smart systems were also invited to indicate what type of smart building systems they would like to use. This was a multi-select answer and out of those who intend to use smart technology, 55.7% would like to use energy building equipment, mostly renewable sources and energy storage, 36.4% would like to use energy management systems, 33% would like to use long life appliances, mostly to control lighting and domestic hot water (DHW), and only 11.4% selected the option of short life appliances, and particularly washing machines and fridges.

On the other hand, those who currently use smart systems, were invited to specify the type of systems used. 59.1% of respondents who already enjoy smart building systems and services, currently use long life appliances, mostly radiators and boilers, and 46.8% currently use short life appliances, mostly washing machines and fridges. Finally, 41.6% of the users have indicated they currently use energy building equipment, mostly renewable sources and energy storage, and 27.9% use smart energy systems.

In the next section, the perceived beliefs as extracted by the surveys, are translated into social barriers and enablers, and subsequently, to social-based requirements for the adoption of smart building technology

4 SOCIAL BARRIERS AND ENABLERS PERTINENT TO THE PHOENIX PROJECT

4.1 Overview of social barriers and enablers

Identifying the primary obstacles and promoters for applying smart systems via the PHOENIX project is of crucial importance for the project's implementation. Based on the analysis above, several social barriers and enablers related to the PHOENIX project have been identified and measured, and are being analysed in this section with the aim to reveal further potential strategies for the uptake and exploitation of PHOENIX solutions.

One of the major findings is the fact that most people have a positive attitude (behavioral beliefs) towards the idea of smart building technology and services, and perceive themselves as prone to using new products (tendency), even if they are currently unknown to them. This indicates that they are open to changing their current lifestyles if there are better alternatives or incentives to change. Those who currently use smart systems or are familiar with the concept are more positively inclined towards it than non-users, who do not value the benefits as highly, reflecting their uncertainty about the concept. In line with this, non-users also raise concerns about their ability to exert control over smart technology, either in terms of knowledge to handle it or in terms of financial capacity to adopt it. Further, non-users do not seem to be much affected by the social norms, while users are generally motivated by their social environment. These perceptions are further diversified mainly across different age groups, income levels, education levels and others.

Perceived risks of smart building technology use are a result of uncertainty in relation to manageability, data security and affordance, which have a negative influence on intention, and therefore are considered as barriers. In contrast, expectations about the potential benefits of smart building technology, along with the social-psychological factors that motivate people towards a specific behavior positively affect intention and are thus considered as enablers. The next sections contain an in-depth analysis of the key barriers and enablers, as extracted by the survey results.

4.1.1 Barriers

4.1.1.1 Privacy concerns

For the upgrade of existing buildings to smarter ones, smart devices connected to the internet, such as BMS and sensors, are needed. These devices collect, process and analyze vast amounts of data in order to provide tailored services to end users in a way that optimally supports their lifestyle. Such information could be, for instance, the consumers' energy use, or information about their movement around the house using sensors or cameras. Further to that, as remote control is an inextricable part of smart home services, for instance, for controlling the lighting through a mobile device, there are also concerns about potential network breaches that might also impact personal privacy. Subsequently, users feel that they may not be able to oversee when and by whom data are collected and stored in databases, as well as how their data are being used and potentially exploited. The surveys revealed that over 63% of the people who currently use smart systems agree that privacy is a concern for buildings' transformation. From those who currently do not use smart devices, over 68% consider privacy concerns to be a significant barrier to engaging with smart technology. Out of both groups, people who are more concerned about privacy are people aged between 26-65, followed by people aged between 16-25, while those over 65 years old, are less concerned about privacy issues.

4.1.1.2 Cost and affordability

The cost for the replacement of legacy equipment or the installation of new smart devices, in some cases can be high. Additionally, there is currently a lack of a clear business case for the deployment of smart systems in buildings and this may confuse the way in which the technological upgrade can take place. The general feeling, however, is that smart buildings technology is expensive and when there are no financial incentives or public funding, end users have to absorb this cost. This is reflected in the results of the survey where in both groups (users/non-users) more than 51% of respondents believe that smart building technology is expensive. The survey results showed that this variable is not income-driven, meaning that high income respondents seem to consider the technology as too expensive, although they have might have the financial capacity to pay for smart energy equipment. This has clear implications on their willingness to pay.

On the other hand, the survey showed that half of the group of non-users believe that they do not have the financial capacity to upgrade their building to a smart one. Such upgrades, require infrastructure investments and thereby upfront capital, raising consumers' concerns about affordability, particularly for people with limited financial resources. Therefore, although monetary savings are highly appreciated by the respondents, the up-front investments that have to be incurred, seem to demotivate them, since, as the literature suggests, such costs are usually measured against the private returns and the payback time, which is often considered by consumers as quite long [28].

4.1.1.3 Lack of perceived control on the technology

The degree to which people feel they can use technology makes them comfortable or uncomfortable with the concept of living in smart buildings. The survey has shown that regarding the group of non-users, only a small part of them (19.3%) feels comfortable to live in a smart building, while the largest part of them feels neutral, reflecting their uncertainty about the concept and their control over it. Hence, the lack of perceived ability to live with smart building equipment, that is identified here for the case of non-users of smart systems, is a barrier for the upgrade to smart homes. The groups of non-users that mostly find it difficult to adapt to the environment of a smart buildings are the retired people, mostly aged above 65 years old and those who are not technology savvy.

Along with ability, concept understanding and knowledge also determine the degree to which a person feels comfortable or uncomfortable with the idea of obtaining and using smart devices or equipment. The lack of understanding or the perceived complexity of smart building equipment is a barrier for upgrading to smart homes for non-users, and especially for people who are not particularly technology oriented.

As it is expected, smart building systems and services, as any new technology, face challenges to adoption. Many people are concerned about how a smart building will affect their lives until they have a clear understanding of the concept and its benefits. At this point, it should be stressed that, as the survey revealed, the public response is not unfavorable to the smart building concept: the majority of people have a positive attitude and already use or intend to use smart technology at some point in the future. This means, that even if people are unaware of smart systems or reluctant to adopt it in fear of their ability to adapt, they are not uninterested or indifferent.

The following table summarizes the key barriers to smart building uptake.

Table 4. Social barriers as extracted from the survey results

Barrier	Aspect	Comments/Level of importance
Data security	Privacy	Very important barrier for the upgrade of smart buildings
Financial	Cost	An important barrier for the penetration of smart equipment in buildings
	Lack of financial capacity	Prohibits the upgrade of a building to a smart one for non-users
Lack of Control	Lack of perceived ability to adapt in a smart building environment	Restricts smart systems' adoption in buildings for non-users
	Lack of knowledge of how to use smart building equipment	It is an obstacle to smart systems operation for non-users at low computer literacy level

The social barriers in ranking order, as perceived by the groups of non-users and users, distinctively, are illustrated in the following figure. At this point, it is worth noting that users perceive high cost to be a main barrier, indicating reluctance of willingness to pay, although the solution might be affordable. On the other hand, non-users' major financial concern is their capacity to pay, as they feel they lack the financial resources to upgrade their building to a smart one.

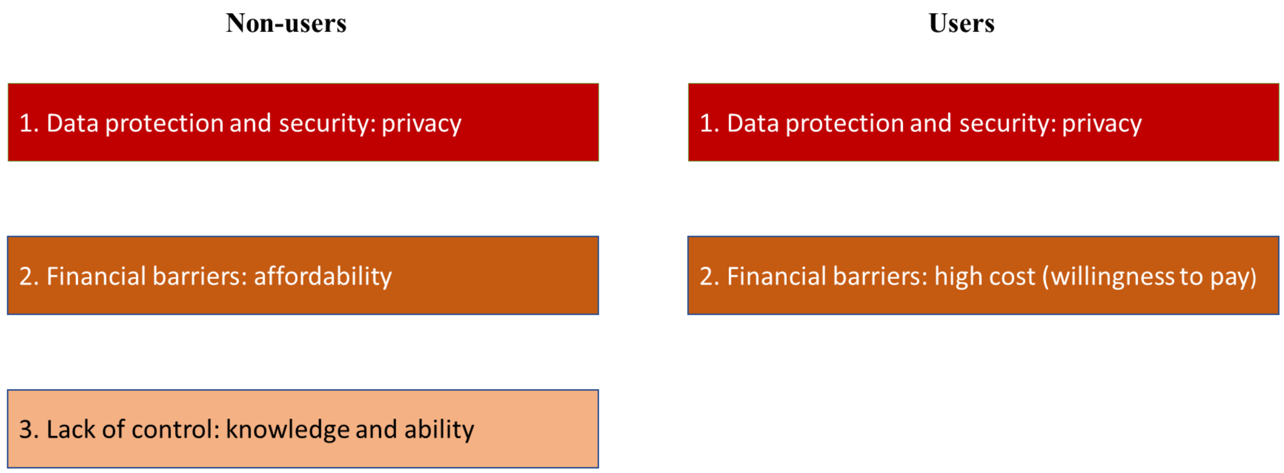

Figure 39. Key social barriers in order of importance for the group of non-users of smart systems (left) and the group of users (right)

4.1.2 Enablers

4.1.2.1 Monetary savings

According to the survey's results, the possibility of financial benefit in terms of saving money is a very strong incentive in order to participate in actions and services related to smart building upgrades. Replacement of legacy equipment as well as installation of new, non-cost-effective devices can bring financial benefits in most cases, by optimizing energy consumption and decreasing at the same time the energy demand. From the survey's results it seems that for the majority of respondents - 75% of non-users and 73.4% of users - money savings is considered as a very important enabler.

4.1.2.2 Energy conservation

The reduction of energy consumption is a European-wide challenge in recent years and many efforts are being made to address it. Energy savings can be considered as the basis of multiple benefits of energy efficiency and link to many other economic, social and environmental benefits. Energy demand reduction is promoted in many ways today (e.g. through governmental regulations and funding) and thus it is not surprising that more than 72.5% from those who currently use smart devices and 75% of those who don't, believe that energy saving, which is the primary purpose of the technological upgrade of the building, is a very important incentive to engage in the process of replacing old appliances/equipment to smart ones.

4.1.2.3 Perceived qualities & attributes

A very important factor for the majority of respondents in order to deal with the energy upgrade of their buildings is the convenience offered by smart devices. In the complexity of today's lifestyle, the simplification of procedures and actions that at the same time result in energy savings and economic benefits is leading to the adoption of new forms of energy management. According to the survey results, 54.5% of people who do not currently use smart devices and 65.6% of users who already use smart devices agreed that convenience is a factor that can lead to a smart upgrade.

Many home appliances can be controlled through smart devices having a practical and beneficial use, as they can automate many common daily routines, freeing up time to perform other tasks. For the group of people that already enjoy smart devices, usefulness is a very important incentive for the technological upgrade of the building, as well as time savings. From the respondents that do not use smart devices yet, those aged between 16-50 also find time savings to be a strongly motivating factor.

The broader concept of quality of life includes complete physical, mental and social well-being, capturing dimensions, such as safety, health and environmental quality, beyond convenience and time savings, which for the scope of this task were examined individually, since they have been cited in the literature as very important drivers of intention to adopt smart technology (Section 2). A building that has technological equipment that regulates the indoor conditions of the space such as air quality, temperature, humidity, shading, etc., creates for their occupants a sense of comfort and tranquillity that improves living conditions in everyday life. 74.7% of smart systems users point that the anticipated improvement of life is a strong enabler towards building's smart upgrade, while the same opinion is shared by 53.4% of non-users according to the survey's results.

