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Societal appreciation of energy security

Volume 2: Long-term security (EE, NL and PT)

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Societal appreciation of energy security. Volume 2: Long-term security (EE, NL and PT).

The report presents the results of a multi-country survey providing qualitative and quantitative information on the level of appreciation of customers and of regulators, suppliers and other key actors involved in electricity markets. The survey was conducted in Estonia, the Netherlands and Portugal.

Contents

Foreword

This report was developed in the framework of the joint DG Energy – Joint Research Centre project entitled *Societal Appreciation of Security of Energy Supply (SASOS).*

Other publications in the series *Societal appreciation of energy security:*

- Volume 1: Value of lost load – households (EE, NL and PT)
- Volume 2: Long-term security (EE, NL and PT)
- Volume 3: Non-residential actors (EE and NL)
- Volume 4: Value of Lost Load - Greece

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Executive summary

The study offers an overview on a survey that investigates energy security and its implications from different angles. The survey was conducted in Estonia, the Netherlands and Portugal. The data covers subjects such as the context in which energy users live, the technological components and energy sources used for satisfying needs of energy services. After profiling respondents' energy use, the survey describes the way in which energy users appreciate security of energy supply. The analysis provides insights on the type and importance of inconveniences occurring in case of interruptions of electricity supply. The study investigates the level of openness of energy users to the transitions that are likely to affect the energy system, and their acceptance of strategies for securing energy supply. The study offers a monetary evaluation of the economic benefits that the respondent assigned to the improvements of long term security of energy supply.

Main findings

The responses show that the fuel mix for supporting space heating and cooling, cooking and water heating differs across countries. Thus, the inconveniences from disruptions of electricity supply can substantially differ among the three countries.

We also find that individual values significantly contribute to explain, alongside more common socioeconomic and demographic individual traits, the propensity of residential energy users towards smart home technologies and acceptance of strategies to improve security of energy supply. The respondents did not express a strong or enthusiastic support to the potential innovations typical of enhanced power grids (smart metering, storage, diffused generation, and systems for direct load control), but they indicated acceptance toward goals of securing energy supply, and for adjusting their behaviours to reduce energy consumption.

The study also offers empirical evidence of the appreciation of citizens for additional security of energy supply. Respondents have been asked to evaluate their willingness to support a EU roadmap for energy security. Estimated benefits of a long-term strategy for energy security differ by country. In particular, the willingness-to-pay through increases in the energy bill is 39.04 euros in Estonia, 50.97 euros in the Netherlands, and 42.14 euros in Portugal.

Related and future JRC work

The study builds upon a previous JRC report that offers the economic assessment of the Value of Lost Load for the three countries (SASOS, Volume I), which focused on how households value improvements or losses in the short-term security of the supply of electricity. This report (Volume II) emphasises long-term appreciation, always from the perspective of residential energy users. A forthcoming third volume will investigate more the meaning of energy security, comparing preferences of the households with those of industrial, commercial customers, regulators, and retailer electricity suppliers. In this way, we will explore to which extent the convergence among different market/societal actors may support various components of energy security.

Quick guide

The study attempts to bridge many methodological domains from different disciplines, connecting them to the theme of energy security. Statistics, economics and social psychology have been closely supporting the various steps of the implementation of the study, from the design of the questionnaire to the fieldwork of collection of data through interviews, and in the quantitative analyses. For the monetary evaluation, the study involves methods for design of choice experiments and econometric analyses. An original trait of the study is the attempt to conjugate an economic approach with the application of social psychology and behavioural sciences.

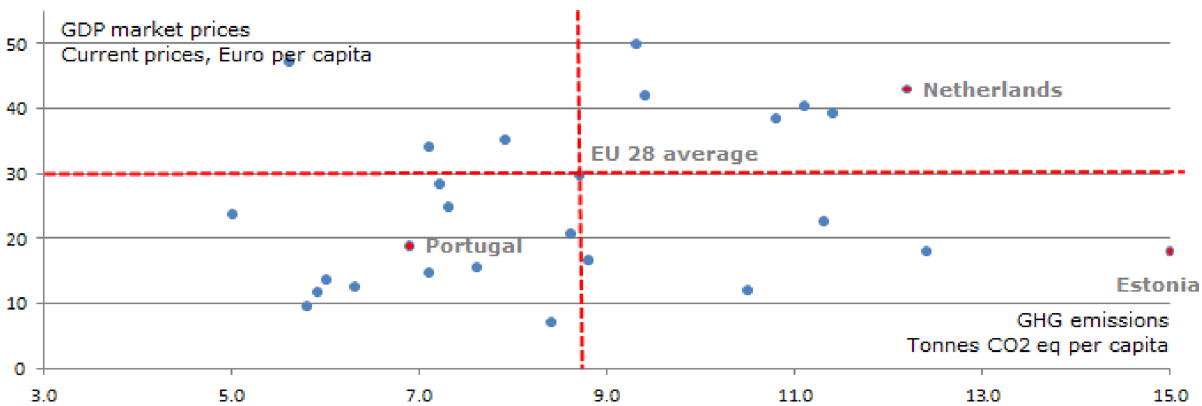
1 Introduction and background

The concept of energy security has an increasing importance for the development of modern energy systems. In the EU framework, energy security, sustainability and competitiveness have been endorsed as key long-term goals for the ongoing transition of the energy system. The present report aims at providing some empirical evidence as to the perception of the topic 'energy security'; from a socio-economic perspective. Investments in energy security can require substantial funds, e.g. for physical infrastructures, while the public acceptance and their perceptions/knowledge about the topic may be low, or uncertain. To address this issue, the report captures quantitative and qualitative information from survey data collected within three EU countries: Estonia (EE), the Netherlands (NL) and Portugal (PT). The study proposes a set of methodologies develop for observing public preferences over a comprehensive set of aspects targeting a long-term perspective on energy security.

At an academic and practitioners' level, a unified theory defining the meaning of 'energy security' or 'security of energy supply' is a challenging task. Different interdependent technological, institutional and social systems evolve in defining the needs and the general concept of security. Different disciplines have developed specialized measurement approaches for this topic, for example the use of quantitative indicators of the vulnerability of physical energy networks (Badea, Rocco, Tarantola, & Bolado-Lavin, 2011). Systemic approaches to qualify security over long-term scenarios have been devised (Scheepers, Seebregts, De Jong, & Maters, 2006; Jansen & Seebregts, 2010) also with the purpose of modelling the behaviour of energy systems, as in the case of the Global Energy Assessment model (Cherp, et al., 2012) or the Model of Short-term Energy Security (IEA International Energy Agency; Jewell, Jessica, 2011). Analyses dealing with energy security implicitly need to define what is a *concern* for security, and "whether such a concern is significant is between facts and perceptions" (Cherp & Jewell, 2010). While applied measurement approaches tend to describe the concerns for security more in terms of facts, as measurable properties of systems, in this study the emphasis is shifted radically on the perceptions of final energy users and on the subjective components that shape the societal needs of security, and its *appreciation.*

The three countries (EE, NL and PT) were selected for the survey on residential energy users, as they are in different situations regarding experienced reliability of energy supply, per capita income and carbon intensity of the economy (Figure 1). In a previous study (Longo, Giaccaria, Bouman, & Efthimiadis, 2018) survey data were used to inform an assessment of the Value of Lost Load for the three countries, as a proxy of the value of the short term damage from disruption of energy supplies. Two further volumes are in preparation: one develops for EE, NL and PT an exploration of the preferences of Distribution System Operators, energy retailers, industrial and commercial consumers, and consumers' associations on policy measures for energy security; while the other will regard an integrated study only for Greece.

Figure 1. Estonia, the Netherlands and Portugal by per capita gross domestic product and GHG emissions (Eurostat data 2017)



Sources: own elaborations on Eurostat data (2017)

The first part of this report presents a profile of consumers. A comprehensive set of information, reported through descriptive analyses, illustrates beliefs, values, technological choices and habits of the respondents. The purpose is to characterize with a wide set of quantitative and qualitative variables how energy services are provided. This section also offers some insights on the way consumers see the future possible choices in a system in transition, given the past and current experience. We further explore the respondents' experienced level of insecurity and attitudes toward the adoption of energy technologies to improve security of supply, with a special focus on electricity.

A set of drivers of the preferences over energy security is additionally represented by personal values, gathered through the survey data. Although all individuals share similar sets of values (Rokeach, 1973), they differ in the way they prioritize certain values over others. Thus, individuals have their own value system, in which different values are hierarchically ordered based on the importance the individual attaches to each value (Rokeach, 1973; Schwartz, 1994, 2003, 2006; Schwartz et al., 2012). These value systems are often used to characterize individuals, groups, and cultures. The study searches for evidence, of statistical association among personal values and individuals' behaviours, attitudes, and beliefs on energy security.

The report is focused on an evaluation of the perceived benefits from a long-term EU energy security strategy. A Contingent Valuation exercise (CV) is presented to determine the monetary value residential users put on such long-term benefits.

2 Profiles of residential energy users

The perspective of the residential energy users is quantitatively and qualitatively gathered through survey data, gathered in October 2017. The sample for the online survey was drawn at random by Survey Sampling International (SSI S.A.) from an online panel of adults. The panel size was 22,000 for EE; 265,000 for NL and 60,000 for PT.

Quotas were set to ensure that the resulting sample was broadly representative of the target populations. The target population include those individuals having some responsibility in the choice of purchasing energy for residential uses. We decide to focus on the older than 25([1]). Younger respondents were excluded to focus on preferences of those who are usually the ones purchasing security as embedded within their choices as customers (e.g. energy contract) or voters. Younger citizens are less likely to have a say or responsibility with regard to energy, and less familiarity with purchase decisions under income constraints[2].

The approach is similar to other multicountry studies, such as the pan-European survey developed in the framework of the FP7 project SESAME([3]) and two studies by London Economics tendered by DG Justice on the functioning of the retail electricity market ([4]). In the questionnaire for the online interview (see Annex A), respondents were asked to describe themselves, their household, and their energy consumption pattern.

2.1 General demographics

For the three countries (EE, NL and PT) the differences between the target and the obtained number of interviews are reported in Table 1. The differences remained within the 5 % deviation threshold. In Figures 2 and 3 we report the frequencies of age for the sampled data.

Table 1. Count of data (collected in the fieldwork versus target sample)

			target	obtained	diff
Estonia	male	25-34	105	76	**-2.58 %**
		35-44	105	104	**-0.09 %**
		45-54	95	96	**0.09 %**
		55-64	84	86	**0.18 %**
		65+	84	77	**-0.62 %**
	female	25-34	105	105	**0.00 %**
		35-44	95	96	**0.09 %**
		45-54	95	95	**0.00 %**
		55-64	175	183	**0.71 %**
		65+	179	125	**-4.81 %**
the Netherlands	male	25-34	95	91	**-0.37 %**
		35-44	105	101	**-0.37 %**
		45-54	116	115	**-0.09 %**
		55-64	95	91	**-0.37 %**
		65+	116	112	**-0.37 %**
	female	25-34	95	91	**-0.37%**
		35-44	105	101	**-0.37 %**
		45-54	116	112	**-0.37 %**
		55-64	95	91	**-0.37%**
		65+	137	133	**-0.37 %**
Portugal	male	25-34	95	96	**0.05 %**
		35-44	105	106	**0.05 %**
		45-54	105	106	**0.05 %**
		55-64	84	85	**0.05 %**
		65+	116	118	**0.09 %**
	female	25-34	95	96	**0.05 %**
		35-44	105	108	**0.14 %**
		45-54	105	105	**0.00 %**
		55-64	95	97	**0.09 %**
		65+	158	142	**-0.75 %**

Source: SSI S.A.

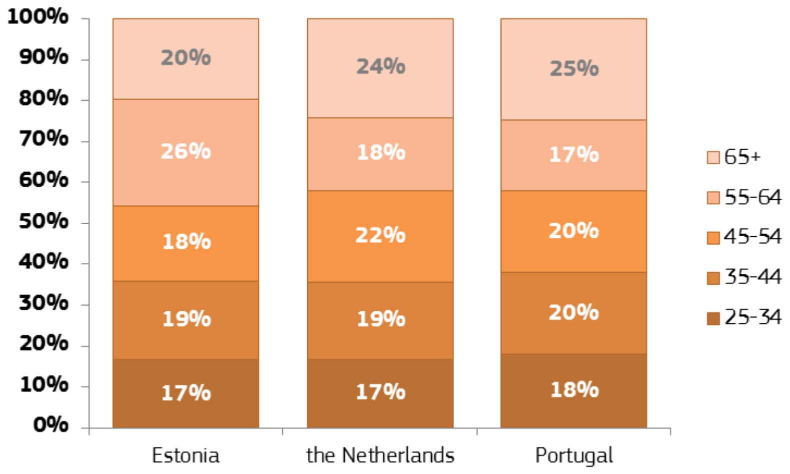
Figure 2. Sample distribution of age (%)

([1]) Demographic groups by age and gender quotas are defined through the most updated national statistical information available in the three countries.