Lastly, although reliability or unreliability is a subjective concept, it is an important parameter of decision making when it comes to network-based systems. When a product or service is considered reliable, it provides a consistent and predictable experience. Results of the present research show that, on the one hand, users find the smart systems somewhat reliable (approximately 40% of the users consider smart systems unreliable), and on the other hand, non-users find the smart systems extremely reliable (only 10% of the non-users consider smart systems unreliable). As a result, the concept of unreliability as a barrier not only it does not exist for the case of users, but it may be perceived as an enabler for the case of smart building technology.

4.1.2.4 Concept valuation

Smart devices allow apartment/building owners to optimize consumption and reduce electricity use, in order to benefit from energy-related cost savings. These devices are interconnected through the internet, allowing users to control various functions remotely such as temperature, lighting, and security access. The management of these devices through a mobile application provide an ease of overall control to the building and thus, a great number of respondents - 60.2% of non-users and 71.4% of users - value the use of smart devices positively.

Furthermore, the upgrade of the equipment of a building in general provides comfort to the owners and users of the building in terms of safety, overall lower maintenance costs and feeling of renewal. Moreover, the majority of new smart devices have very low operational requirements in terms of energy consumption and provide overall increase in energy efficiency. This, in turn, may enable users to consider upgrades as it can be combined to a general renovation process. According to the survey's results, equipment upgrade is also evaluated positively, as 60.2% of non-users and 69.5% of users agree on that.

4.1.2.5 Value growth

The value of a property usually refers to the value of a building based on its market price. This price is influenced by several aspects, one of which is the technological upgrade of a building in light of energy savings. A percentage of 69.5% of smart systems users believe that an energy efficient building equipped with smart devices can increase its market value.

4.1.2.6 Enabling customer control

People value the level of control smart building systems offer. For instance, lighting control systems play a critical role in energy savings and are used widely in recent years. The basic functionalities provided from these systems are flexibility to satisfy user visual needs and automation to reduce energy costs, thus improving sustainability. Heating/cooling control applications are used to monitor and control internal thermal conditions in real time. An efficient control of different systems could result in significant energy consumption savings without users' comfort being affected. It is worth mentioning that, according to the surveys' analysis, the group of people that currently do not use any smart device does not value lighting control systems as much as users, but the majority of respondents, either users or non-users, value heating/cooling control.

People's sense of control is further enhanced by their confidence to manage and operate smart technology. This means that, apart from valuing the benefits of automated systems, consumers are more likely to engage with a behavior if they feel they can enact it successfully. The degree to which people are able to operate smart systems makes them comfortable enough with the idea of obtaining smart devices or equipment. Based on the findings of the present research, both non-users but even more so users of smart devices/equipment declare at a large extend able to operate smart building equipment. Regarding the ability to live in a smart building, only a small part of the respondents (14.3%) answered negatively, while the largest part of them feel either neutral or positive with this idea. Hence, the feeling of capability to handle smart technology in general and smart building equipment, that is identified here for the case of users of smart systems, is a strong motivator.

4.1.2.7 Social norms and lead user

Social pressure from people who are considered important, such as friends and family, combined with a person's motivation to comply with various norms, seems to influence certain societal groups' perspective of possessing smart devices. Overall, users of smart devices seem to take normative beliefs more into account, compared to non-users. In particular, higher income respondents of both categories are more positive to normative beliefs than those of lower income. One more finding regarding the connection of people's profession who are already users of smart devices/ equipment with their normative beliefs, is that architects and planners are mostly susceptible to social pressure from their peers. Therefore, people's opinion is an enabler for purchasing a smart device and also for proceeding with an upgrade in a building towards a smarter one, but mostly to people of high income, with some sort of professional affinity to smart technology.

Further to that, there is a share of consumers that are ahead of the market and who are willing to be early adopters of smart technology in order to cover needs the market cannot yet meet (Lead User Theory, [29]). In this respect, social innovativeness in the era of smart technology that we live in generally plays an important role. Traits, such as social value, induce a positive force towards the upgrading of existing building equipment/services to smart ones, but they cannot be considered as barriers to this upgrading when absent. Social value is highly important for smart devices/ equipment users, but rather indifferent and non-important for non-users, yet value is a strong enabler particularly for people of higher incomes. Social impression is also considered a strong enabler for users of smart technology. Moreover, it is found that architects and ICT professionals are more positive for social innovativeness compared to other professions.

4.1.2.8 Tendency to change

A large share of respondents has declared positive tendency to change. Tendency inherently captures whether people are prompted to modify their habits, not necessarily as early adopters. People's reaction to change, and more specifically, to new products, is an enabler when the reaction is positive. Smart devices, services and equipment are products of technological development and have created a new market in the building industry. Users, at large, tend to be more positive to change. On the other hand, non-users tend to react either neutrally or positively (one quarter of non-users are negative) towards trying new products, depending on different parameters that seem to affect human inertia. For example, people over 51 years old, and particularly those retired, as well as the unemployed, are more neutral to their tendency to change, likely reflecting their uncertainty on the concept or their lower level of capacity to engage with smart technology. Therefore, people's inclination to trying new products, even if they are currently unknown to them, is considered an enabler pertinent to specific societal groups.

A summary of the key enablers is presented in the following table:

Table 5.Social enablers as extracted from the survey results

Enabler	Aspect	Comments/Level of importance
Economic benefits	Monetary savings	Financial benefits are considered as the strongest incentive for the majority of respondents
Energy conservation	Energy savings	The decrease of energy consumption is a very strong incentive to engage in the process of replacing old equipment to smart for 3/4 of the respondents
Perceived attributes and qualities	Convenience	Indoor comfort is a strong enabler for building upgrade for the majority of respondents
	Usefulness	Equipment's usefulness tends to be a very important enabler, mostly for the users
	Reliability	Reliability is a strong enabler, especially for the non-users, as smart technology is considered unreliable by the 40% of the users and only by the 10% of the non-users
	Time savings	Important enablers for the active work force group, aged between 16-50, and particularly for the group of users
	Quality life improvement	The improvement of life's quality tends to be a very important enabler for the majority of respondents
Concept valuation	Smart device use	The feeling that using a smart device is a good idea tends to be a very important enabler for the majority of respondents
	Building equipment upgrade	The feeling that by upgrading the legacy equipment is a good idea tends to be a very important enabler at the same extend as it is for the use of smart devices
Value growth	Property value increase	Positive enabler for the users, but indifferent for the non-users

Enabler	Aspect	Comments/Level of importance
Enabling customer control	Energy control	Energy control is a very important factor for building's smartification only for the users
	Ability to use smart devices and live in a smart environment	Important factor, particularly for those who currently use smart systems, as they feel more in control of the technology, and hence are likely to continue using it
	Concept knowledge & understanding	The capacity to operate smart systems enables their usage for users, and especially vocational and post grads, who already have relevant experience
Normative beliefs and lead user	Social pressure	Low importance enabler for smart device and building upgrade for users, not considered as enabler at all for non-users
	Social innovativeness	Low importance enabler for smart system users, indifferent for non-users
Tendency to change	Tendency to try new products	Strong enabler for new smart technologies for users and neutral for non-users

The social enablers in ranking order, as perceived by the groups of non-users and users, distinctively, are illustrated in the figure below. Further breakdown of results by age, income level and other socio-demographics, might slightly change the order.

Non-users	Users
1. Economic benefits	1. Perceived qualities: usefulness|quality of life
2. Energy conservation	2. Economic benefits
3. Concept valuation	3. Energy conservation
4. Perceived qualities: convenience	4. Concept valuation
5. Enabling customer control	5. Property value upgrade
6. Perceived qualities: usefulness|quality of life	6. Enabling customer control
6. Perceived qualities: reliability	7. Perceived qualities: convenience|time savings
	8. Tendency to use new products
	9. Social norms & lead user

Figure 40. Key social enablers in order of importance for the group of non-users of smart systems (left) and the group of users (right)

4.2 Social-based requirements for the adoption of smart building systems/services

Consumer acceptance is largely dependent on a clear sense of the smart building concept benefits. As such, it is important for the PHOENIX project to tap into opportunities that offer the most advantages with the least cost, providing solutions that first and foremost, are properly designed to meet consumers' requirements and budget. Monetary savings are valued very highly and hence, consumers need to be clearly informed well in advance about the potential financial gains when engaging with smart building technology. At the same time, the majority of respondents raised concerns about the high upfront costs for the purchase and installation of smart building equipment. Particularly for low-income respondents it would be more reasonable to continue with the use of their current equipment until those fail or become highly expensive to maintain. This means that, for most people to be motivated enough to upgrade their building to a smarter one, a short payback period would be required, or a program providing economic incentives supporting smart technology adoption.

A major concern for most respondents is the fear of their privacy being compromised and customers being profiled over their consumption patterns, amongst others. On the other hand, such customers' data could be beneficial for companies' commercial purposes. To address this gap, specific legal requirements have already been established with the EU's General Data Protection Regulation[7] (GDPR), compliance with which ensures a certain level of data protection. Within this context, a key requirement is to find the right linkage between privacy issues and commercial use of data collection and management. Appropriate data privacy planning and implementation as well as careful, well-planned resourcing are needed to reinforce consumers' trust, and to ensure that information flows maintain consents and a certain level of restrictions relevant to personal data.

Furthermore, amongst the consumers, those who appear more reluctant about their capacity to use smart technology or not appreciative of its benefits, are those who are not that aware of the technology or its functions in practice. To further extend the favorable attitude across more societal groups, consumer awareness is a fundamental prerequisite. Information about the concept, its workings and its benefits would be appreciated by the respondents. Besides, most them have expressed their interest in the concept and are willing to adopt it at some point in the future, as long as they feel comfortable with it. Information provision could act as a catalyst for translating interest into actual engagement with the concept. Those who are familiar with the smart technology and thus feel more in control over it, are also more appreciative of the benefits it provides. For instance, remote lighting control or heating/cooling control are quite popular benefits perceived very positively amongst those who currently use smart systems. This is a clear indication that consumers' requirements are geared towards solutions that enable them to have control, and this is key to enhancing positive behaviors.

Last but not least, there are people who identify themselves as early adopters of new technologies. Such consumers have requirements and needs not yet met by current markets, and as such are willing to take the opportunity and make efforts to first bring the innovation to the market. Targeting those people's needs and requirements is particularly important at the early stages of an innovation because such people may influence other consumers, thus contributing to the market uptake.

[7] https://gdpr-info.eu/

5 BUSINESS USE CASE DEFINITION

5.1 Methodology

Following the definition of the social barriers and enablers as reported in the previous section, one of the main objectives of this task is to define a concrete business case for the PHOENIX innovations. At first the brief methodological framework and background for the definition of the PHOENIX business cases is provided in this section.

Based on the terminology, a business (use) case is defined as the process to describe the more general interaction and steps between a business system (in our case the PHOENIX solution) and the users/actors of that system to produce business results of value [30]. A business use case is described in technology-free terminology which treats the **technical process as a black box and describes the business process that is used by its business actors** (people or systems external to the business) to **achieve their goals** [30]**.**

Moving beyond the strict terminology of the business use case, the scope of this section will be also to proceed with the examination of the market environment in order to perform **the assessment at the product level on whether the PHOENIX solution may solve existing market problems by producing services that will (presently or possibly eventually) compete with other products in the market**. Therefore, the business case definition will set an examination of a potential market opportunity at the product/service level.

It is evident that the definition of the business case is tightly linked with other activities performed in the project. More specifically, there is a clear connection with the activities performed in D2.1. In this document, the key business users/actors have been described along with the PHOENIX business scenarios, system use cases (where we specify the functions/ service that the PHOENIX system will provide to the users) and the business requirements for the final solution. In addition, the definition of social aspects of the project as presented in the previous section will be considered towards the definition of a business use case that fits the different segments of end users. Moreover, the presentation of the PHOENIX innovations in D1.3 will pave the way for a clear representation of the PHOENIX business case.