([2]) This last condition is suggested to improve the evaluation of willingness-to-pay to support a hypothetical strategy for energy security of the EU, the objective of the Section 3 of the study.

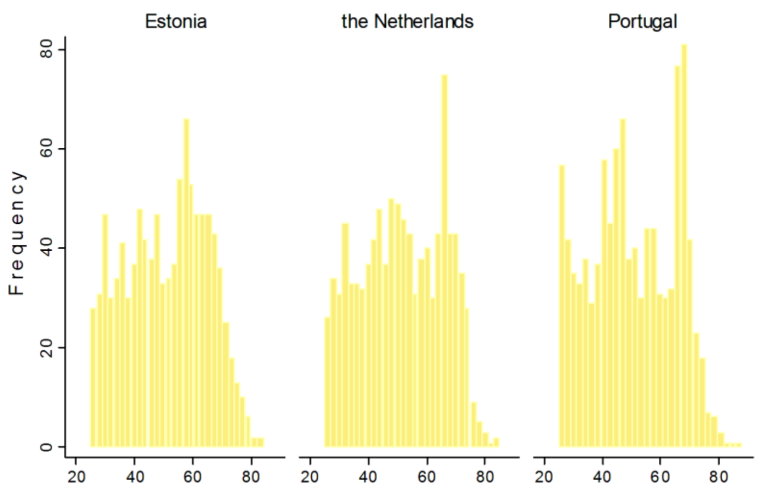
([3]) Documentation available at https://www.sesame-project.eu/

([4]) Documentation available at http://ec.europa.eu/newsroom/just/item-detail.cfm?item_id=533



Source: own elaborations

Figure 3. Distribution of Age



Source: own elaborations

2.2 Household characteristics

2.2.1 Number of persons living in the residence

Single occupancy households represent 23 % in Estonia, 28 % in the Netherlands and 15 % in Portugal (Figure 4).

2.2.2 Size of residence

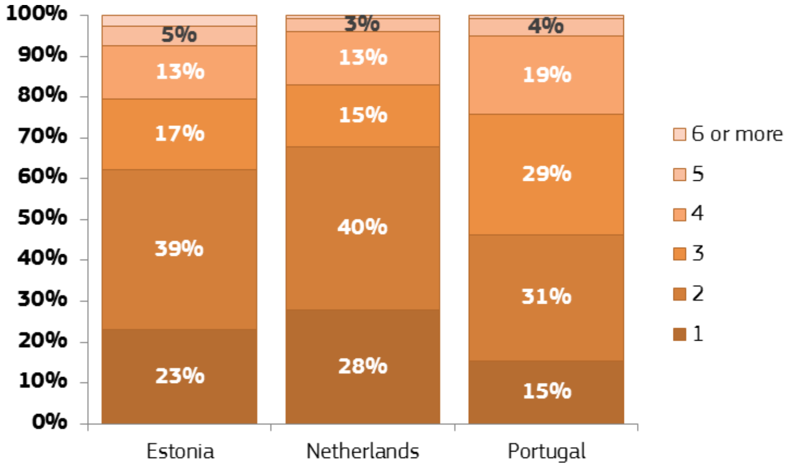
The size of the residence by country, and by size of household, is illustrated in Figure 5. We can see that the highest median is in PT, followed by NL. Residences inhabited by 6 or more persons are the only exception to this ranking, where EE has a higher median than NL, but also a more dispersed distribution. Data are truncated at 500 square meters and houses 6 persons or more are grouped together, as their number in the sample is residual.

2.2.3 Area of residence

From Figure 6 we see that respondents stating that they live in a 'big city' represent 28 % of the sample in EE, 23 % in NL, and slightly higher 32 % in PT. For 'suburbs and outskirts of a big city' we find 14 % of the sample in EE, 17 % in NL, and 25 % in PT. Respondents declaring to live in a 'town or small city' are 28 % in EE, 35 % in NL, and 33 % in PT. For the 'country village' the shares are 18 %, 22 % and 8 % respectively for

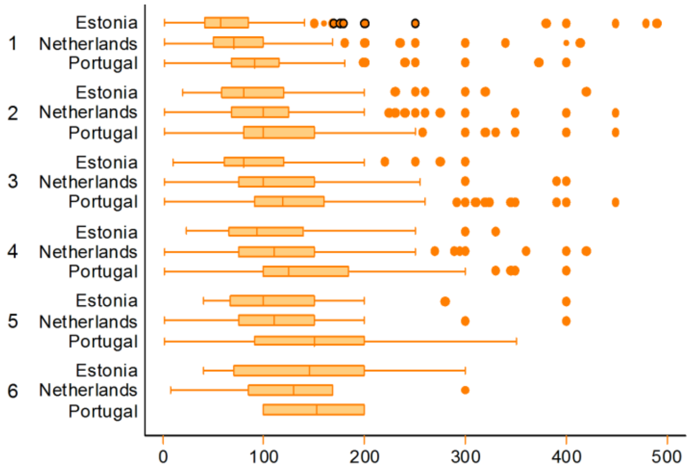
EE, NL and PT. Last, 'farm homes in countryside' represents 12 %, 3 % and 2 %, respectively for EE, NL and PT. We consider the first three categories as more densely populated areas, and the last two as sparsely populated.

Figure 4. Number of persons living in the residence



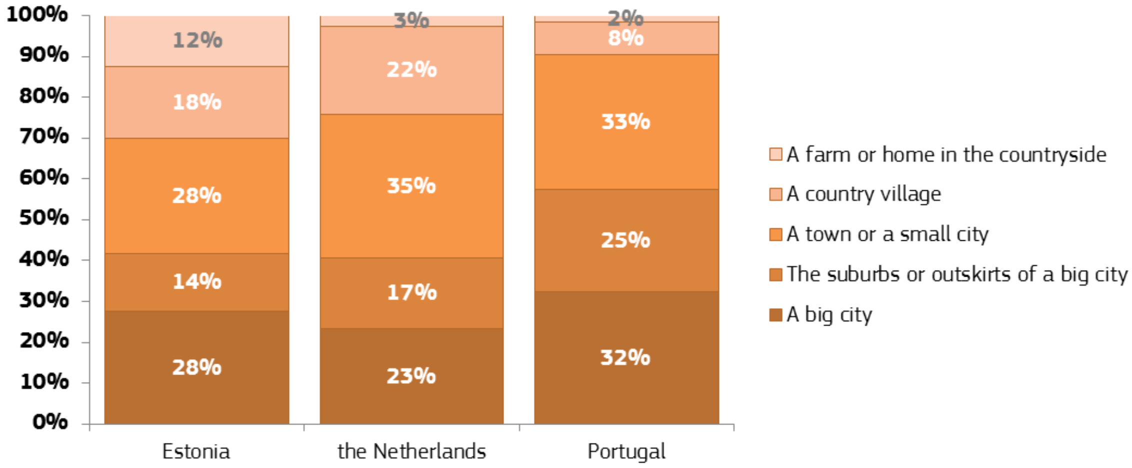
Source: own elaborations

Figure 5. Boxplots of the size of the house in square meters, categories by country and number of persons living in the house



Source: own elaborations

Figure 6. Share of responses from different territorial contexts



Source: own elaborations

2.3 Energy-related profile of households

The monthly expenditures for the supply of different fuels are reported in Figure 7. Respondents further were asked to indicate the main energy fuel they used to heat their residence, cook, and heat water. Depending on the fuel, these energy behaviours are interrupted (or not) in case of a blackout electricity outage. For example, gas boilers often require electricity to function, whereas heating using wood often does not require electricity.

Respondents clearly differed on the main energy fuel used to heat (cool) the house, which is always a large share of households' energy consumption (Figure 8):

- in EE, the main fuel to heat the house is wood (49 %), followed by electricity (15 %), and gas (10 %)
- in NL the main fuel is gas (76%), followed by electricity (17 %), and wood (3 %), and
- in PT the main fuel is electricity (56 %) followed by wood (21 %) and then gas (16 %).

Accordingly, most respondents in NL and PT are not able to heat their residencies when the supply of electricity is interrupted.

For cooking and heating water, respondents in NL and PT relied mostly on gas, followed by electricity (Figures 9 and 10). In EE, electricity was used as the main fuel for cooking and heating water, followed by gas and wood.

Figure 7. Monthly expenditure for the supply of different fuels (euros). On the right, boxplots for the amount of the family; on the left, boxplots of per capita values

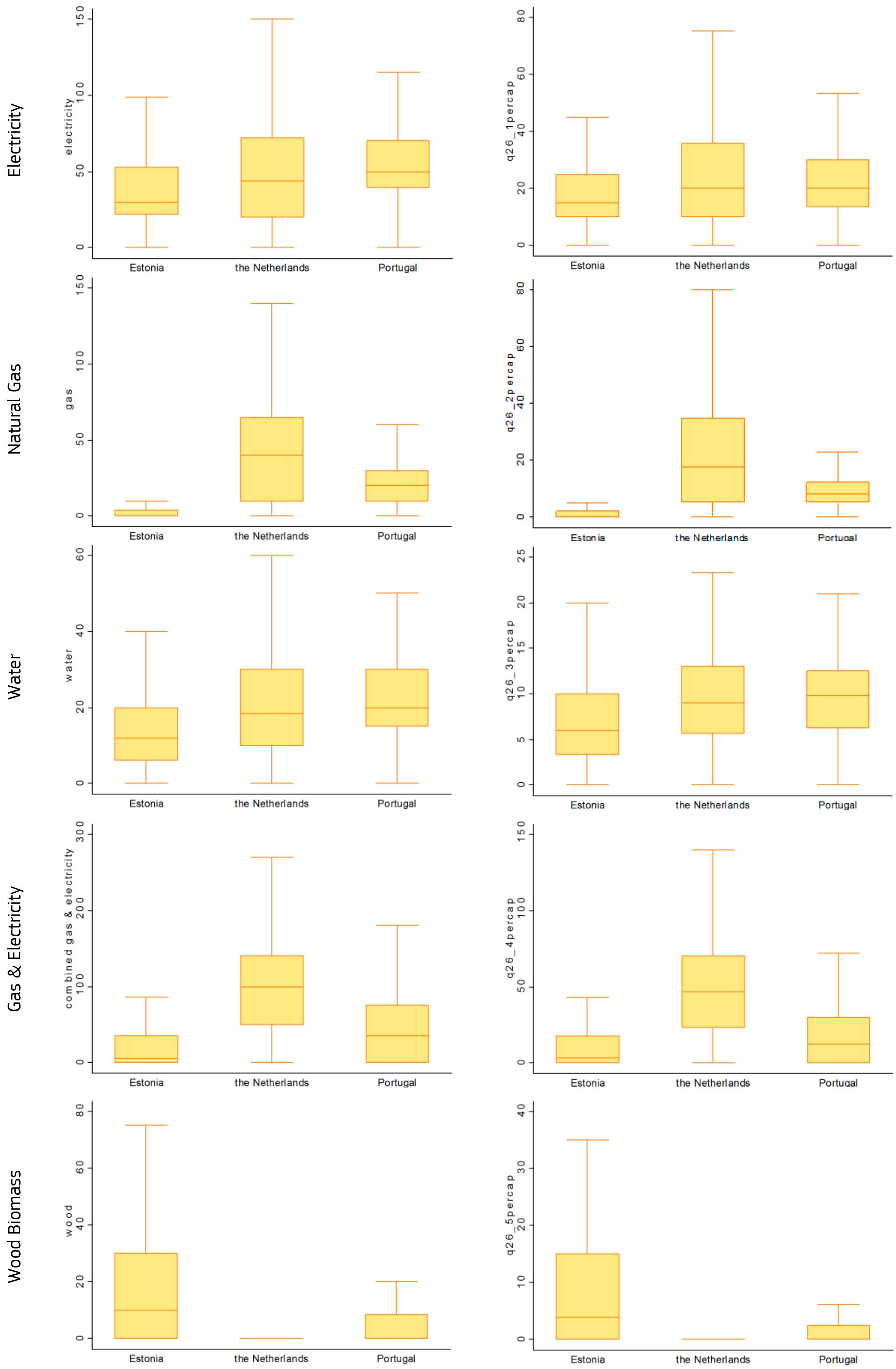


Figure 8: Main fuel used for space heating/cooling in the house

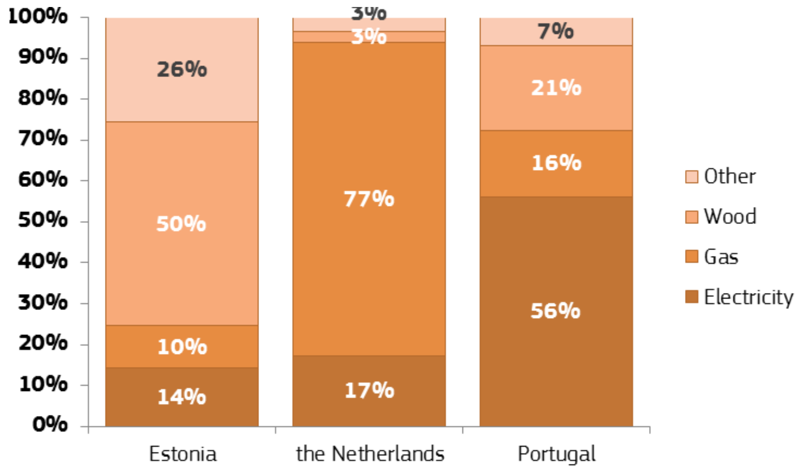


Figure 9. Man fuel used for Cooking

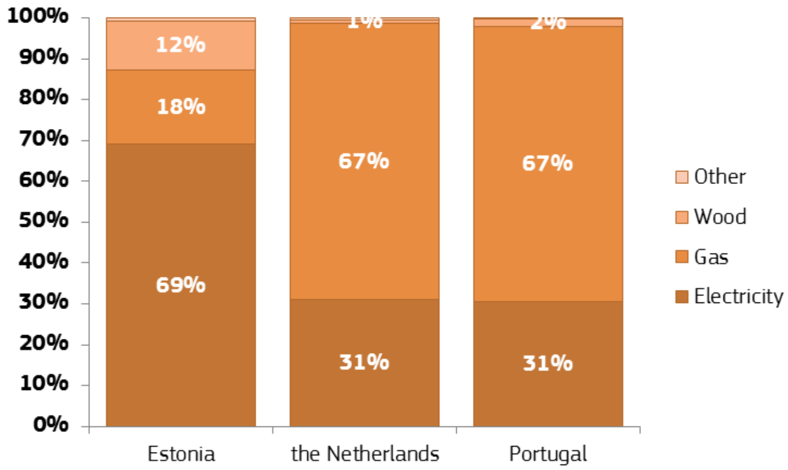
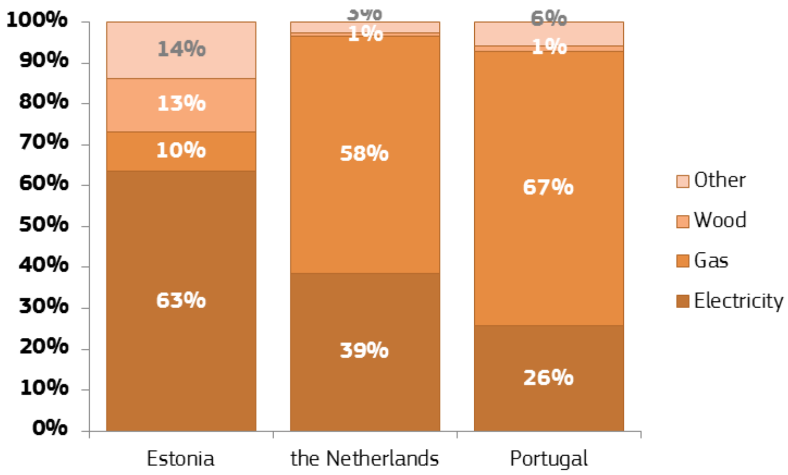


Figure 10. Main fuel used for water heating



Source: own elaborations

3 Experiences with interruptions in energy supply

3.1 Inconveniences caused by interruptions

Respondents also choose from a pre-defined list the activities that they would be unable to do in the case of a power cut (Figure 11). Indoor lighting is clearly the most chosen activity in the three countries. Electricity seems to be more necessary for the Netherlands for warming/cooling rooms, washing dishes, talking on the telephone, cleaning floors, and having a bath/shower, which corresponds to the earlier mentioned household energy consumption profile. On the contrary, EE is less dependent from electricity, especially for warming rooms (see Figure 8).

In the survey, we asked respondents to indicate which inconvenience they would generally consider as *relevant* in the case of blackout (Figure 12) where we found that respondents are generally most concerned about spoiled food due in the fried or freezer. In addition, for respondents in NL, the inability to heat the house was also considered an important inconvenience. Furthermore, compared to the other countries, respondents in EE were relatively concerned about being unable to recharge their mobile telephones, and respondents in PT were relatively concerned about being trapped in an elevator.

3.2 Personal values

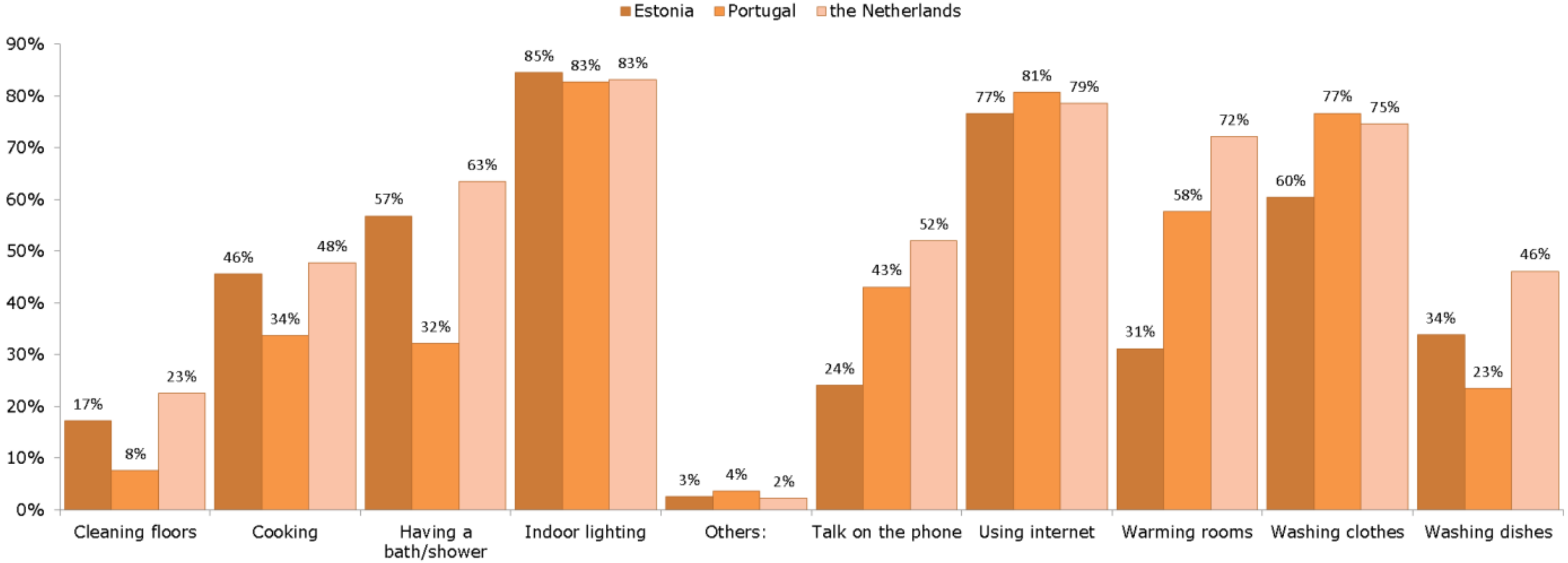
As mentioned, individuals have their own value system, in which different values are hierarchically ordered based on the importance the individual attaches to each value (Rokeach, 1973; Schwartz, 1994, 2003, 2006; Schwartz et al., 2012). These value systems are often used to characterize individuals, groups, and cultures. In addition, values are generally seen as important and stable underlying predictors of individuals' behaviours, attitudes, and beliefs.

Personal values could thereby provide critical insights for policymakers (Jans, Bouman, & Fielding, 2018; Lopes, Antunes, & Martins, 2012; Steg, Bolderdijk, Keizer, & Perlaviciute, 2014; Steg, Dreijerink, & Abrahamse, 2005; Steg, Perlaviciute, & Van Der Werff, 2015; Steg, Shwom, & Dietz, 2018; Van der Werff & Steg, 2015). In the context of the current report, values could provide insights on why individuals prioritize certain dimensions of energy security over others, and why individuals are willing-to-pay (WTP) for energy security or accept lower levels of energy security. Moreover, a better understanding of personal values could help with understanding evaluations of the benefits of energy security, both in the short and in the long term. This information is crucial for understanding citizens' choices, attitudes, beliefs, and behaviours, and provides key insights on how individuals could be approached, and which types of feedback, information or incentives are likely to be effective (Abrahamse & Steg, 2009; Abrahamse, Steg, Vlek, & Rothengatter, 2005; Bolderdijk, Gorsira, Keizer, & Steg, 2013).

In the value literature, values are measured by 57 items (Schwartz, 1994; Schwartz et al., 2012), which are then categorized in more specific value clusters (Schwartz, 1994, 2003; Schwartz et al., 2012). However, environmental and energy research typically employ a shortened and adapted version of this measure (Bouman, Steg, & Kiers, 2018; De Groot & Steg, 2008; Steg, Perlaviciute, Van Der Werff, & Lurvink, 2014; Stern et al., 1998), consisting of 16 (SVS) or 17 (E-PVQ) value items that identify four value clusters that steadily and consistently predict energy behaviours, attitudes and beliefs. Those four values are:

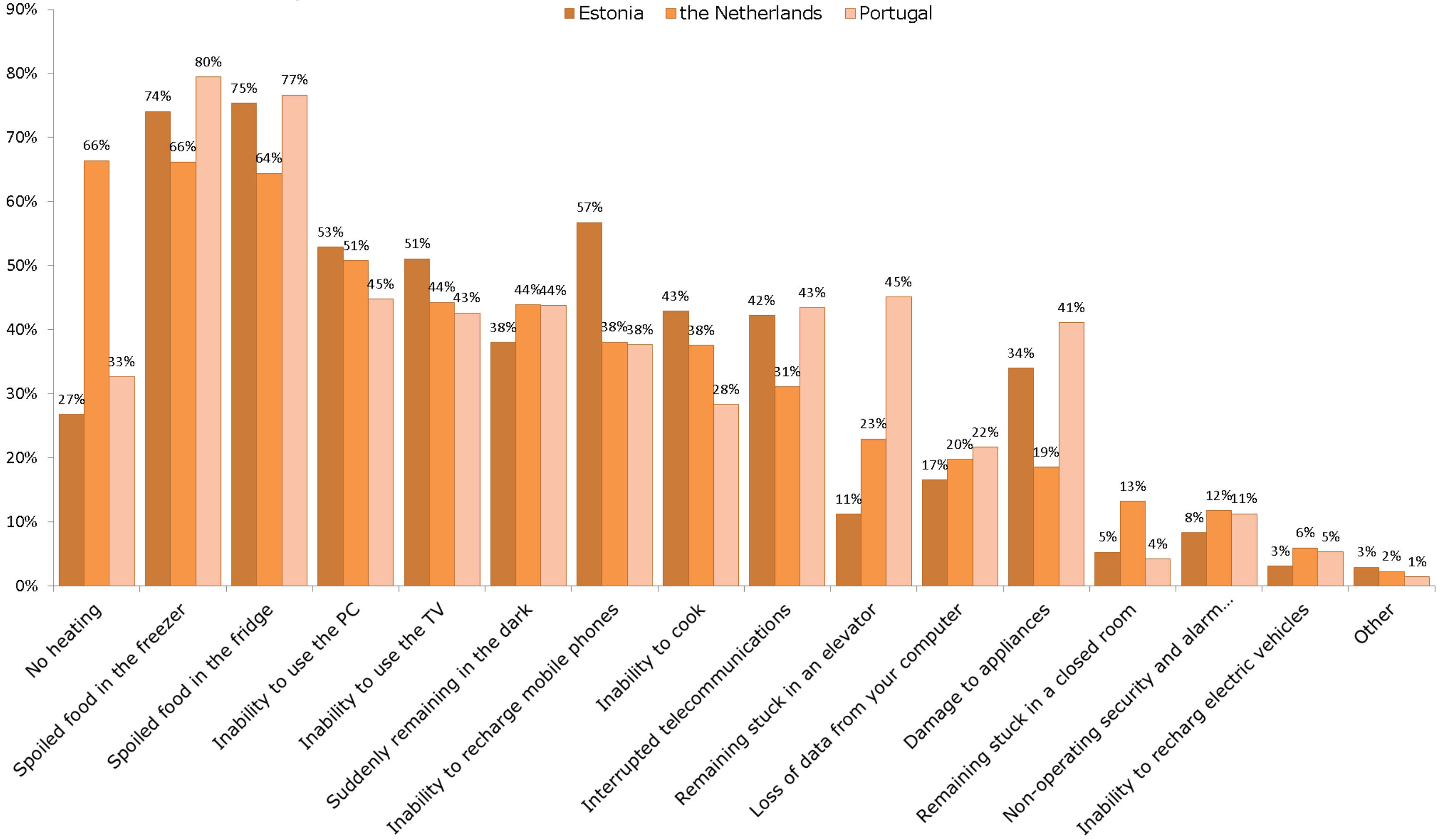
- Altruistic values, e.g. a concern for the welfare and fair treatment of others
- Biospheric values, e.g. a concern for nature and the environment
- Egoistic values, e.g. a concern for personal resources and power
- Hedonic values, e.g. a concern for pleasure, comfort and reducing effort

Figure 11. Activities that cannot be done at home in absence of electricity



Source: own elaborations

Figure 12. Inconveniences from blackouts classified by respondents as "more relevant"



Source: own elaborations

Each of these values represent a different motive to invest (or not) in energy security and engage (or not) in a sustainable energy transition. For example, altruistic and biospheric values are likely to positively correlate with WTP for energy security if investments in a more secure energy system are associated with environmental (e.g. larger penetration of renewables, locally generated energy) and societal (e.g. secure and stable supply of energy) benefits. Similarly, hedonic values might positively correlate with WTP when investments are perceived to reduce inconveniences related to loss of load, unless such policies or measures are perceived as inconvenient (e.g. require a lot of effort). For egoistic values, this relationship is more ambiguous. On the one hand, investments in energy security could be associated with financial costs, which would suggest a negative correlation between egoistic values and WTP and a positive correlation with willingness-to-accept (WTA) compensations. On the other hand, investments in energy security could be associated with economic benefits and independence of other countries and power, which would suggest a positive correlation between egoistic values and WTP.