In addition, and towards examining the potential of the PHOENIX solution to stand as a market ready solution, the review of the market analysis performed in D2.1 will stand as the starting point. By providing the assessment of the PHOENIX to solve existing market problems, it will pave the way for the business planning and exploitation activities to be performed in T8.3: Business modelling, IPR management and exploitation planning. A visual representation of the different links of this task to PHOENIX activities is performed in the next figure.

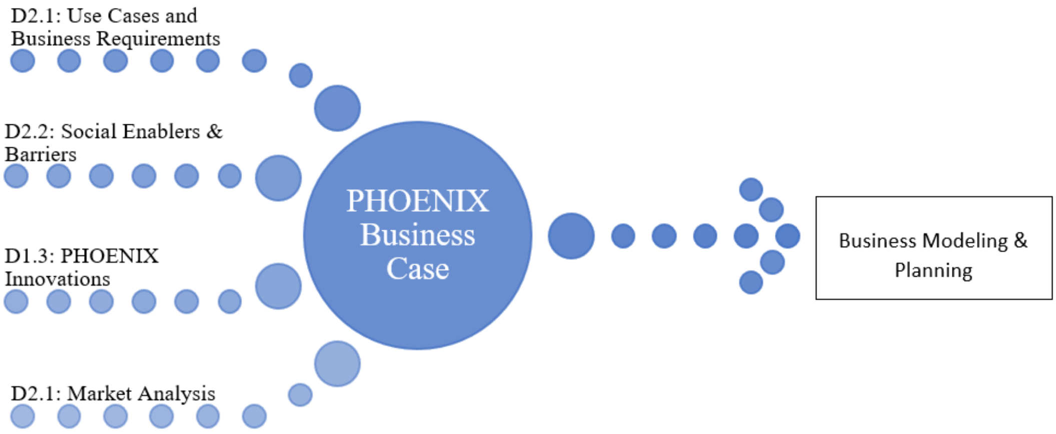

Figure 41. PHOENIX Business Case Methodology

The template that we are going to use for the business case description is presented in the following figure, adopting a typical methodology for the representation of the PHOENIX business case

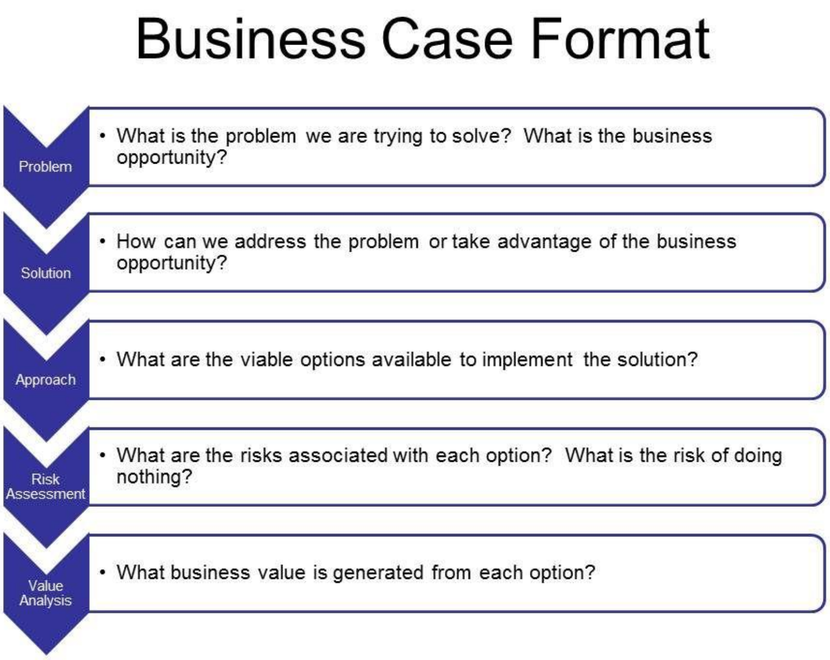

Figure 42. Business Case Format

So initially, the **Problem** formulation, states what specific market problem the PHOENIX is trying to solve. The **Solution** presents a description of how PHOENIX can solve the problem. **Approach** describes the viable solutions based on social/regulatory/market enablers while **Risk Assessment** pinpoints the social/regulatory/market barriers of the possible solutions. Finally, **Value Analysis** summarizes the value that PHOENIX will bring in all the involved stakeholders.

5.2 Business case description (summary of scenarios pertinent to removing barriers and promoting enablers)

<u>Problem and Opportunity</u>

The openness of the energy market in Europe has enabled significant progress in several aspects, including energy targets/goals establishment for energy efficiency and CO_2 emissions, growing market competition, decreasing wholesale prices, and the enhanced uptake of renewable energy sources. Nevertheless, and even though Consumer Empowerment has become a top priority in European energy policy, still their engagement in energy efficiency and demand response schemas has remained limited.

Today, the energy system is largely driven by the perspective of suppliers and only few consumers are able to track their energy usage or actively participate in the market. While possibilities for larger commercial and industrial consumers have started to develop and active consumer engagement in energy efficiency and demand response programs is gaining in relevance, this is not yet the case for most residential and medium/small tertiary consumers. Commercial and industrial premises "are technically and economically ready" to participate in demand side management schemas, however, residential and tertiary buildings are still excluded from the market, though they count for 36% of Europe's CO_2 emissions and 40% of its energy consumption [31].

Towards this direction, there is a clear motivation supported by latest evolutions in EU energy policies that are continuously and drastically transforming energy markets and adversely affecting traditional business models towards the provision of innovative energy services rather than commodity sales. EU has introduced extensive energy efficiency policies and standards, notably for buildings, appliances and energy efficiency. These new regulations set a target for increasing by at least 32.5% the energy efficiency of Europe in all energy sectors by 2030. The building sector accounts for around 40% of the final energy consumption in developed countries, and for 36% of the greenhouse emissions in Europe. It is, therefore, important to give a particular emphasis on the improvement of the energy performance of buildings. At present, about 45% of the EU's buildings are over 50 years old and almost 75% of the building stock can be considered as energy inefficient. This issue is even worse regarding that 75–90% of the existing buildings are expected to be standing by 2050. At the same time, only 0.4-1.2% (depending on the country) of the building stock is rebuilt each year. Refurbishment of existing buildings could lead to significant energy savings and play a key role in the clean energy transition, as it could reduce the EU's total energy consumption by 5-6% and lower CO_2 emissions by about 5%.

Under the Energy Performance of Buildings Directive (EPBD) of 2010, the EU developed the first strategy to increase the energy efficiency of buildings, which consists of the creation of Energy Performance Certificates (EPCs) for buildings that are being constructed, sold, or rented. An EPC provides information to the customers about the energy performance rating of the building and recommendations for cost-effective improvements. One step further has been taken by the EU in the 2018 revision of the EPBD, which aims to further promote smart building technologies, in particular through the establishment of a Smart Readiness Indicator (SRI) for buildings. The SRI shall provide information on the technological readiness of buildings for interacting with their occupants and the energy grids, and their capabilities for more efficient operation and better performance through ICT technologies in the form of services. Therefore, the SRI should accelerate the transformation of the European Building Stock from standard and manually managed buildings to smart buildings. Smart buildings integrate cutting edge ICT-based solutions for energy efficiency and energy flexibility for their daily operation. Such smart capabilities can effectively assist in creating healthier and more comfortable buildings with lower energy consumption and carbon footprint.

Moving beyond the regulation, in the market field, the realisation of smart buildings depends mainly in the digital transformation with ICT technologies (i.e. Internet of Things - IoT, Artificial Intelligence – AI and Data Analytics) that is inundating all sectors (such as health care with the e-Health or industry with the Industry 4.0). In the case of buildings, this transformation is expected to have a large impact, highly beneficial for society when carried out in an adequate way. It will enable the connection and adaptation of various smart devices (including shading, windows, lighting, ventilation, white and entertainment appliances etc.) which are more widely used and can communicate with each other especially with the increasing growth of M2M communication systems, new product development, and improvements on the

Internet of Things (IoT). There can lead to the provision of energy or non-energy services in the building environment.

Apart from technical innovations at building level, enhancing the market role of consumers by offering a wide range of services and providers to choose is a key objective for the future. Consumers need to be free to choose their preferred form of active participation in energy markets, either if it has to do with the selection of programs that they will opt-in (implicit or explicit demand response, or both), or by being given the option of direct or indirect participation (through official intermediaries like aggregators or ESCOs). The advancement of technology enables the tracking of the residential consumer behavior which could be used either by themselves for the optimization of energy performance and consumption or by the energy suppliers who can benefit from the ideal segmentation of their portfolio. Moreover, the aggregators can benefit from the consumer-centric DR market that is still evolving during the last decade, and provides the ability to collect specific demand-side flexibility data by smart energy assets (certain loads, batteries for energy storage) that lead to the shaping of consumer behavioral and flexibility profiles.

It is evident that there is an emerging demand (both in regulation and the market trends) for smart energy services in the building environment. Although multiple trials have been conducted demonstrating the energy savings value that demand-side flexibility offers and despite the fact that the incorporation of smart meters//EV equipment/PV and Battery systems is significantly progressing, the business wise applicability of residential and small tertiary energy efficiency & demand side management programs has been slow, mainly due to the fact that available infrastructures (mainly metering systems and legacy equipment) cannot support any kind of innovative energy services that are mainly based on continuous data exchange and real-time interaction between energy actors and consumers/prosumers.

<u>Business Solution</u>

To realize the open and transparent energy market for consumers, technically feasible and reliable solutions are required, based on open standards, and ensuring unbundling from proprietary services and equipment, to enable vendor lock-in avoidance and easy switching between suppliers or service providers. This will ensure that consumers cannot only choose the energy supply-service deal that best fits their needs (and reduces their energy costs), but will open new opportunities for further energy cost reduction (even 45-50%) through participation in demand response programs (under the umbrella of intermediaries, e.g. aggregators, that properly guide them to optimize their energy profiles, either by shifting consumption away from periods with high energy prices, while enabling them to bid their flexibility in ancillary and balancing markets).

This transition and increase of consumer empowerment are directly linked to the availability of smart ready buildings with metering and other smart-enabled devices to cope with real-time optimization requirements imposed by the rapidly increasing de-centralized and distributed nature of power networks, which in turn increases complexity in any optimization function. Smart technologies for consumers, buildings and networks need to be widely deployed, highly replicable and easy to install and use. They need to simplify the interaction of consumers with energy markets, by tackling technical barriers and enabling standards-based two-way communication, plug-and-play installation and data exchange and integration across brands and protocols. Intelligent energy management systems need to be deployed offering sophisticated features for human-centric control and automation in a holistic optimization framework that considers energy prices (elasticity of consumers), demand profiles and consumer preferences (comfort, indoor environment quality contributing to the definition of flexibility profiles), local generation and storage capacity. Compliance with open standards is therefore required to ensure end-to-end semantic and technical interoperability, while enabling integration of Demand Response Management Systems, with Building Energy Management

Systems (BEMS) and Smart Home components and facilitating communication between the different actors involved in the energy market.

The introduction of new user and grid services will enable for sure the optimization of energy efficiency. Unfortunately, most of the current automation technologies in smart buildings, focus only on that aspect, without taking into account the human factor. The energy-driven automated operation of systems and appliances has created human-related problems such as health issues, uncomfortable workplaces, overall dissatisfaction with automation, etc. Therefore, new user-centric services need to be created to meet the recently defined SRI objectives to place building occupants at the center of energy transition and promote the development of smart services in buildings which will empower consumers to benefit from energy cost savings, while ensuring preservation of high comfort and indoor environmental quality. On the other hand, services for grid flexibility (e.g., demand response) has been studied for many years, however, their application at distribution level has been limited. Thus, new services for the grid need to be created to successfully apply these flexibility requirements. Such guidance shall also promote the concept of self-consumption, in the case of prosumers, in a holistic optimization framework that balances renewables output and energy demand (also considering storage capacity) to ensure the minimization of energy consumed through energy networks.