Having a better understanding of these values could help policymakers in multiple ways (e.g. Bolderdijk et al., 2013; Leijten et al., 2014; Van Den Broek et al., 2017). Firstly, based on individual or group-level value systems indicating how value clusters are hierarchically ordered, one could select and tailor information, feedback and incentives that correspond to those values that are most strongly endorsed. For instance, information highlighting sustainable benefits of energy security might be effective when biospheric values are strongly endorsed, but ineffective when other values (e.g. egoistic) are more prominent and activated. Secondly, when one knows the importance attached to each value, one could predict which barriers and opportunities policies might face and act accordingly. For example, knowing that egoistic values are strongly endorsed could indicate that individuals are unlikely to spend money (i.e. barriers), unless they get financial or power benefits in return (i.e. opportunity). Lastly, identifying correlations between values and key energy behaviours, attitudes and beliefs, provide insights in which individuals are (un)likely to accept and adopt certain policies enabling policymakers to identify early adopters and laggards.

Values are measured on a scale consisting of 17 items (in randomized order), which is an adapted and shortened version of the Schwartz Value Survey (Schwartz, 1994, 2003, 2012; Steg, Perlaviciute, et al., 2014; Stern et al., 1998) and has been validated in earlier research (Bouman et al., 2018; Schwartz, 2003, 2012). The value scale uses 17 short verbal portraits of another person – gender– matched to the participant – in which a value is described that is important to this person (e.g. 'It is important to her to enjoy life's pleasures.'). Respondents are asked to indicate the extent to which each portrayed person is like the respondent herself or himself, ranging from 1 (entirely not like me) to 7 (entirely like me).

3.2.1 Scale construction

At first, we computed the value clusters out of the single items and inspected whether the items loaded correctly on the corresponding value clusters. For this we used the Oblique Multiple Group method (OMG method; e.g. Guttman, 1952; Nunnally, 1978; Stuive, 2007) of confirmatory factor analyses, as well as multidimensional scaling to visualize the value clusters. The OMG method was applied in three steps:

First, the mean score was calculated for each value scale:

Altruistic values = $\frac{\sum(QA1_{a-e})}{5}$

Biospheric values = $\frac{\sum(QA1_{f-i})}{4}$

Hedonic values = $\frac{\sum(QA1_{j-l})}{3}$

Egoistic values = $\frac{\sum(QA1_{m-q})}{5}$

Second, for each value item we calculated its correlation with each of the composite value scales, while the correlation between an item and the scale to which it theoretically belongs is being corrected for 'self-correlation'.

Third, we checked whether the corrected correlation between an item and the scale to which it was supposed to belong was stronger than its correlation with the other scales, which would confirm that the item loads on the right cluster (see Nunnally, 1978).

From the application of the OMG method, we find that the mean value scores show a clear general pattern (see also Table 2 and Figure 13). Overall, respondents assigned the highest scores on altruistic values (M_{total} = 5.64, SD_{total} = 1.02), followed by hedonic values (M_{total} = 5.54, SD_{total} = 1.08) and biospheric values (M_{total} = 5.38,

SD_{total} = 1.22), while scoring clearly lower on egoistic values (M_{total} = 3.84, SD_{total} = 1.17). PTscored comparatively high on all values, whereas respondents in NL endorsed hedonic values relatively strongly and biospheric values relatively weakly.

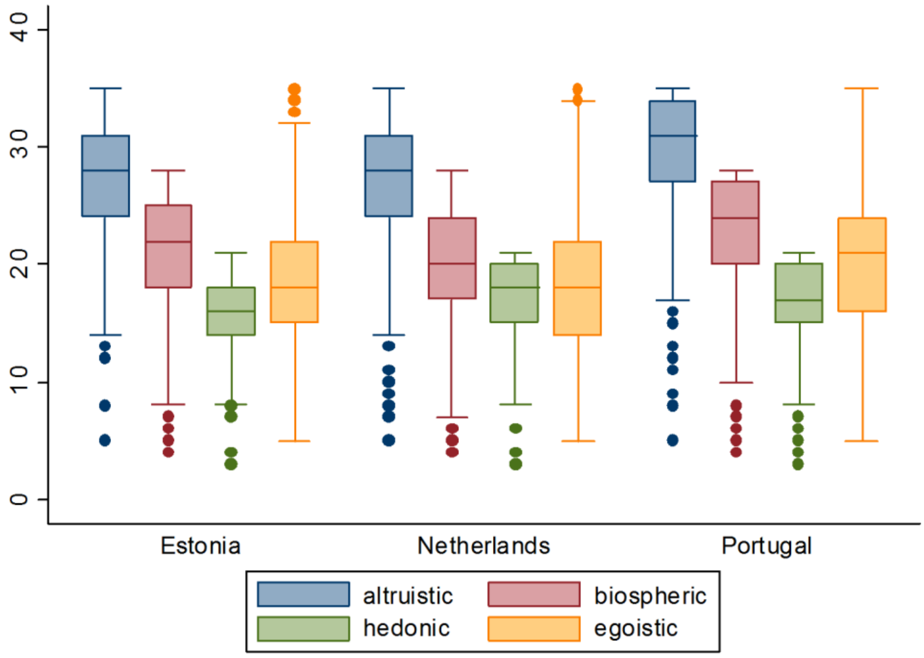
After performing the OMG method, we used multidimensional scaling to plot the items on the theorized two-dimensional scale (illustrated in Figure 7). For this purpose, we used the PROXSCAL program in SPSS, employing 20 random starting configurations as well as the classical Torgerson starting configuration, and set the convergence values at .0001, and fixed the maximum number of iterations to 100. We only report two dimensional solutions, as these portray the structure well enough, i.e. dispersion accounted for (DAF) around 95 %. From the 21 differently started analyses, we selected the ones with lowest stress.

Table 2. Scores of components of values

	Estonia				the Netherlands				Portugal			
	Alt	Bio	Hed	Ego	Alt	Bio	Hed	Ego	Alt	Bio	Hed	Ego
Altruistic	**Cronhach's α = .775**				**Cronhach's α = .840**				**Cronhach's α = .835**			
Equal	**.58**	.46	.36	.08	**.66**	.46	.40	.07	**.66**	.53	.42	.00
social justice	**.66**	.57	.41	.05	**.71**	.49	.47	.02	**.69**	.54	.40	.01
taking care	**.59**	.49	.29	.14	**.63**	.46	.31	.15	**.61**	.52	.36	.14
peace	**.37**	.38	.21	.03	**.57**	.48	.39	.06	**.59**	.48	.40	.05
helpful	**.60**	.50	.30	.09	**.67**	.47	.47	.08	**.64**	.55	.43	.11
Biospheric	**Cronhach's α = .886**				**Cronhach's α = .905**				**Cronhach's α = .873**			
pollution	.58	**.78**	.29	.08	.52	**.82**	.32	.16	.58	**.77**	.40	.05
protection	.54	**.74**	.29	.07	.50	**.80**	.31	.18	.54	**.67**	.39	.13
respect	.60	**.77**	.33	.06	.57	**.72**	.48	.05	.60	**.73**	.40	.06
Unity	.55	**.72**	.30	.09	.54	**.81**	.33	.13	.58	**.75**	.36	.08
Hedonic	**Cronhach's α = .696**				**Cronhach's α = .833**				**Cronhach's α = .738**			
pleasure / fun	.27	.20	**.53**	.30	.41	.35	**.69**	.18	.40	.34	**.58**	.24
enjoying life	.31	.28	**.54**	.30	.49	.38	**.70**	.10	.39	.36	**.64**	.21
self-indulgent	.45	.36	**.48**	.15	.46	.32	**.68**	.10	.47	.41	**.48**	.22
Egoistic	**Cronhach's α = .766**				**Cronhach's α = .824**				**Cronhach's α = .786**			
social power	.04	.01	.24	**.67**	.06	.12	.10	**.72**	.12	.12	.25	**.59**
authority	.04	.05	.13	**.62**	.02	.07	.02	**.65**	-.02	-.01	.10	**.59**
influential	-.10	-.07	.12	**.63**	-.01	.05	.00	**.73**	-.09	-.04	.04	**.63**
wealth	.24	.18	.28	**.35**	.26	.25	.26	**.46**	.20	.19	.31	**.49**
ambitious	.17	.15	.41	**.42**	.06	.07	.19	**.55**	.11	.10	.31	**.52**

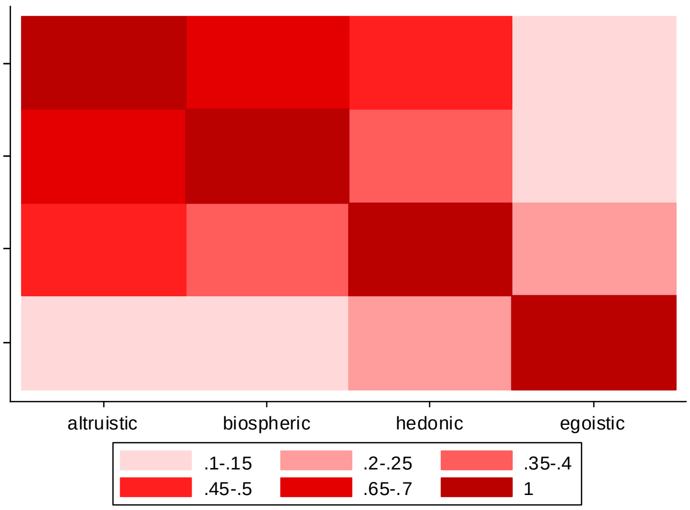
Source: own elaborations

Figure 13. Sum of the scores for the altruistic, biospheric, hedonic and egoistic values



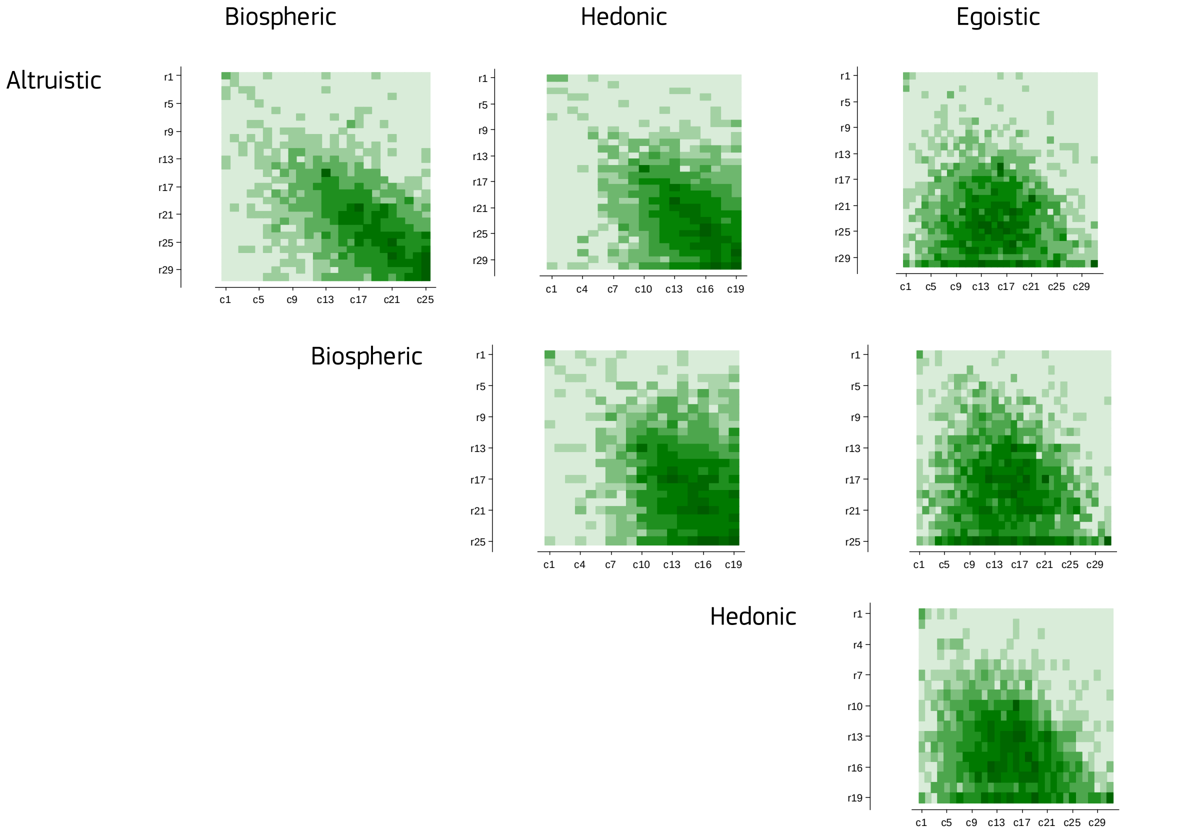
Source: own elaborations

Figure 14. Correlation among the values components



Source: own elaborations

Figure 15. Two-way frequency tables, in colours. The vertical axes are reversed with larger values downwards