The overall concept should aim to target the business opportunities derived from two distinct business scenarios as defined in D2.1 [reference]:

- **Prosumers** to enjoy the value and benefit of innovative energy and non-energy services by increasing the smartness of their building premises;
- Traditional (**retailers**) and new (**ESCOs and Aggregators**) energy business stakeholders to increase their profitability and improve their business sustainability through the provision of added value energy services to their customers.

Business Case Approach

By defining the business solution in the previous section, the next step of work is to clearly state the details of the approach to be followed for the delivery of the overall solution. The business approach is derived from the list of use cases defined in D2.1 along with the definition of business requirements (D2.1) and social enablers/barriers reported in section 4 of this document.

From previous analysis, it is evident that the provision of advanced energy services, as well as smart non-energy services requires the implementation and integration of smart systems in the building premises, either by smartening legacy systems or by replacing them to improve the building energy performance. They also increase the convenience and comfort, the control over the building operations and mitigate the risk for unpredicted faults of the equipment. They also represent an attractive upgrade that satisfies the occupant's tendency to change equipment and habits. Moreover, they have an impact on the social status of the occupant and increase the overall impression and the actual value of the property. The Adapt & Play integration of domestic appliances, legacy equipment and building systems is a key objective for the implementation of the smart building concept.

Data coming from the building environment (generation, consumption, specific loads, indoor temperature and air quality, etc.) should be combined with data from external sources (weather data, dynamic energy pricing by the supplier, etc.) as a means to provide added value services for the customers. The heterogeneity of data sources requires a semantic alignment and mapping of the different data elements in order to boost data accessibility and interoperability, both in building scale (BMS) but also in network scale (energy market). This means that the definition and development of the most suitable data standards is mandatory.

On top of data management, knowledge extraction is a key aspect to be considered. Data by itself does not give intelligence to the building, but the data analytics and knowledge creation techniques can do it. All data gathered by different sources can be properly analysed to support decision-making of individuals (occupants, managers, energy utilities agents) and/or artificial intelligence related to the operation of the systems and appliances in the building. The extraction of user profiles can take into account environmental conditions, the experience from the building occupant interaction in context conditions, the indoor air quality monitoring, the building demographics and routines, and the occupancy when it is available, in order to provide optimised hints and alerts, or even on-the-fly decision activations according to the needs of the occupant. The consumption, generation and storage forecasting at building and asset level with the use of ML-based techniques can provide optimized maintenance scheduling for the mitigation of energy losses and the maximization of the building energy performance, as well as useful reports and predictions for the energy retailers.

At the prosumer side, one of the main challenges in the energy transition era is to ensure consumers empowerment and participation in innovative services, especially when these are bundled with the deployment of smart building automation and IT solutions. Through the definition of a multitude of innovative SRI-oriented energy services including energy savings, maintenance automation and scheduling features, will provide the consumers the mechanisms in order to increase the energy performance of building premises. On the other hand, as highlighted also in SRI, the focus should be delivered also to the provision of non-energy: Comfort, Convenience and Wellbeing services to building occupants. These different services will be packaged under a **human-centric framework** where any action is delivered by fully preserving comfort & convenience preferences, as a main pillar of the recently established SRI. These user preferences will not be manually defined, rather these will be automatically derived following the demonstration of a self-learning, dynamically adaptive, context-aware behavioral profiling framework, ensuring that way the minimum of intrusiveness of end users at the operational phases of the project. Last but not least, the overall framework should deliver an **intuitive visualization dashboard for the building consumers** providing information about consumption patterns & demand flexibility potential, further enhanced with fine grained recommendations about real time building operation or further enhancements on the way to increase the level of smartness of building.

At the business side, and with the goal to set a clear business perspective for the provision of energy services to the customers, the aim is to establish a more flexible energy relationship between the building stock and the energy providers. Towards this direction, the traditional & new business actors should be given the means and tools to:

a) analyze the level of smartness of their portfolio and
b) exploit at the maximum level the available demand flexibility in innovative business schemas as they emerge in the deregulated electricity markets.

In this sense, a key business objective is the provision of new business schemas and services to intermediaries and third parties that will facilitate consumers' involvement into energy markets by acting on their behalf and making the most out of consumers' flexibility value in terms of energy bills minimization and revenues maximization. At first, the provision of flexible billing services and smart contracts from the retailers to their customers provide added value as they minimize overhead costs for the management of these processes. On the other hand, the retailers are able to offer personalized/ individualized services to their customers, increasing that way the acquisition rate (as more customers are interested to get access on services that fit to their needs and preferences. In addition, by performing portfolio flexibility analysis and configuration, they can provide valuable services to the grid operators as the building sector of the distribution network will participate in the peak shaving/shifting which can further boost RES penetration and optimized grid operation concerning both the technical aspect and its operational cost. Finally, advanced energy services promoting the self-consumption optimization can mitigate the energy costs for the main beneficiary of the asset (building occupant/owner, ESCO), as well as reduced loads for the network operators.

To summarize all the above, the PHOENIX solution will attempt to promote the following use cases:

Table 6. PHOENIX use cases

PHOENIX Use Cases	***Related Actors***
Adapt & Play integration of domestic appliances, legacy equipment and building systems	Building occupants
Building knowledge enhancement to upgrade the smartness of buildings	Retailers, ESCOs/Facility Managers, Aggregators
Services for building occupants to maximize their energy efficiency and increase overall building performance	Building Occupants
Provision of Comfort, Convenience and Wellbeing services to building occupants	Building Occupants
Portfolio flexibility analysis and configuration to optimize grid operation	Aggregators, Building Occupants
Flexible billing services and smart contracts for the retailer customers	Retailers, Aggregators, Building Occupants
Advanced energy services to promote self-consumption optimization	ESCOs/ Facility Managers, Building Occupants, Building Owners

<u>Business Risk Assessment</u>

We highlighted in previous section the key approaches to be considered as part of the solution. In this section, the critical barriers and limitations that have to be considered as part of the design phase are reported.

Regarding the **Business Case Risk Assessment**, some identified barriers could include the high initial investment cost of some of the proposed solutions, especially when replacing legacy systems for new smart ones, or when upgrading equipment to improve comfort and performance, which could be overcome when future cost savings are ensured, or even with advanced provision of such services through ESCOs. Phoenix addresses this point by ensuring the provision of savings schemes through the active user participation and the real time interaction of their data with energy stakeholders.

Another possible obstacle is the social lack of knowledge both on the added value of such services and implementations, the use and control of smart equipment, and the difficulty to manage and gain insight from data and analytics. It is certainly an important issue for the successful implementation of new technologies and services to make them accessible and understandable by as many social groups as possible, especially to the elderly who seem to be more sceptical to both the advantages and their capability to cope with new technologies. The Phoenix user dashboard shall thus provide a user friendly and intuitive way for the user to interact with the building and gain easily useful insight from his surroundings.

Moreover, it should be noted that the residential customer penetration to markets and services other than the default energy supply by the retailers, is still in very low levels compared to commercial and industrial. Energy as a Service with focus on energy performance and flexibility services cannot provide clear revenue streams, especially since they are yet not very common in the domestic sector. The exploitation of the analytics presentation in a widely accessible manner as well as the dissemination should focus on the inertia of the market behaviour of the domestic sector in order to prove that these services can not only be feasible, but also can provide certain profit.

To conclude, the most critical barrier reflects data security and privacy, both in matters of social acceptance, but also to ensure that every possible data transfer and transaction conforms to GDPR rules. In fact, the European and national regulatory frameworks are repeatedly updated in order to set the limits on one hand, but also to promote the use of advanced smart services, IoT, advanced markets etc., in a trusted and reliable way.

Business Value Analysis

Finally, the **Business Value Analysis** of the PHOENIX solution, depending on the key actor involved, is summarized in the following points:

Building occupants:

- The proliferation of smart devices under the new paradigm of the Internet of Things (IoT) provides increasing ROI and enables the provision of advanced non-energy services to move from traditional houses to smart homes with increased comfort and safety for their occupants.
- The intelligent control of their demand through the deployment of real-time pricing and their involvement in implicit demand response programs provides energy savings, and energy cost reduction.
- The provision of ancillary services to the network by residential, commercial and industrial consumers can be achieved with demand response and flexibility utilization which creates monetary benefits for the occupant.
- The personal analytics that are derived by the user behavioral profiles provide personalized (comfort-preserving) guidelines and behavioral triggering to intelligent controls and automation. Such human-centric innovations increase the levels of health and comfort for the building occupant.
- The establishment of open and transparent flexibility markets empowers the participation of the occupant in the markets through their direct negotiation with aggregators.

Energy retailers:

- Accurate demand forecasting and real-time automated control over flexibility loads provided by customers of their portfolio mean significant reduction of imbalance charges for the energy retailers.
- The advanced flexible billing can affect the portfolio demand behaviour, shifting loads to time zones with lower energy cost which both reduces the imbalances and increases profit for the retailers.

ESCOs – building/facility managers:

- There is a growth in Energy Efficiency and Maintenance services, which can be attributed to factors such as increasing DER, decreasing cost of renewable power generation and storage solutions, and availability of federal and state tax benefits for energy efficiency projects. The continuous update of the regulations promotes these concepts and relevant types of services by ESCOs, too.

- There is an increasing need for energy data analytics in DER for better monitoring, fault detection and predictive maintenance, generally for asset optimization and control. In addition, the volatility in oil prices leads to high expenditure in energy-related projects, which creates demand for big data analytics for the building managers.
- The accurate generation/consumption forecasting and, therefore, the precise and optimized energy control and management mitigates the risks of Energy Performance Contracting, since ESCOs evade deviations from the energy performance guarantees and obligations. This results in more attractive ROI and revenue streams.
- The self-consumption maximization through the accurate demand forecasting and peak shaving/shifting can provide serious energy cost reduction.

Demand-side flexibility aggregators:

- The emerging of smart meters and devices enables the consumers to have a clear idea of their loads which empowers their participation in energy flexibility markets. The aggregators can expand their portfolio with domestic consumers, too.
- An optimized portfolio management can increase the accuracy of the aggregator predictions reducing imbalances.

The PHOENIX solutions will cause side benefits to network operators, too. More specifically, the adoption and empowerment of the flexibility markets enable increasing peak load reduction and avoidance of grid congestions. Moreover, it allows for an increased RES penetration to the grid electricity mixture, since the flexible loads can more easily follow the intermittent RES generation. Finally, the maximization of self-consumption reduces the demand to be satisfied by the grid and loads that cause grid congestion.

All the above indicate how multiple stakeholders can benefit from the added value and the increased revenues created by the provision and exchange of the abovementioned services and data streams.

6 CONCLUSIONS

The PHOENIX project aims at upgrading the legacy equipment of existing building stock through smart innovations. Within this context, one of the primary considerations is to identify the behavioral and individual drivers and barriers to the smart building market development in order to elicit the social based requirements, which, along with the regulatory and other user requirements, are necessary to define the project’s business use case.

Despite the overarching goal to decarbonize energy systems, there is still a lot to be done towards this direction, and in order for this vision to be realized, a fundamental prerequisite is to ensure user acceptance. To that end, the present report analyses the social and individual barriers and enablers that might promote or hinder, respectively, the upgrade of existing buildings into smarter and more connected ones. For the scope of this project, TPB was selected as the appropriate methodology in order to understand consumers’ behavior pertaining to smart building technology in the EU. The TPB model was applied in designing two surveys, one administered to building occupants in the PHOENIX pilot sites and, for further expanding and complementing the results, one administered to consumers in EU countries with a relatively old building stock. Five types of beliefs were determined for the elicitation of consumers’ perceptions on the smart building concept, namely: behavioral beliefs (attitude), social norms (social pressure), control beliefs, social innovativeness and tendency to change. A total of 242 responses were received from the pilot sites and from the public survey, and the results were analyzed by means of descriptive statistics.