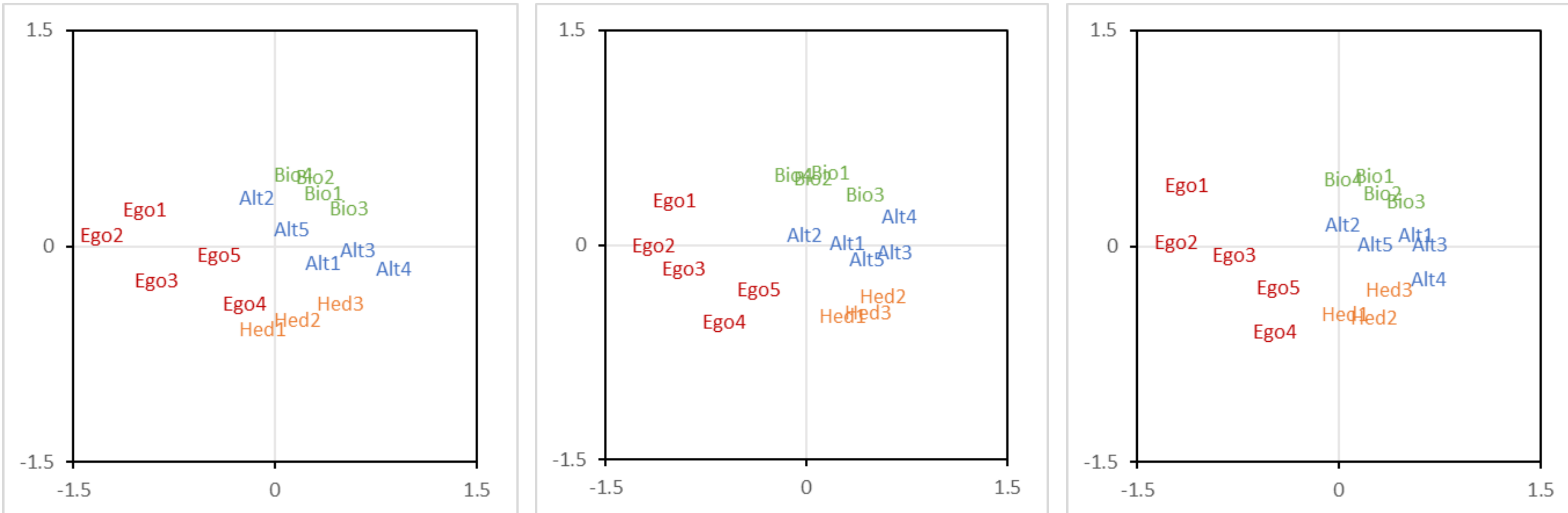


Source: own elaborations

The raw scores and computed mean scores for each value could be used as predictor variables in regression analyses, MDS and factor analyses. However, if one is interested in only one value as a predictor or in group-mean comparisons, one could also choose to use the centred value score to correct for scale use biases (this choice depends on the assumptions one has about scale use and the exact question one wants to answer). Centred value score can be computed by following these steps (Schwartz, 2003; Schwartz et al., 2012): 1) compute the mean score for each value (as indicated above), 2) compute for each individual the mean score across all 17 items (i.e. MRAT), and 3) subtract the MRAT from each of the four mean value scores (computed as indicated above). The current analyses presented below are based on the mean scores and not the MRAT.

The Figure 16 indicates that items which are theoretically assumed to relate to each other (i.e., because they aim to measure the same construct), indeed closely relate to each other. That is, based on theory, the items with the same colour should be located close to each other and form clusters/clouds, which is mostly the case. Accordingly, it confirms our clustering into egoistic, hedonic, biospheric and altruistic values. Moreover, it suggests that, at least on one dimension, the egoistic cluster differs quite strongly from the other clusters.

Figure 16. Two-dimensional multidimensional scaling for the PVQ value scale for each country.



Estonia | the Netherlands | Portugal

Notes: PVQ items (e.g., Alt1) are plotted on a two-dimensional space, where the distance between the items represents their resemblance. The closer two items are located to each other, the stronger their resemblance. Pre-defined theory-based clusters are indicated in colours (egoistic cluster = red, hedonic cluster = orange, biospheric cluster = green, altruistic cluster = blue), and are supported by our data (i.e., items belonging to the same cluster are located close to each other). Item abbreviations (e.g. Alt1) correspond to the ordering of the items as presented in Appendix A (e.g. first item measuring altruistic values).

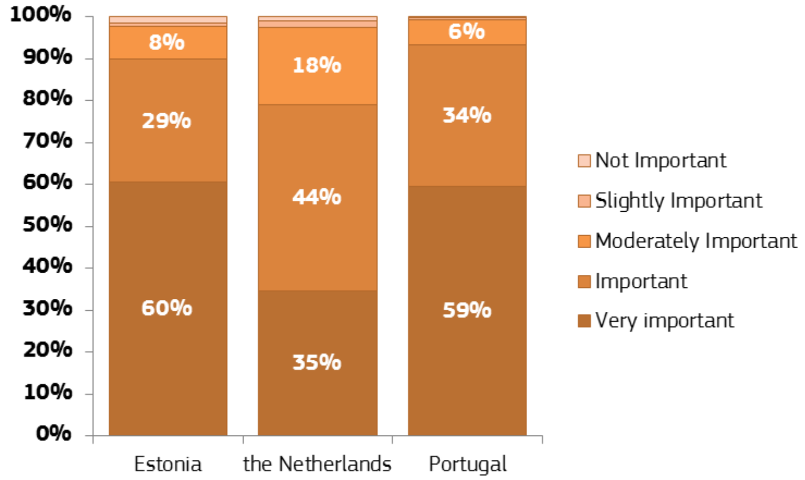
Source: own elaborations

4 Needs for additional reliability and affordability of energy supply

As previously mentioned, energy security is not a monolithic concept. From an epistemological point of view, there is a major difference if one just refers to the analysis of physical and technological dimension, checking for the vulnerabilities of energy systems to assess risks of interruptions or shortages, or if we accept to consider subjective components of society around the meaning of "security" when speaking of energy (Cherp, Defining energy security takes more than asking around, 2012). Making reference to two specific dimensions of energy security, *reliability* and *affordability*, consumers have been asked to choose to which level of importance they agreed regarding the following statement:

"How important do you think it is **to increase** the reliability and the affordability of energy supply implementing the EU Energy Security Strategy?"

Figure 17. Shares of respondents by level of importance assigned to improved reliability and affordability



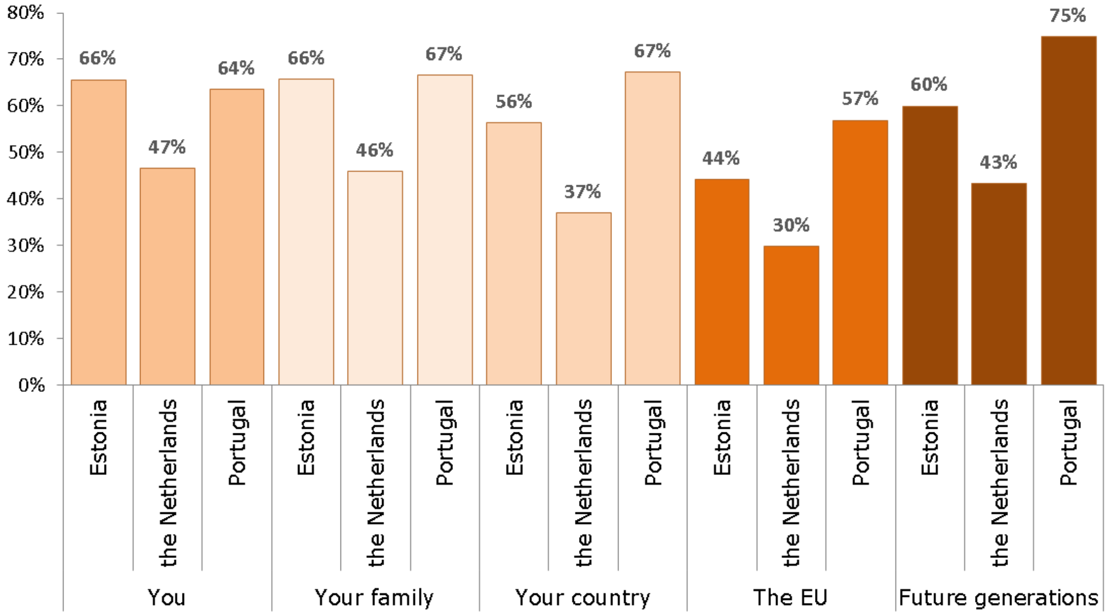
Source: own elaborations

Estonian and Portuguese respondents agreed with the statement that the need to increase the two issues are "Very Important" in approximately 60 % of responses. Netherlands on the contrary limit to 35 % the share of respondents with specific concerns for additional reliability and affordability.

Across countries, most respondents rated energy security as highly important for themselves, their family, their country of residence, the European Union, and future generations (see Figures 18 and 19). In general, respondents from NL attached slightly less importance to energy security compared to the other countries, perhaps due to fact that the country has traditionally been an energy exporter (given the indigenous production of natural gas) with reliable infrastructure (further detail on measured continuity of supply is discussed in the next paragraph).

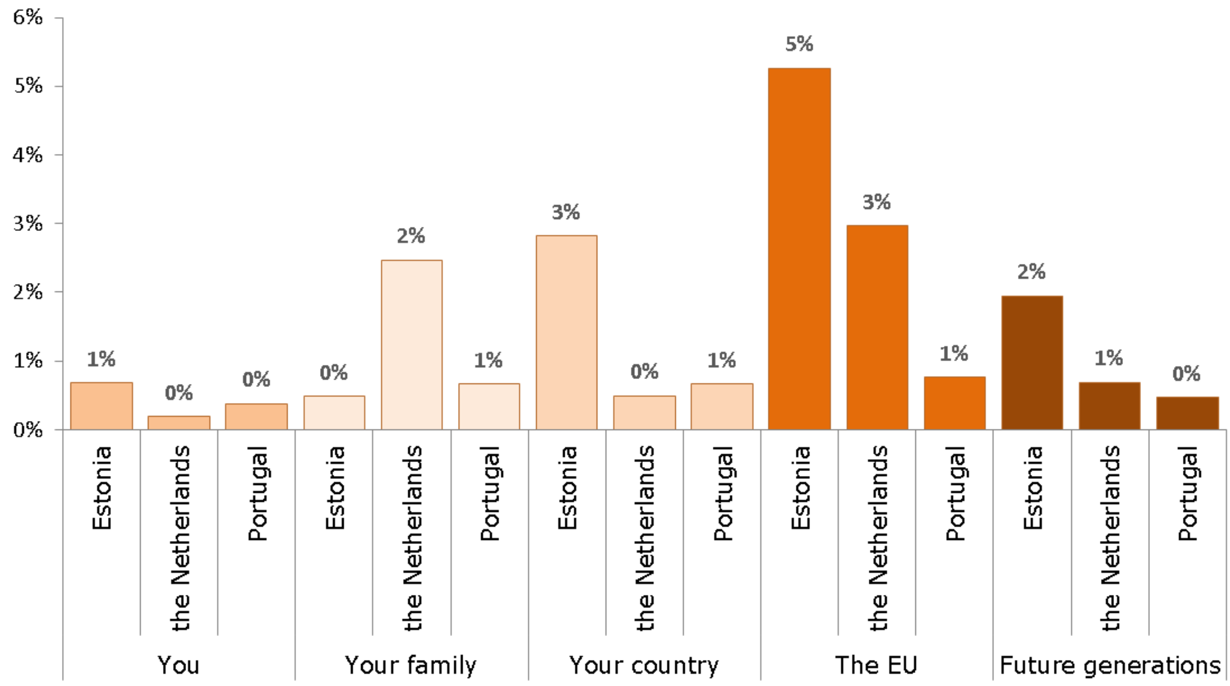
In explaining for whom enhancing reliability and affordability is expected to count, respondent tend to prioritize the protection of their inner circles (them, the family), Future generations are emphasized are meaningful receivers of the benefits of additional security (see Figures 18 and 19).

Figure 18. Respondents agreeing with the statement "reliability and affordability of energy supply are very important for..."



Source: own elaborations

Figure 19. Respondents agreeing with the statement "reliability and affordability of energy supply are **not** important for..."



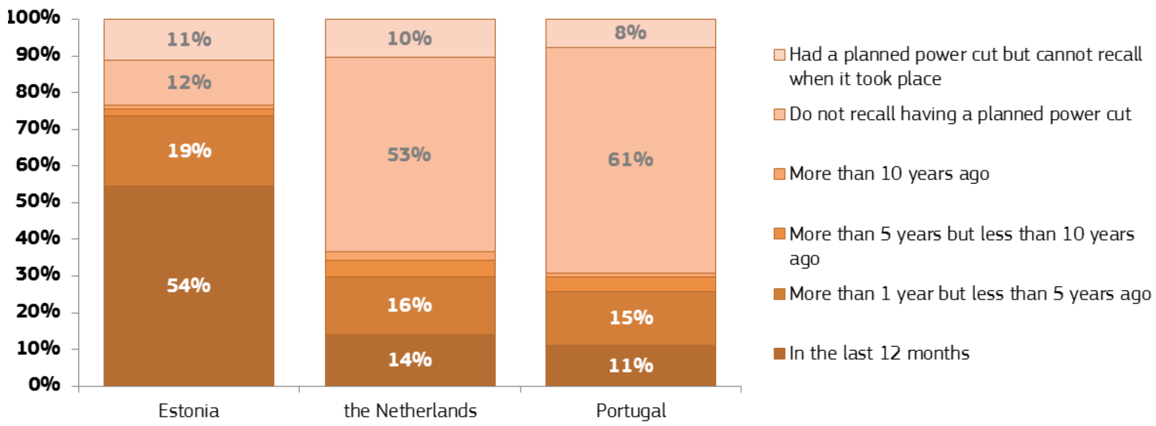
Source: own elaborations

5 Experienced planned and unplanned interruptions

The questionnaire included an introductory statement to clarify the distinction between planned power cuts (e.g. due to planned maintenance and known in advance) and unplanned (e.g. due to unforeseen malfunctioning and/or shortage of supplies).

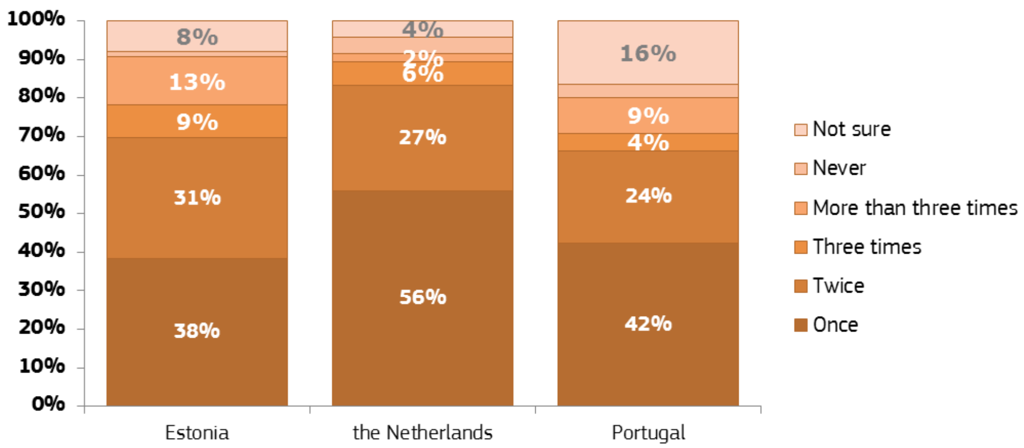
54 % of respondents in EE recall the last planned power cut occurring in the last 12 months. The same figure amounts respectively 14 % for NL and 11 % for the PT (Figure 20). Regarding the frequency of planned power cuts, 55 % of the NL sample recalled just one, while the majority of the EE and PT recalled several more (see Figure 21). In all the three countries, the duration of the longest planned interruption is perceived to have lasted less than four hours, despite a non-negligible share of the respondents (15 % in NL and PT, 18 % in EE) declared to have suffered a planned blackout during more than 4 hours (see Figure 22).

Figure 20. Experienced of planned blackouts



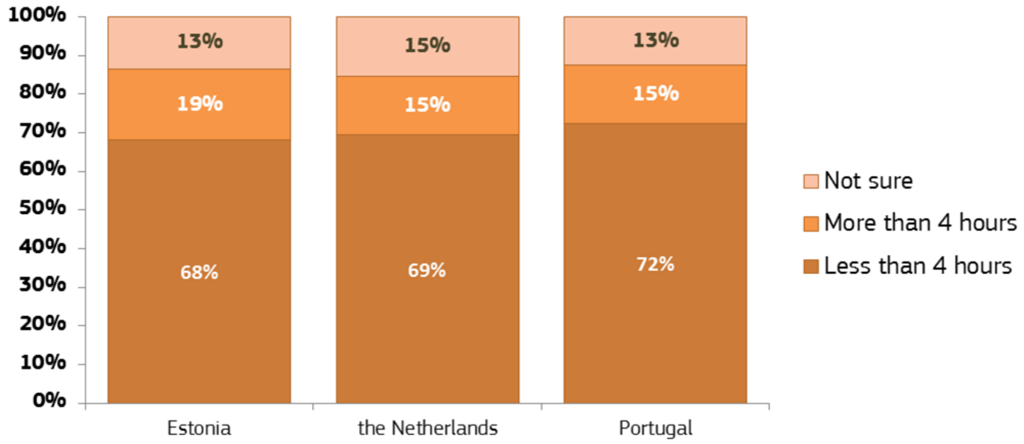
Source: own elaborations

Figure 21. Frequency of planned blackouts stated by respondents



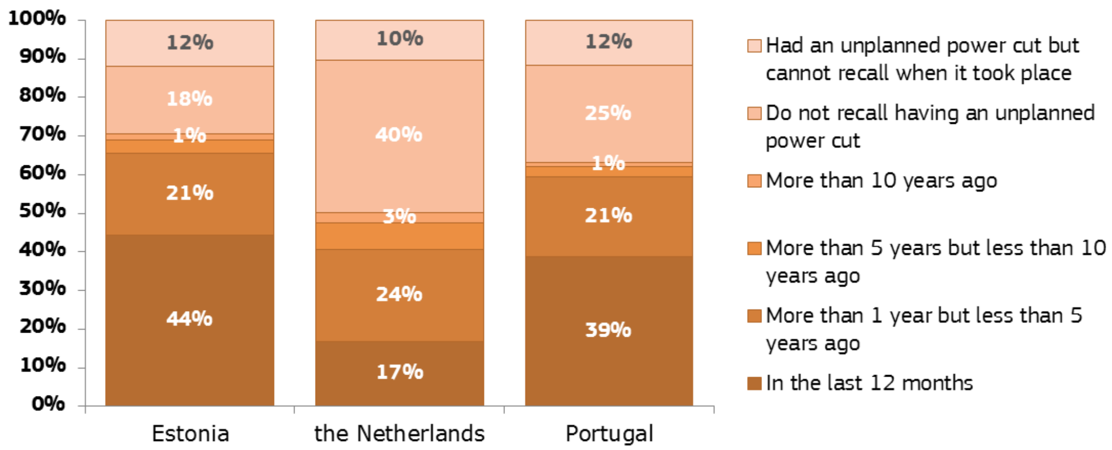
Source: own elaborations

Figure 22. Duration of the longest planned power cut during the last 12 months



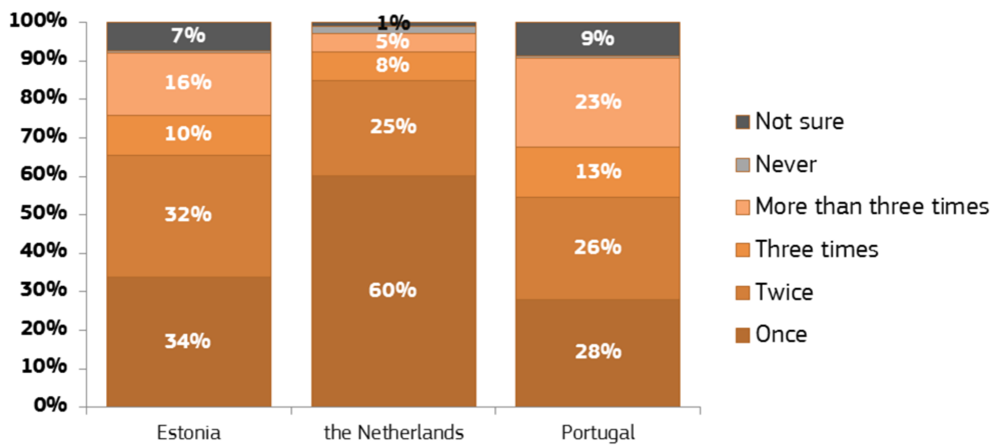
Source: own elaborations

Figure 23. Last unplanned power cut



Source: own elaborations

Figure 24. Thinking about the last 12 months how many times have you experienced an unplanned power cut?



Source: own elaborations

The number of unplanned events experienced by respondents also varied across countries. For most respondents in EE and PT, the last recalled unplanned interruption took place in the last 12 months (44 % and 39 % respectively) or in the last 1 to 5 years (21 % for both). For respondents in NL, this was considerably longer ago (17 % in the last year, 24 % in the last 1 to 5 years). Similarly, most respondents in EE last had a planned power cut during the past year (54 %), whereas the respondents in NL and EE did not recall the occurrence of the last planned power cut (52 % and 61 %, respectively).

When looking at the number of times respondents experienced a power cut in the last 12 months, one could also observe that power cuts are more frequent in EE and PT than in NL. When respondents in NL experienced a power cut, this was almost always only one time in the last 12 months, whereas in EE and PT power cuts were, in general, experienced more frequently. In all countries, power outages mostly lasted shorter than 4 hours. For unplanned power cuts, Figure 24 reports the frequencies, and Figure 25 report the duration of the events stated by respondents.

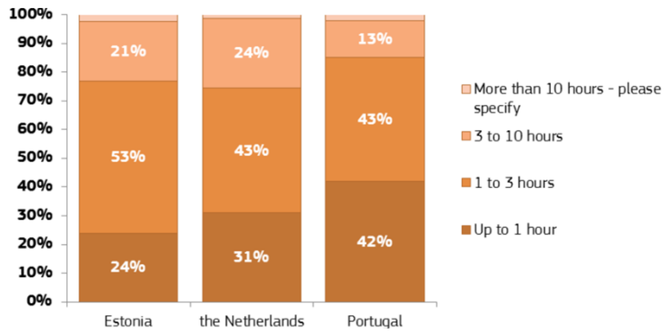
The Council of European Energy Regulators (CEER) provides some benchmarks of the performances of country-wide energy systems in terms of continuity of electricity supply and some measured indexes can be broadly compared to the perceptions reported by the participants to the survey. In particular, the System Average Interruption Duration Index (SAIDI) and the System Average Interruption Frequency Index (SAIFI) are calculated to represent the presence of blackouts on the system. Continuity at a customer level is defined by the Customer Average Interruption Duration Index (CAIDI) and the Customer Average Interruption Duration Index (CAIFI).

Compare observed interruptions of supply with the survey data, we find the share of respondents which are likely to have provided an accurate description of the actual duration of the experienced power cut. Some caution should be placed on the interpretation of this comparison, as respondents may have indeed faced localised blackouts lacks, while SAIFI and SAIDI refer to performance of the whole system. Furthermore, respondents may not have been aware of planned interruptions.

According to SAIDI, the planned interruption customers suffered in EE was 73.75 minutes, thus, at least 19 % of Estonian sample may have substantially overstated the duration of the planned interruption. This is also valid for NL, where the planned SAIDI in 2016 was 6.28 minutes (while 15 % stated more than 4 hours) and in PT, where planned SAIDI was 1.91 minutes and 15.1 % of respondents declared more than 4 hours.

Unplanned SAIDI is also used to check potential biased perceptions. Comparing CEER data with shares in Figure 25 we see that for the EE sample a share of 21 % of respondents declaring a duration from 3 to 10 hours, while the sum of all the unplanned including exceptional events captured by unplanned SAIDI is 148 minutes. For NL unplanned SAIDI is 21 minutes and 68 % of respondents declaring a duration of more than one hour for the longest event. For Portugal the total unplanned SAIDI is 75.74 minutes with a 13 % stating three or more hours for the longest event.

Figure 25. Duration of the longest unplanned blackout



Source: own elaborations

6 Measures to improve energy security

6.1 Willingness to reduce energy use

Respondents rated on a 7-point scale (from 1 *completely disagree* to 7 *completely agree*) whether they were willing to reduce their energy consumption. In general, respondents in Estonia (M = 5.05, SD = 1.69) and in the Netherlands (M = 5.13, SD = 1.62) agreed with the statement to reduce their energy consumption, whereas respondents in Portugal *strongly* agreed with this statement (M = 6.14, SD = 1.26).