The surveys revealed that consumers at large have a positive attitude to the smart building concept and are prone to engaging with smart technology and services. Nevertheless, concerns are raised as to the protection of their privacy, the high cost of smart technology and the complexity of the concept. These constitute important barriers to the adoption of the smart building concept. Further differences in the perceived concepts are observed across societal groups, mainly driven by age, income level, education level, computer literacy and employment, as well as other socio-demographic characteristics. The key outcome highlighted from the findings, however, is that for the majority of respondents, financial gains from the upgrade of their existing building, protection of their personal data and reducing concept complexity, are main appeals.

These findings constituted the social based requirements for the PHOENIX business use case definition, which within the scope of this deliverable, was developed as an examination of the potential market opportunity for the project’s innovations. The framework includes the problem definition, solution description, business case approach, risk assessment and business value analysis, and concludes on how multiple actors: building occupants, energy retailers, ESCOs, aggregators but also network operators, can benefit from the PHOENIX value proposition. The outcomes shall serve as input for the upcoming work packages WP3, WP4, WP5 and WP6 in terms of social requirements and specifications considered for the development and integration of the PHOENIX smartness hub with ICT tools and services, as well as for WP8 which constitutes the Business Planning, Exploitation and Communication activities of the PHOENIX project.

REFERENCES

[1] I. Ajzen, "The theory of planned behaviour," *Organizational behavior and human decision processes,* pp. 179-211, 1991.

[2] N. Balta-Ozkan, R. Davidson, M. Bicket and L. Whitmarch, "Social barriers to the adoption of smart homes," *Energy Policy,* pp. 363-374, 2013.

[3] I. Ajzen, "From intentions to actions: A theory of planned behaviour," pp. 11-39.

[4] B. Sheppard, J. Hartwick and P. Washaw, "The theory of reasoned action: a meta-analysis of part research with recommendations for modifications and future research," *Journal of consumer research,* pp. 325-343, 1988.

[5] T. Lam and C. Hsu, "Theory of planned behavior: potential travelers from China," *Journal of hospitality and tourism research,* pp. 463-482, 2004.

[6] C. Perri, C. Giglio and V. Corvello, "Smart users for smart technologies: Investigating the intention to adopt smart energy consumption behaviors," *Technological forecasting and social change,* 2020.

[7] T. Ramaya, K. Rouibah, M. Gopi and G. Rangel, "A decomposed theory of reasoned action to explain intention to use Internet stock trading among Malaysian investors," *Computers in human behavior,* 2009.

[8] S. Taylor and P. Todd, "Decomposition and crossover effects in the theory of planned behavior: A study of consumer adoption intetnions," *International journal of research in marketing,* pp. 137-155, 1995.

[9] S. Al-Gahtani, G. Hubona and J. Wang, "Information technology (IT) in Saudi Arabia: Culture and the acceptrance and use of IT," *Information and management,* 2007.

[10] S. Cheng, T. Lam and C. Hsu, "Testing the sufficiency of the theory of planned behavior: a case of customer dissatisfaction responses in restaurants," *International journal of hospitality management,* pp. 475-492, 2005.

[11] S. Scott, P. Hughes, I. Hodkinson and S. Kraus, "Technology adoption factors in the digitization of popular culture: Analyze the online gambling market," *Technological forecasting and social change,* 2019.

[12] C. Camerer, G. Loewenstein and M. Rabin, "Advances in behavioral economics," Princeton University Press, 2004.

[13] A. Hong, C. Nam and K. Seongcheol, "Analysis of the barriers that consumers encounter when smart home service is introduced in South Korea," 2017.

PHOENIX

[14] G. Roehrich, "Innovativites hedoniste et sociale: Proposition d'une echelle de mesure," *Recherche et Appliactions en Marketing,* pp. 19-42, 2004.

[15] C. Viot, C. Bayart and A. Lancini, "The consumer intention to adopt smart connected products: does the category matter?," St Gallen, Switzerland, 2017.

[16] M. Broman Toft, Consumer adoption of sustainable energy technology - the case of smart grid technology, 2014.

[17] D. Singh, I. Psychoula, J. Kropf, S. Hanke and A. Holzinger, "Users' perceptions and attitudes towards smart home technologies," in *Smart homes and health telematics, designing a better future: urban assisted living*, 2018.

[18] N. B. B. A. O. Balta-Ozkan, "European smart home market development: Public views on technical and economic aspects across the United Kingdom, Germany and Italy," *Energy research and social science,* pp. 65-67, 2014.

[19] C. H. T. Wilson and R. Hauxwell-Baldwin, Smart homes and their users: a systematic analysis and key challenges, London: Springer-Verlag,, 2014.

[20] S. Caird, R. Roy and H. Herring, "Improving the energy performance of UK households: Results from surveys of consumer adoption and use of low and zero carbon technoplogies," *Energy Efficiency,* vol. 1, no. 2, pp. 149-166, 2008.

[21] B. Ablondi, Consumer attitudes and the benefits of smart grid technologies, 2010.

[22] P. Aspinwall, K. Mims and P. Malmsten, "Consumer involvement with smart grid technology and home energy generation," Worcester Polytechnic Institute, 2012.

[23] D. Mah, J. van der Vleuten, P. Hills and J. Tao, "Consumer perceptions of smart grid development: Results of a Hong Kong survey and policy implications," *Energy Policy, Elsevier,* vol. 49, pp. 204-216, 2012.

[24] K. Bolderdijk, L. Steg, E. Geller, P. Lehnman and T. Postmes, "Comparing the effectiveness of monetary versus moral motives in environmental campaigning," *Nature Climate Change*, pp. 413-416, 2013.

[25] C. Wilson, T. Hargreaves and R. Hauxwell-Baldwin, "Benefits and risks of smart home technologies," *Energy Policy,* vol. 103, pp. 72-83, 2017.

[26] D. Midgley and G. Dowling, "Innovativeness: the concept and its measurement," *Journal of consumer research,* vol. 4, no. 4, pp. 229-242, 1978.

[27] R. Goldsmith and C. Hofacker, "Measuring consumer innovativeness," *Journal of the academy for marketin science,* vol. 19, no. 3, pp. 209-221, 1991.

[28] M. Broman-Toft, "Consumer adoption of Sustainable Energy Technology - the Case of Smart Grid Technology," 2014.

[29] E. Heiskanen and K. Matchoss, "Consumers as innvators in the electricity sector? Consumer perceptions on smart grid services," *International journal of consumer studies,* vol. 40, no. 6, pp. 665-674, 2016.

[30] "https://online.visual-paradigm.com/diagrams/tutorials/use-case-diagram-tutorial/#:~:text=A%20business%20use%20case%20is,or%20the%20service%20that%20the," [Online].

[31] L. Pérez-Lombard, J. Ortiz and C. Pout, "A review on buildings energy consumption information," *Energy Build*, vol. 40, no. 3, pp. 394-398, 2008.

ANNEX I

Questionnaire template

Smart technology in buildings

General Information

Please specify country of residence

Please select your corresponding age group:

- ☐ 16-25
- ☐ 26-35
- ☐ 36-50
- ☐ 51-65
- ☐ >65

Please, select the gender you identify most with:

- ☐ Female
- ☐ Male

What is your highest level of education?

- ☐ Middle school
- ☐ High school
- ☐ University
- ☐ Post-graduate
- ☐ Vocational/Technical college

What is your employment status?

- ☐ Student
- ☐ Employed for wages
- ☐ Self-employed
- ☐ Out of work and looking for work
- ☐ Out of work and not looking for work
- ☐ Retired

Please select your corresponding household income group[8]:

- ☐ Lower I
- ☐ Lower II
- ☐ Middle I
- ☐ Middle II
- ☐ High I
- ☐ High II
- ☐ High III
- ☐ Prefer not to tell

Please indicate relevance of your profession/field to one of the following:

- ☐ Architects, planners, surveyors and designers
- ☐ Engineering professionals
- ☐ Information and communications technology professionals
- ☐ Other

What is your computer literacy level?

- ☐ Beginner
- ☐ Basic knowledge
- ☐ Moderate
- ☐ Expert

What is the type of property tenure?

- ☐ Owned
- ☐ Rent

What type of building you live in?

- ☐ Detached
- ☐ Semi-detached house
- ☐ Apartment building

How many people permanently live in your building?

[8] The respective income ranges were defined in the questionnaires for each country separately

Which description best suits your residential situation

- ☐ I live alone
- ☐ I live with family
- ☐ I live with a partner without children
- ☐ I live with a partner with children
- ☐ I live with others: co-housing

Are you familiar with the smart home devices/systems concept?

- ○ Yes
- ○ No

Do you currently use any smart devices/systems?

- ☐ Yes
- ☐ No

If yes, please indicate which of the following are part of your applied smart system?

- ☐ Short-life appliances
- ☐ Long-life appliances
- ☐ Energy building equipment
- ☐ Management systems to monitor and control legacy equipment

Please select type:

- ☐ Fridges
- ☐ Ovens
- ☐ Washing machines
- ☐ Microwaves
- ☐ Dishwasher
- ☐ Dryer

Please select type:

- ☐ HVAC (Heating, ventilation and air conditioning)
- ☐ Boilers
- ☐ Radiators

- ☐ DHW (domestic hot water) devices
- ☐ Ventilation
- ☐ Lighting

Please select type:

- ☐ Renewable sources (e.g. PV)
- ☐ Energy storage (e.g. batteries)
- ☐ E-vehicle recharging points
- ☐ Other energy demanding points
- ☐ Smart meters
- ☐ Smart actuators

If no, which of the following existing equipment/services would you like to upgrade to smart ones?

- ☐ Short-life appliances
- ☐ Long-life appliances
- ☐ Energy building equipment
- ☐ Management systems
- ☐ None of the above

Please select type:

- ☐ Fridges
- ☐ Ovens
- ☐ Washing machines
- ☐ Microwaves
- ☐ Dishwasher
- ☐ Dryer

Please select type:

- ☐ HVAC (Heating, ventilation and air conditioning)
- ☐ Boilers
- ☐ Radiators
- ☐ DHW (domestic hot water) devices
- ☐ Ventilation
- ☐ Lighting

Please select type:

- ☐ Renewable sources (e.g. PV)
- ☐ Energy storage (e.g. batteries)
- ☐ E-vehicle recharging points
- ☐ Other energy demanding points
- ☐ Smart meters
- ☐ Smart actuators

Please provide the hours of active presence status in the building within a day

- ☐ 0-5 hours
- ☐ 6-10 hours
- ☐ 11-15 hours
- ☐ 16-20 hours
- ☐ Over 20 hours

What do you think of the following (Likert scale 1: Strongly disagree to 5: Strongly agree)?

Privacy is an important barrier for me to engage in the upgrade of the existing building equipment/servicesto smart ones

Saving money is an important factor for me to engage in the upgrade of the existing building equipment /services to smart ones

Saving time is an important factor for me to engage in the upgrade of the existing building equipment /services to smart ones

Saving energy is an important factor for me to engage in the upgrade of the existing building equipment /services to smart ones

Convenience in daily life is an important factor for me to engage in the upgrade of the existing buildingequipment/services to smart ones

Increase of property value is an important factor for me to engage in the upgrade of the existing buildingequipment/services to smart ones

What is your attitude towards the smart building concept?

I feel using a smart device is a good idea

I feel upgrading the existing building equipment/system is a good idea

I like using smart applications to control lighting energy consumption of the building

I like using smart applications to control heating/cooling energy consumption of the building

I like using smart applications to manage short-life appliances

I like using smart applications to manage energy building equipment

I feel that using smart home equipment will improve the quality of life

I feel that smart home services are useful

I feel that is difficult to handle or understand the smart building concept

I feel that smart building technology is unreliable

I feel that smart building technology is too expensive

Social aspects (Likert scale 1: Strongly disagree to 5: Strongly agree)

Most people who are important to me would think that I should acquire a smart device/service

Most people who are important to me would think that I should upgrade my building towards a moreconnected/smart one

I love to engage in smart building services that impress others

I prefer to try new smart devices/services with which I can present myself to my friends and neighbors

I like to own a new smart device/service or a smart building that distinguishes me from others who do notown this smart service or building

Capacity (Likert scale 1: Strongly disagree to 5: Strongly agree)

I am able to operate smart building equipment

I have the ability to live in a smart building

I have the resources to upgrade the existing building equipment to a smart one

I have the knowledge and ability to use smart building equipment

Habbits & Change (Likert scale 1: Strongly disagree to 5: Strongly agree)

I am inclined to use new products even if they are currently unknown to me

Intention

I intend to live in a smart building or upgrade my building equipment in a smart one in:

- ☐ The near future
- ☐ During 5-10 years
- ☐ During 11-20 years
- ☐ More than 20 years
- ☐ Never

ANNEX II

IBM SPSS Database template

File Edit View Data Transform Analyze Graphs Utilities Extensions Window Help

	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
10	VAR00010	Numeric	6	0	Gender	{1, male}...	None	6	Right	Nominal	Input
11	VAR00123	Numeric	8	0	Education level	{1, Middle s...	None	8	Right	Ordinal	Input
12	VAR00122	Numeric	8	0	Employment st...	{1, Student}...	None	8	Right	Ordinal	Input
13	VAR00121	Numeric	8	0	Income level	{1, Low I}...	None	8	Right	Ordinal	Input
14	VAR00011	Numeric	7	0	Age	{1, 16-25}...	None	7	Right	Nominal	Input
15	VAR00012	Numeric	2	0	Computer literacy	{1, Beginner...	None	2	Right	Ordinal	Input
16	VAR00013	Numeric	2	0	Profession	{1, Architect...	None	2	Right	Ordinal	Input
17	VAR00014	Numeric	2	0	Housing tenure	{1, Onwed}...	None	2	Right	Nominal	Input
18	VAR00015	Numeric	2	0	Building type	{1, Detache...	None	2	Right	Nominal	Input
19	VAR00016	Numeric	2	0	People in building	None	None	2	Right	Scale	Input
20	VAR00017	Numeric	2	0	Residential stat...	{1, I live alo...	None	2	Right	Nominal	Input
21	VAR00018	Numeric	2	0	Familiarity	{1, Yes}...	None	2	Right	Ordinal	Input
22	VAR00019	Numeric	2	0	Smart system ...	{1, Yes}...	None	2	Right	Nominal	Input
23	VAR00020	Numeric	4	0	Short life applia...	{1, YES}...	None	4	Right	Scale	Input
24	VAR00021	Numeric	4	0	Long life applia...	{1, YES}...	None	4	Right	Scale	Input
25	VAR00022	Numeric	4	0	Energy building...	{1, YES}...	None	4	Right	Scale	Input
26	VAR00023	Numeric	4	0	Management s...	{1, YES}...	None	4	Right	Scale	Input
27	VAR00024	Numeric	5	0	Fridges	{1, YES}...	None	5	Right	Scale	Input
28	VAR00025	Numeric	5	0	Ovens	{1, YES}...	None	5	Right	Scale	Input
29	VAR00026	Numeric	5	0	Washing machi...	{1, YES}...	None	5	Right	Scale	Input
30	VAR00027	Numeric	5	0	Microwaves	{1, YES}...	None	5	Right	Scale	Input
31	VAR00028	Numeric	5	0	Dishwasher	{1, YES}...	None	5	Right	Scale	Input

ANNEX III

Behavioral beliefs

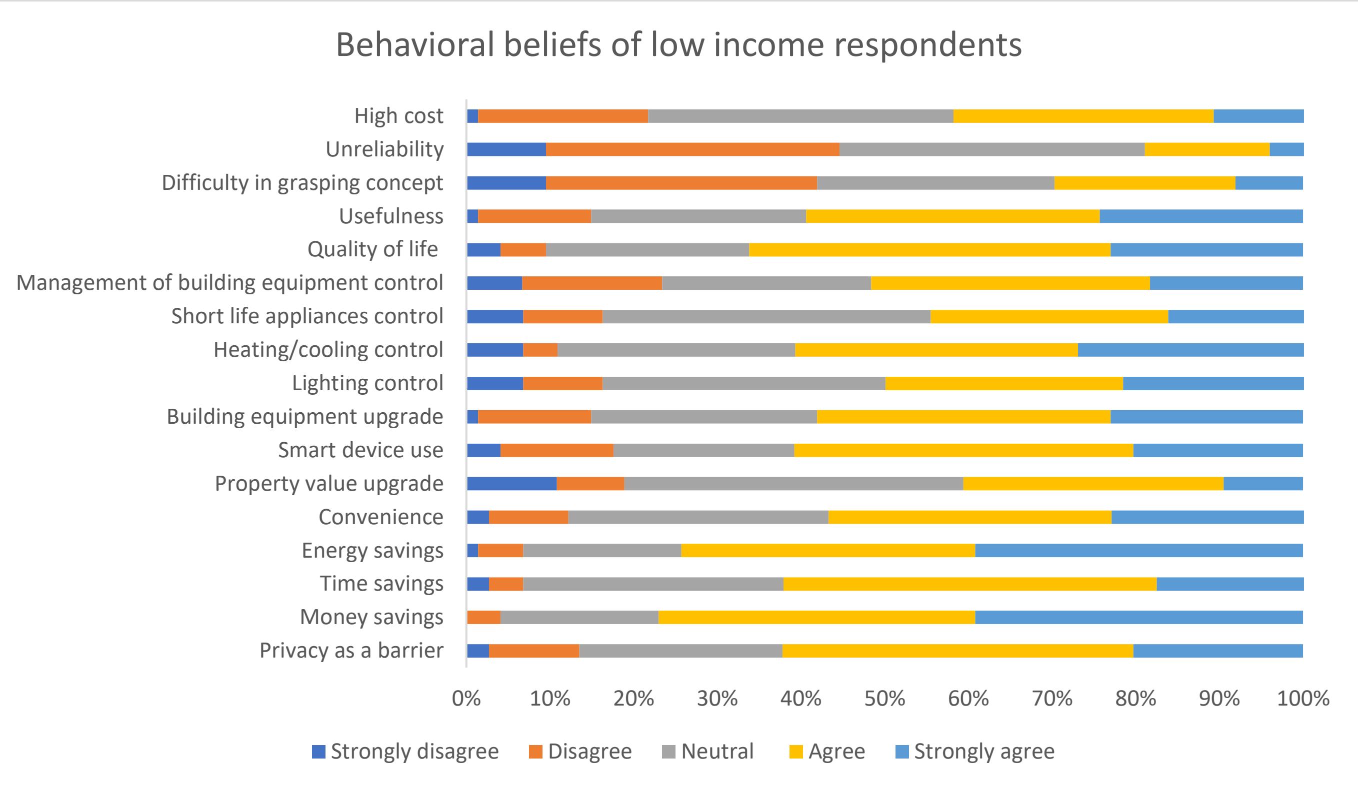

Figure 43. Behavioral beliefs of low-income respondents (all respondents, both users and non-users)

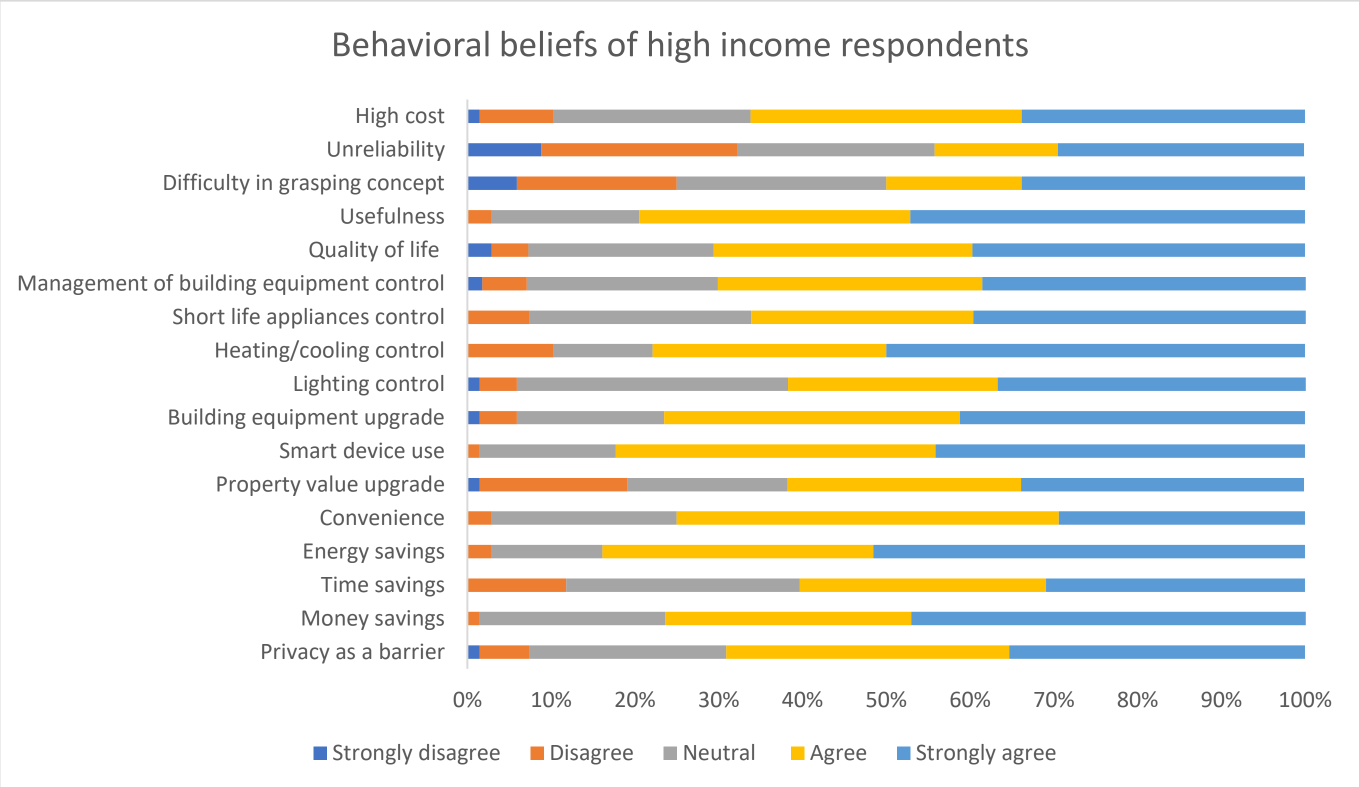

Figure 44. Behavioral beliefs of high-income respondents (both users and non-users)