Regression analyses revealed that standard demographic variables did not explain the variance in energy savings in the three countries. However, adding personal values increased the explained variance by 4 % in EE, 8 % in NL, and 4 % in PT. Biospheric values positively related to willingness to reduce energy use in EE and NL. In addition, in NL, altruistic values are positively related to the willingness to reduce energy use, while egoistic values are negatively related.

6.2 Investments in energy technologies

6.2.1 Willingness to invest

For different technologies respondents were asked to indicate whether they owned the technology or were planning to buy the technology for household use. Except for smart meters, the adoption of all technologies is quite low across countries, less than 15 % (Figure 26), and the intention to buy such technologies in future was also quite low in EE and NL, but a bit higher in PT. Still for almost every technology, the majority of the respondents indicated to not own the technology and also not having the intention to purchase it in the near future.

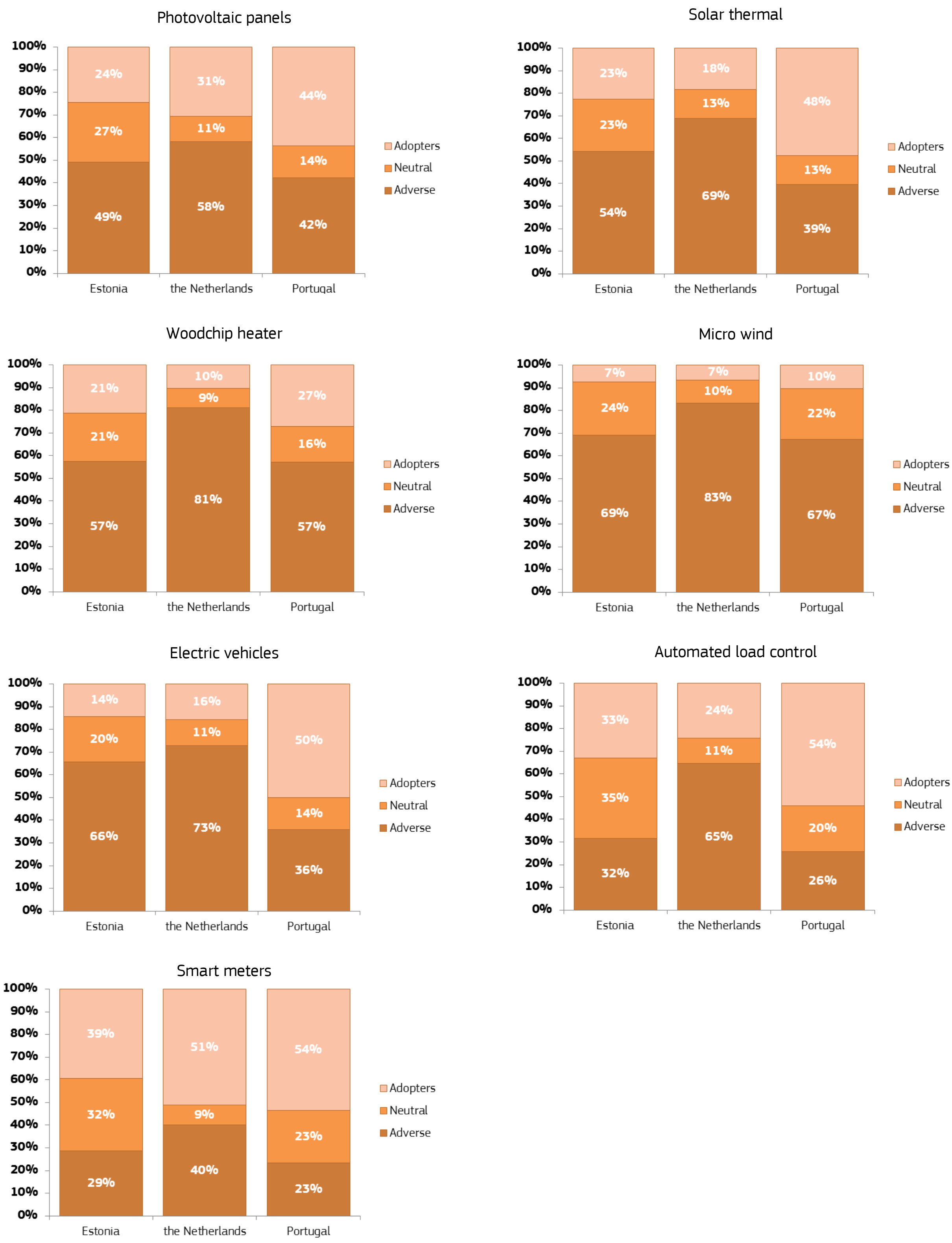
6.2.2 Acceptability of measures to improve energy security

Acceptability of four different methods to improve energy security were measured, i.e. centralized fossil fuels, decentralized renewables, manual energy matching, and automated energy matching. For each method, respondents had to answer two items on 7-point scales (from 1 *very unacceptable* and *very negative* to 7 *very acceptable* and *very positive*), for which the means are:

- centralized fossil fuels, M = 3.62, SD = 1.71, r = .81;
- decentralized renewables, M = 5.68, SD = 1.30, r = .74;
- manual energy matching, M = 5.39, SD = 1.27, r = .70;
- automated energy matching, M = 4.77, SD = 1.60, r = .80.

When looking at specific solutions to increase energy security, more sustainable options (i.e. energy matching, decentralized energy production from renewables) were seen as more acceptable and more positive than unsustainable options (i.e. centralized energy production from nuclear, coal, and gas). In addition, manual/decentralized options were preferred over automatization, indicating that people prefer some kind of control over the solutions.

Figure 26. Attitudes of respondents toward the adoptions of energy technology options



Source: own elaborations

6.2.3 Acceptability of measures to improve energy security

Regression analyses with only demographic variables as predictors explained between 1 % and 5 % of the variance in acceptability of single ways to improve energy security. However, the addition of personal values improved all modes (see *R^2s* in Table 10).

Across all countries, biospheric values were positively related to acceptability of decentralized renewables, manual energy matching and automated energy matching, and negatively related to acceptability of centralized fossil energy. Accordingly, stronger biospheric values are indicative for more support for sustainable ways to improve energy security, and less support for unsustainable ways to improve energy security. In addition, in the Netherlands and Portugal, altruistic values positively related to acceptability of decentralized renewable energy and manual energy matching.

Egoistic values positively related to acceptability of centralized fossil energy in all countries, positively related to acceptability of automated energy matching in the Netherlands, and negatively related to acceptability of decentralized renewable energy in all countries. Although some demographic variables were also related to acceptability of certain ways to improve energy security, there was no clear or consistent pattern across countries or variables (Table 5).

Table 3. Personal values and acceptance of technological options of the power system.

	Centralized fossil energy			Decentralized renewable energy		
	EE	NL	PT	EE	NL	PT
Income	-0.05	0.07**	-0.01	0.06*	**0.09****	0.03
Age	0.01	-0.06	**-0.12*****	**-0.19*****	0.07*	**0.10*****
Gender	**-0.17*****	0.01	**0.14*****	-0.07*	**-0.11*****	**-0.11*****
Education	-0.08**	0.07**	0.07**	0.03	-0.02	-0.03
Hh size	-0.06	-0.02	0.00	0.02	-0.02	0.05
Hedonic	-0.03	-0.03	0.09**	0.05	0.02	0.09**
Egoisitc	**0.16*****	**0.22*****	**0.17*****	**-0.07****	**-0.15*****	**-0.09*****
Altruistic	0.05	0.02	0.04	0.08	**0.18*****	**0.14*****
Biospheric	**-0.13*****	**-0.23*****	**-0.17*****	**0.20*****	**0.23*****	**0.15*****
R^2	**0.07*****	**0.10*****	**0.09*****	**0.11*****	**0.17*****	**0.13*****

Note. Boldfaced coefficients are discussed in text, they represent coefficients with *p*-value below .001 ro that approached .001.
*** $p < .01$, ** $p < .05$, * $p < .10$

	Manual energy matching			Automated energy matching		
	EE	NL	PT	EE	NL	PT
Income	0.05	**0.09*****	0.01	**0.12*****	**0.11*****	0.02
Age	0.00	**0.12*****	0.07*	-0.05	0.04	0.06
Gender	0.01	0.04	0.02	**-0.14*****	-0.04	-0.07**
Education	-0.01	0.00	0.00	-0.04	0.04	0.01
Hh size	-0.04	0.03	0.04	-0.04	0.04	0.06*
Hedonic	0.05	0.00	0.03	-0.04	-0.09**	0.05
Egoisitc	-0.05	-0.08***	-0.06*	0.01	**0.13*****	0.01
Altruistic	0.05	**0.14*****	**0.17*****	0.05	0.06	0.02
Biospheric	**0.27*****	**0.24*****	**0.20*****	**0.14*****	**0.15*****	**0.14*****
R^2	**0.11*****	**0.15*****	**0.14*****	**0.05*****	**0.07*****	**0.05*****

Note. Boldfaced coefficients are discussed in text, they represent coefficients with *p*-value below .001 ro that approached .001.
*** $p < .01$, ** $p < .05$, * $p < .10$

Source: own elaborations

7 Long term EU strategy for energy security: a monetary assessment

7.1 Contingent Valuation: model and econometric analyses

7.1.1 The contingent scenario

Contingent Valuation (CV) is a technique belonging to the family of stated preference methods. CV makes use of statements and a baseline reference, usually provided through interviews by a statistical sample of respondents, and is used to define a monetary value typically for non-market goods and services, or for those that are not yet on a market. CV section is used in this project to elicit society's WTP for the long-term security of energy supply[5].

Respondents facing the CV section are first informed that the EU currently imports more than half of all the energy it consumes, with specific data on imports of crude oil (more than 90 %) and natural gas (66 %). Respondents are made aware that the total import bill is more than €1 billion per day. Given this information, respondents are asked how important it is for them, their families, the country they reside in, the EU, and for future generations to have reliable and affordable energy supply. This question has a double objective: To elicit whether respondents' WTP for the long-term security of energy supply is driven by individualistic or altruistic motivations, and to maintain the attention of respondents during the description of the contingent scenario.

Respondents are then told of a "EU Energy Security Strategy" describes a roadmap to 2030 that EU member states would need to follow to increase their energy security, that is, to have more reliable and affordable energy and be less dependent on imports of energy. In particular, the strategy aims to reduce imports of oil by 3 %, gas by 14 % and coal by 12 % compared to the business as usual scenario by 2030. Respondents are also informed that these goals will be achieved by saving energy, producing more local renewable energy, making it easier to transport gas and electricity around Europe, finding different ways and routes to import energy, building good relationships with suppliers and distributers, and having common goals when negotiating with other countries. To elicit respondents' value of the long-term energy security, we inform them that the implementation of the strategy will require an increase in energy prices now for EU member states to be able to undertake all the investments needed for a more reliable and affordable energy in the future. If the strategy is not implemented, sudden prolonged energy disruptions could occur in the future, as well as very large fluctuations in electricity prices. We then ask respondents how important they think it is to increase the reliability and affordability of energy supply implementing the EU Energy Security Strategy.

Next, following the 'double bounded' CV approach (Alberini, Rosato, Longo, & Zanatta, 2005), responds are presented with two closed-ended CV questions where they are asked whether they would be willing to support the implementation of the EU Energy Security Strategy given an annual increase in their electricity bill for the next five years. The initial bid values vary across respondents, with one quarter of respondents being allocated to each of the following initial bid values: €10, €20, €50, and €100. If a respondent accepts to pay the initial electricity bill increase, he/she is asked whether he/she would pay a higher amount (€20, €50, €100, and €200); if not, the follow-up bid is lower than the initial bid (€5, €10, €20, and €50). Table 6 describes the bid values design.

([5])This differs from report I where instead of a CV approach, we presented a discrete choice experiment eliciting respondents' WTP and WTA for variations in the frequency and duration of power cuts.

Table 4. The bid design of the contingent valuation

Initial value (€)	If 'yes' at the initial value (€)	If 'no' or 'don't know' at the initial value (€)
10	20	5
20	50	10
50	100	20
100	200	50

Source: own elaborations

We then enquire respondents to choose between the following options their motivation for supporting, or not, the energy security strategy:

- the reliability and the affordability of energy are important;
- I cannot afford to pay more for my electricity bill;
- I am not interested in the reliability and the affordability of energy supply;
- I don't believe that the Energy Security Strategy can be implemented;
- I don't believe the hypothetical scenario of an increase in electricity bill;
- Other, such as the government and industry, should pay for the Energy Security Strategy.

The answers to this question allows us to identify 'protest' respondents, that is, respondents that do not engage with the CV scenarios, either because they do not believe the hypothetical scenario, or because they deem that other parties should pay for the Strategy. When we analyse the data, we remove protesters from the analysis, as is common practice (Longo, Hoyos, & Markandya, 2012).