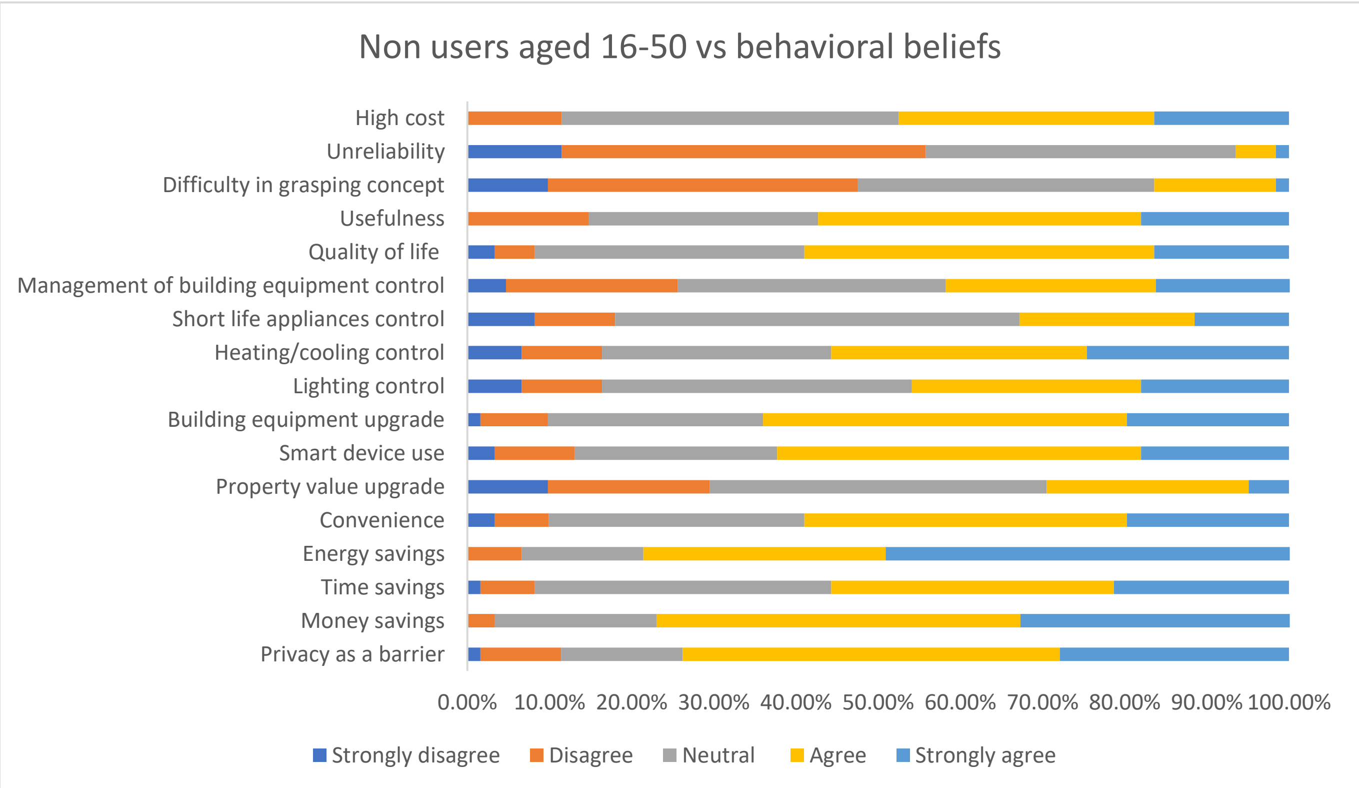

Figure 45. Behavioral beliefs of non-users aged between 16-50

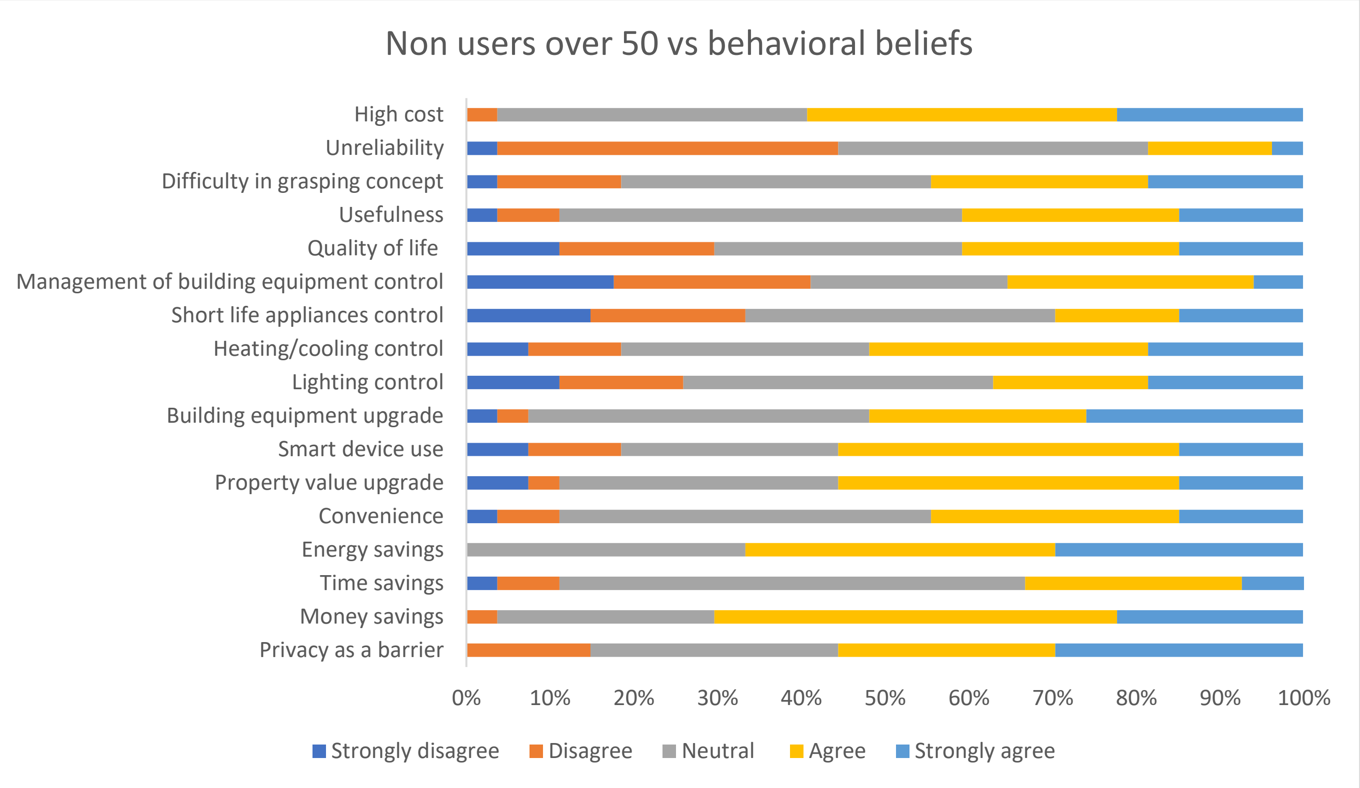

Figure 46. Behavioral beliefs of non-users aged over 50

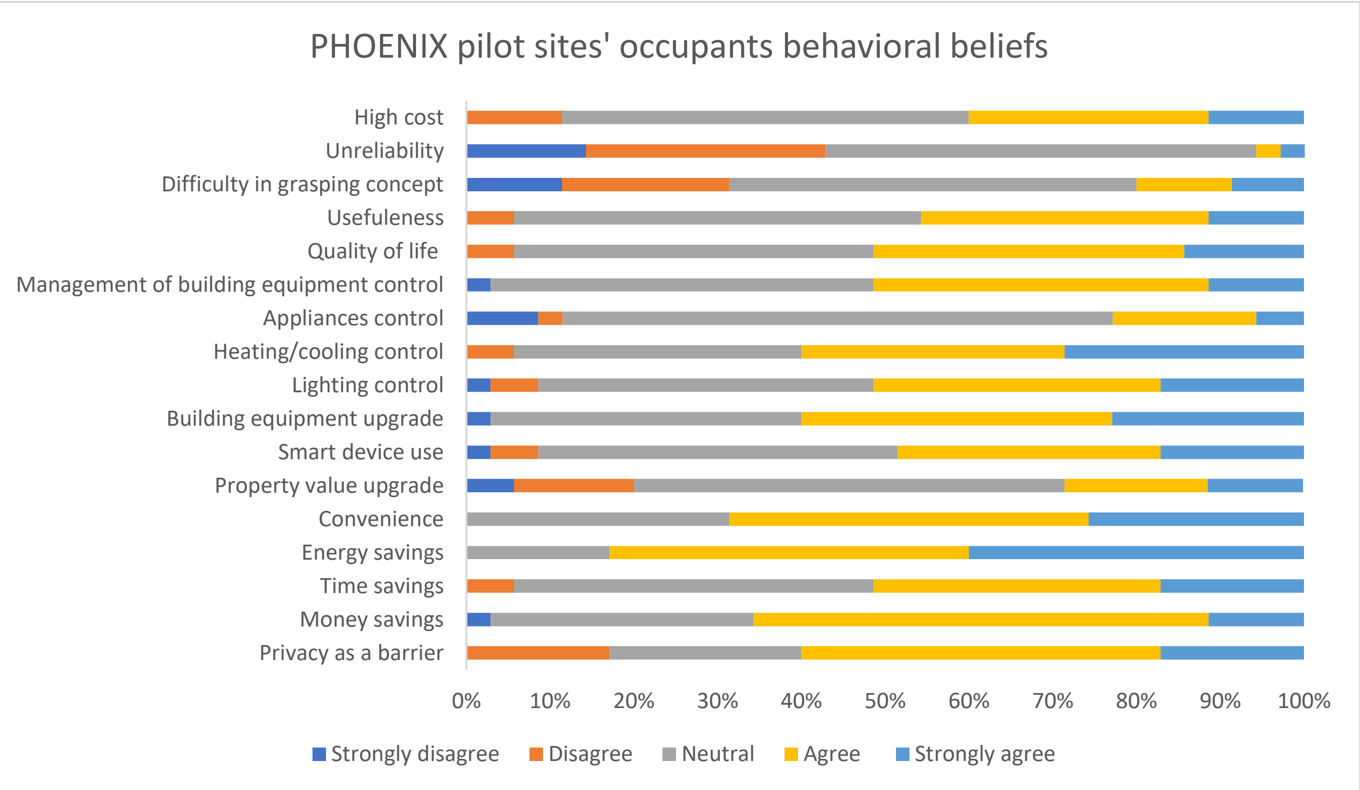

Figure 47. Behavioral beliefs of PHOENIX pilot sites' occupants

ANNEX IV

Normative beliefs

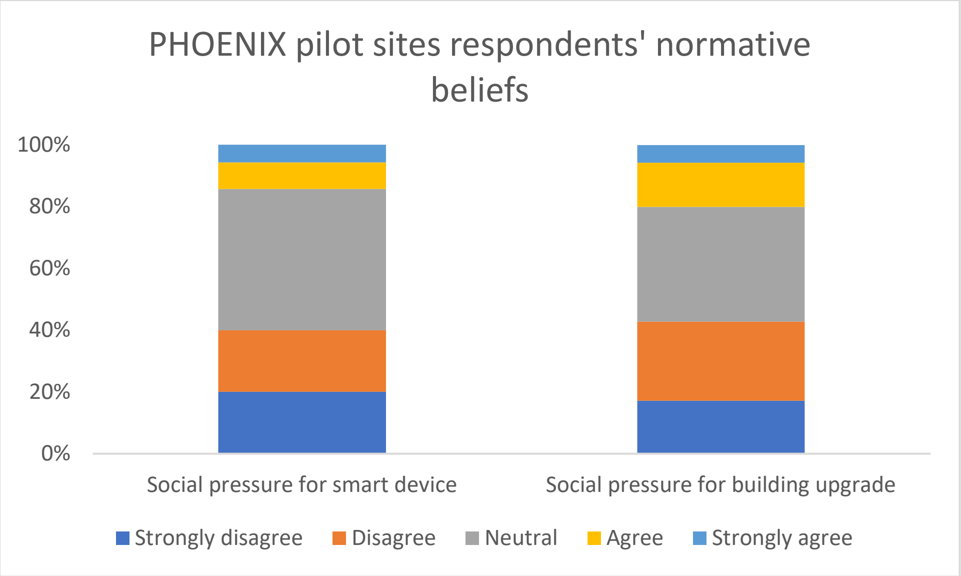

Figure 48. Normative beliefs of PHOENIX pilot sites' occupants

ANNEX V

Social innovativeness

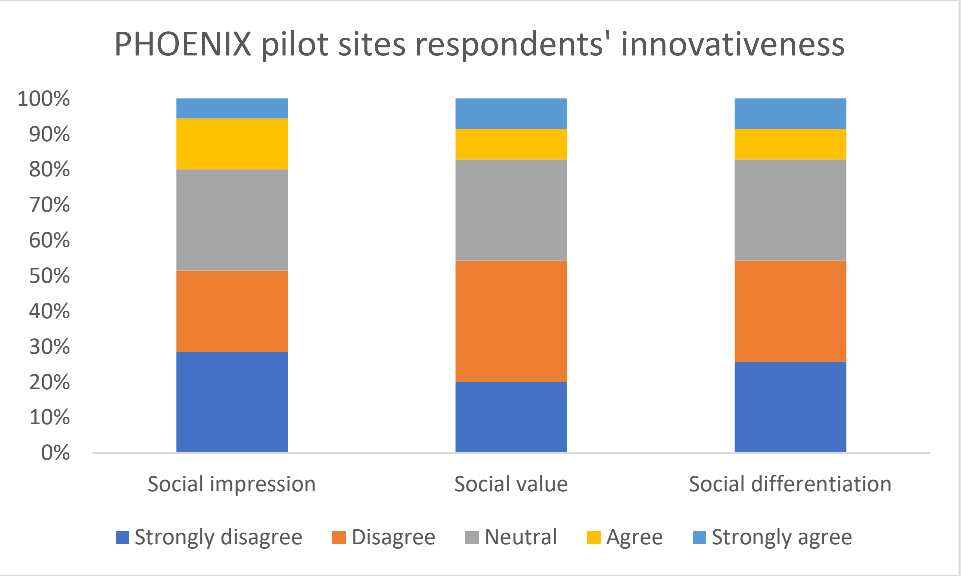

Figure 49. Social innovativeness of PHOENIX pilot sites' occupants

ANNEX VI

Control beliefs

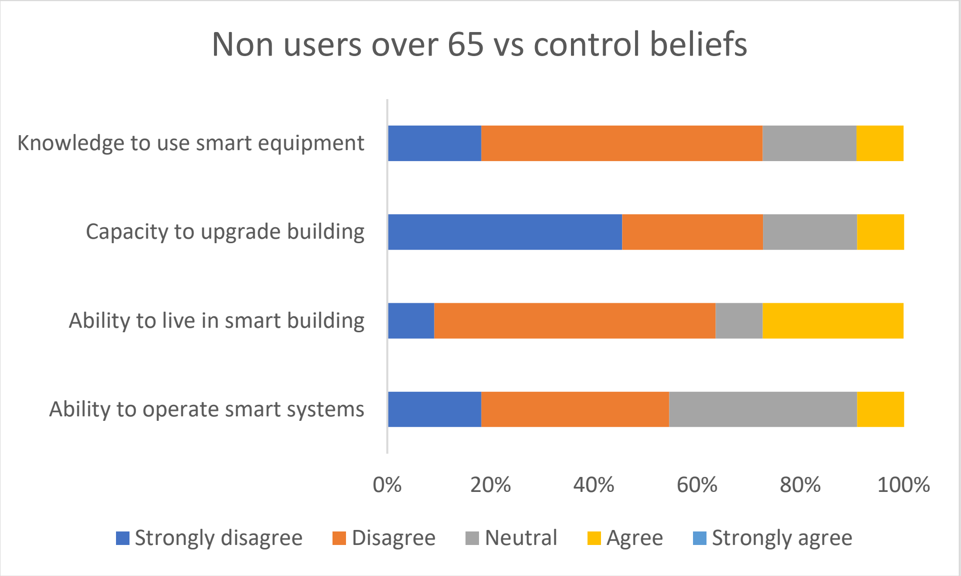

Figure 50. Control belief aspects of non-users over 65 years old

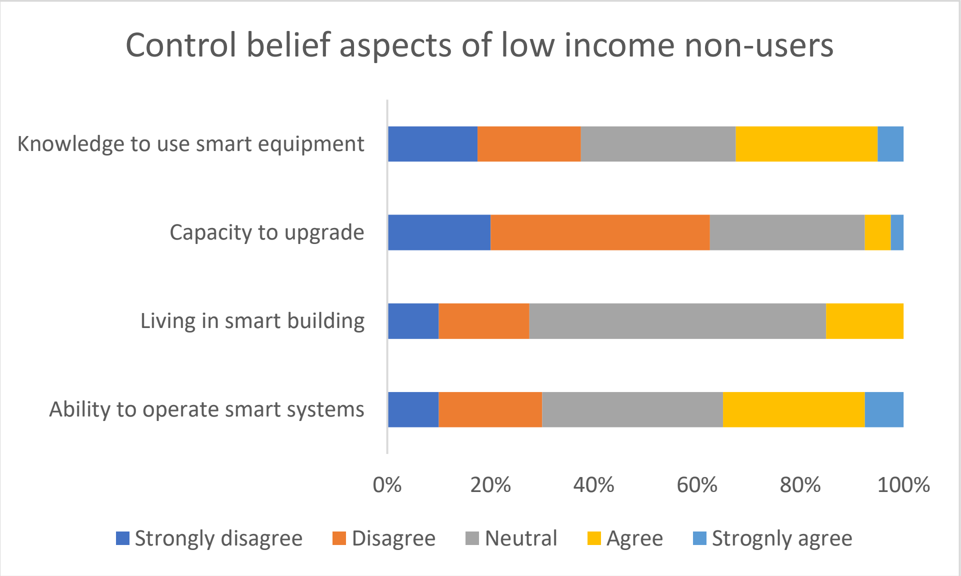

Figure 51. Control belief aspects of non-users with low incomes

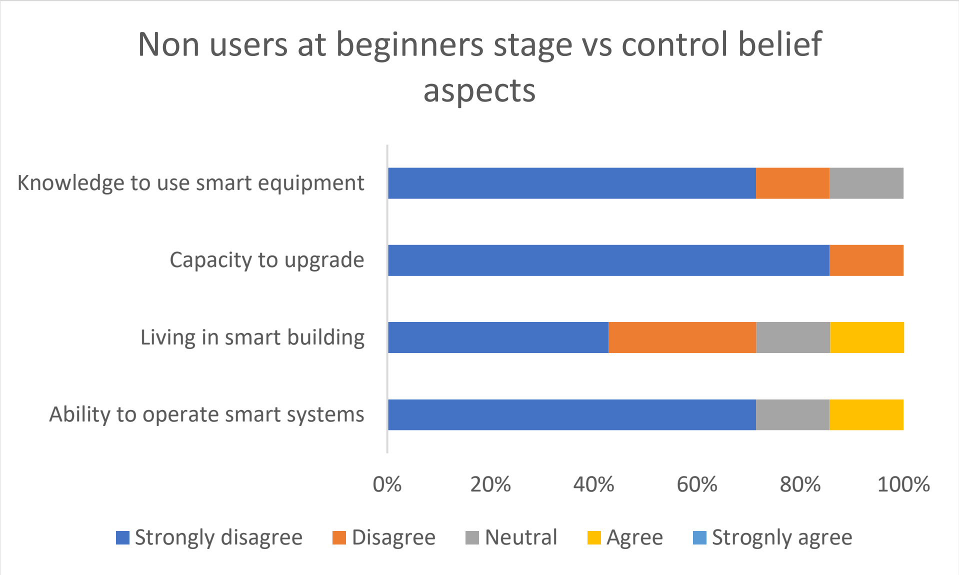

Figure 52.Control belief aspects of non-users at beginners' stage of computer literacy

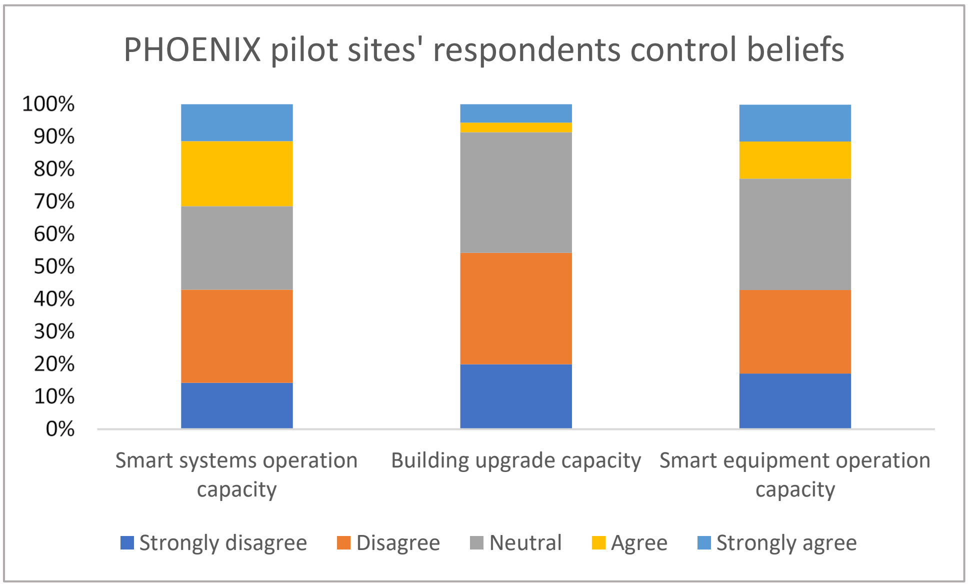

Figure 53.Control beliefs of PHOENIX pilot sites' occupant

ANNEX VII

Tendency to try new products

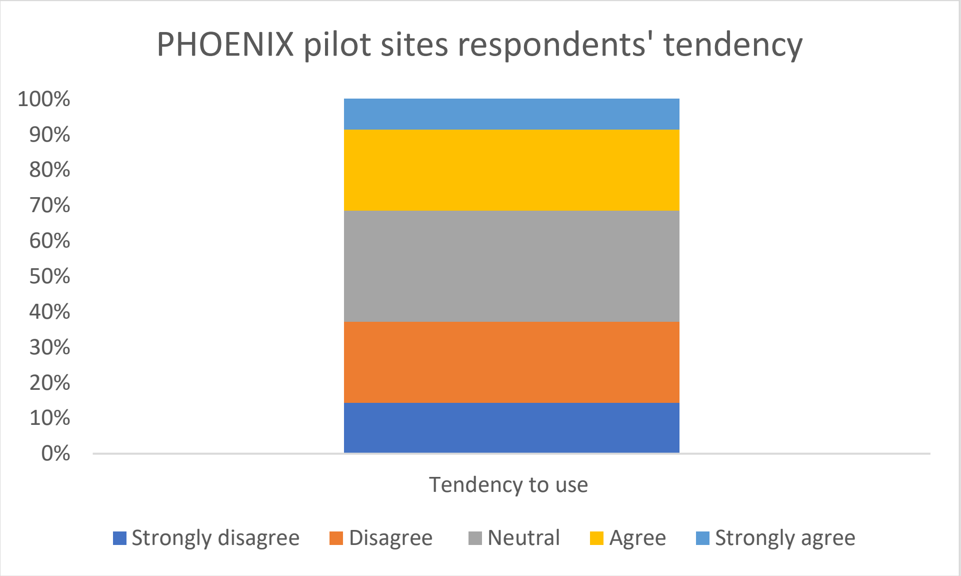

Figure 54.Tendency to change of PHOENIX pilot sites' building occupants