7.1.2 Statistical Models of the Contingent Valuation Responses

To obtain estimates of mean and median WTP for the proposed policy, we assume that WTP is distributed as a Weibull with scale σ and shape parameter θ.[6] Respondents' answers to the initial and follow-up payment questions can be combined to form intervals around the respondent's WTP, and to estimate σ and θ using the method of maximum likelihood.
Given our assumptions, the log likelihood function of the sample is:

$$\log L = \sum_{i=1}^{n} \log\left[\exp(-(WTP_i^L / \sigma)^\theta - \exp(-(WTP_i^U / \sigma)^\theta\right]$$

where WTP^L and WTP^U denote the lower and upper bounds of the interval around the respondent's WTP amount, and *i* denotes the individual respondent[7]. Mean WTP is equal to $\sigma \cdot \Gamma(1/\theta + 1)$, whereas median WTP is $\sigma[-\ln(0.5)]^{1/\theta}$.

7.1.3 Internal validity of the WTP responses

After WTP responses have been collected through the survey, it is important to test for internal validity, that is, to estimate models of WTP that relate the respondents' WTP amounts to the individual characteristics of the respondents and to specific characteristics of the survey.

Firstly, we should expect that the percentage of respondents' WTP the initial amount decreases for larger amounts (Haab & Mc Connell, 2002). Secondly, using the econometric model described above, we explore how respondents' heterogeneity affects WTP using the underlying regression equation:

$$WTP_i^* = \mathbf{z}_i \gamma + \varepsilon_i$$

[6] We work with the Weibull distribution because Weibull variates are defined on the positive semi-axis and have a flexible shape parameter.

[7] The estimates based on the specific likelihood function are often referred to as 'double-bounded' in the CV literature (Hanemann, Loomis, & Kanninen, 1991), under the implicit assumption that respondents refer to the same underlying WTP amount when answering both payment questions.

where WTP* represents the WTP amount,[8] and **z** is an m×1 vector of individual characteristics of the respondents, γ is a vector of unknown coefficients, and ε is the error term. Specifically, we explore whether WTP varies with respondents' socio-economic characteristics and attitudes towards the environment, long term security of energy supply and power outages.

The analysis of the CV data on society's WTP for the long term energy security strategy is reported in this section using the data from the clean sample, that is, after removing the answers from respondents who did not engage with the hypothetical scenario. Firstly, we report in Table 7 the percentage of respondents WTP the initial bid offered them, which decreases with the increase in the bid level, as theory predicts. For example, in PT, of the 198 people that were offered the initial bid of €10, 53 % of them were WTP. As the bid increases, the percentage of respondents WTP decreases. At the bid level of €100, only 24 % of respondents were WTP. The results are quite similar across the three countries. The initial result shows that our questionnaire is robust and provides policy relevant information.

Table 5. Percentage of people WTP the initial bids

	Initial bid	€10	€20	€50	€100	Total respondents
Portugal	Number of respondents presented the bid	198	189	187	183	757
	Percentage of "yes"	53.03	43.39	28.34	23.5	
Estonia	Number of respondents presented the bid	202	210	208	200	820
	Percentage of "yes"	55.94	40.48	27.88	23.5	
The Netherlands	Number of respondents presented the bid	207	193	204	200	804
	Percentage of "yes"	49.28	46.11	31.37	26.5	

Source: own elaborations

Next, we report the results of the econometric models using the interval data model. Table 8 shows the mean WTP for each country and for all the countries pooled together. Mean WTP is to €39 for EE, €42 for PT and €51 for NL. These results show that the NL has the highest WTP, as one would expect given the higher GDP of the country compared to the other two countries.

To test for the internal validity of the data, we augment the model by adding socio-economic variables and variables that control for the location of where the respondents live. Table 9 shows that older respondents are WTP more for the implementation of the energy security strategy, as the coefficient for AGE is positive and statistically significant at the 5 % level for PT and at the 10 % level for EE, but not statistically significant for NL.

[8] WTP is unobserved if we assume that a respondent's WTP lies between the amount stated by the respondent and the next higher amount.

Table 6. Mean WTP

	All countries	Estonia	the Netherlands	Portugal
M WTP	43.77	39.04	50.97	42.14
SE	1.63	2.22	3.68	2.76
n	2381	820	804	757

Source: own elaborations

Female respondents have a lower WTP in all three countries. The size of the household (HSIZE) is only statistically significant for EE, where larger households have a lower WTP.

To capture the effect of income, we included two variables in the model, the logarithm of income (LICNOME) and INCMISS, which is a dummy variable equal to one for respondents who did not report their income. This second variable is not statistically significant for EE and NL (while we had no respondents who did not report their income in PT), indicating that the WTP of people who reported their income is not different to the WTP of respondents who did not report this information. LINCOME is positive and significant in all our samples, indicating a strong effect of income on WTP: the richer our respondents, the more they are willing to pay. This particular result emphasizes the internal validity of our data. The following four variables - BIGCITY, VILLAGE, COUNTRYSIDE, TOWN - capture any geographical difference in WTP across respondents (the reference dummy being SUBURBS). We find that WTP is not affected by where respondents live, in any of the countries.

Table 7. Double bounded estimates for the Weibull distribution: effect of socio economic and location variables

	Estonia		**Portugal**		**The Netherlands**	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
intercept	-1.1205	0.707	-1.1123	0.7676	-2.7839	0.9276
AGE	0.0069	0.0039	0.0084	0.0043	0.0049	0.0045
FEMALE	-0.2655	0.1087	-0.3073	0.1209	-0.2674	0.1262
HSIZE	-0.095	0.0458	0.0021	0.0548	-0.0507	0.0611
LINCOME	0.4862	0.0659	0.4265	0.0776	0.6079	0.0839
INCMISS	1.1257	53.6275	0.0000	.	1.3396	24.2747
BIGCITY	0.0036	0.1709	0.1199	0.1573	0.114	0.1995
VILLAGE	-0.1667	0.1793	0.0764	0.2439	-0.1616	0.2014
COUNTRYSIDE	-0.0413	0.1999	-0.2696	0.4566	0.4745	0.4139
TOWN	0.0128	0.1651	-0.0058	0.1585	-0.0857	0.1797
SCALE	1.3565	0.0521	1.466	0.0591	1.6043	0.0637
Weibull shape	0.7372	0.0283	0.6821	0.0275	0.6233	0.0247
Loglikelihood	-1051.04		-966.95		-1013.52	
AIC	2124.08		1953.89		2049.04	
observations	820		757		804	

Source: own elaborations

We then add a set of variables to capture the importance of energy security on respondents' WTP. We use the answers to the question 'Thinking about energy security for your country of residence in the next five years, how important is it for you ...?' (Table 4). These variables range between 1 and 5, with one indicating that the dimension of energy security captured by that specific definition is extremely not important and 5 if it is extremely important. As we found a large correlation between the responses given to the different dimensions of energy security, we only use five definitions of energy security in the model. Therefore, QA2_1 captures the effect of having a secure supply of oil, gas, coal and uranium. This variable is not statistically significant in any of our models. Also the next variable, QA2_5, which explains the effect of having affordably priced energy services, is not statistically significant at the 5 % level in any of our models. The provision of clean water, expressed by Q2A_5, is positive and significant in the Netherlands, and in Estonia, indicating that it is an important determinant of WTP. The remaining two variables QA2_15 and QA2_16 capture the importance of minimizing the impact of climate change and reducing greenhouse gas emissions respectively. Only the latter is positive and statistically significant for EE and PT.

Table 8. Double bounded estimates for the Weibull distribution: effect of importance of energy security on WTP

	Estonia		Portugal		The Netherlands	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
intercept	-2.5197***	0.9261	-0.6183	0.9253	-3.875***	1.0104
AGE	0.0042	0.004	0.0084**	0.0043	-0.0015	0.0048
FEMALE	-0.3167***	0.1099	-0.3132***	0.1218	-0.2844**	0.1267
HSIZE	-0.094**	0.0455	-0.0019	0.0546	-0.0496	0.0607
LINCOME	0.4579***	0.0657	0.4275***	0.0778	0.5894***	0.0832
INCMISS	1.177	57.3961	0.0000	.	1.1621	24.9865
BIGCITY	-0.0475	0.1719	0.0743	0.1582	0.1559	0.2002
VILLAGE	-0.1803	0.178	0.0342	0.2451	-0.1629	0.2009
COUNTRYSIDE	-0.0693	0.1973	-0.2684	0.4562	0.43	0.4128
TOWN	-0.0315	0.1638	-0.0113	0.1582	-0.1055	0.1792
QA2_1	0.0411	0.0558	0.046	0.0596	-0.0035	0.0627
QA2_5	-0.2086**	0.1068	-0.0907	0.1174	-0.1428	0.0959
QA2_13	0.3586**	0.1511	-0.2255	0.1839	0.2591**	0.1227
QA2_15	-0.0474	0.0996	-0.1575	0.1527	0.0639	0.1416
QA2_16	0.2632***	0.0994	0.3385**	0.1742	0.1789	0.1397
Scale	1.3346***	0.0513	1.4582***	0.0589	1.5891***	0.0629
Weibull shape	0.7493***	0.0288	0.6858***	0.0277	0.6293***	0.0249
Loglikelihood	-1039		-964		-1003	
AIC	2111.46		1958.61		2039.53	
observations	820		757		804	

Source: own elaborations

To further investigate whether WTP is explained by respondents' experience with and attitudes towards power outages and by the regret they may experience if they will be restricted in the use of energy in the future, should the "EU Energy Security Strategy" not be implemented, we added four additional variables to the model:

- UNPLDURM3, which captures the impact on WTP of respondents who suffered unplanned power outages lasting more than three hours, is positive and significant only for EE. Respondents in NL are WTP less for the implementation of the strategy the more they agree with the statement 'I want to reduce my energy consumption', as shown by the negative and statistically significant coefficient for Q56_56. This also means that respondents in NL who do not want to reduce their consumption of energy are willing-to-pay more for the long-term security of energy supply.
- The next two variables Q56_57 and Q56_58 capture the regret that respondents would suffer if the security strategy were not to be implemented. In particular, Q56_57 shows that the WTP for guaranteeing the long-term energy security increases with respondents agreeing with the statement 'If I don't support the implementation of the EU Energy Security Strategy, and then I will be restricted with the use of energy, I will later wish that I had' for all countries.
- Q56_57 captures the effect of more personal regret, Q56_58 shows the effect of a more altruistic form of regret: 'If I don't support the implementation of the security strategy, and then my family will be restricted with the use of energy, I will later feel bad for my family'. The coefficients estimate for this latter variable are strongly positive and significant for PT and NL, showing that in these countries

respondents are particularly concerned about the effect of long term energy security for their families and not only for themselves.

Table 9. Double bounded estimates for the Weibull distribution: effect of experience with unplanned power outages and regret if the EU Energy Strategy is not implemented on WTP

	Estonia		**Portugal**		**The Netherlands**	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
intercept	-2.6888***	0.9051	-0.7123	0.8999	-3.6952***	0.9719
AGE	0.0037	0.0039	0.0077*	0.0041	0.0013	0.0047
FEMALE	-0.2909***	0.1093	-0.2662**	0.1152	-0.2272*	0.122
HSIZE	-0.0633	0.0457	-0.022	0.053	-0.0552	0.0576
LINCOME	0.4359***	0.0645	0.3182***	0.0748	0.5394***	0.0809
INCMISS	0.9393	63.3097	0	.	0.925	29.4954
BIGCITY	-0.1003	0.1708	0.1235	0.1477	0.123	0.192
VILLAGE	-0.2034	0.1776	-0.0487	0.2366	-0.1208	0.1926
COUNTRYSIDE	-0.2067	0.2006	-0.2425	0.4308	0.4729	0.3941
TOWN	-0.095	0.162	-0.0355	0.1484	-0.1107	0.1717
QA2_1	-0.0017	0.0558	-0.0265	0.0579	-0.0238	0.0598
QA2_5	-0.1758*	0.104	0.019	0.1116	-0.2404***	0.091
QA2_13	0.382***	0.1467	-0.2544	0.1746	0.257**	0.1151
QA2_15	-0.0588	0.098	-0.1068	0.1465	0.0276	0.1372
QA2_16	0.2018**	0.0995	0.2155	0.163	0.1075	0.1349
UNPLDURM3	0.3163*	0.1803	0.0759	0.2369	-0.044	0.2977
Q56_56	-0.0478	0.0347	-0.0273	0.0472	-0.0697*	0.0383
Q56_57	0.1894***	0.0382	0.1907***	0.0707	0.0995*	0.0536
Q56_58	0.0000	0.037	0.1618**	0.0742	0.2323***	0.0539
Scale	1.3058***	0.0494	1.3441***	0.0536	1.508***	0.0602
Weibull shape	0.7658***	0.029	0.744***	0.0297	0.6631***	0.0265
Loglikelihood	-1017		-910		-976	
AIC	2074.395		1858.046		1993.448	
observations	820		757		804	

Source: own elaborations

The next model explores the effect of personal values on people's WTP. We add four variables, Hed, Ego, Alt and Bio to capture the effect of endorsing hedonic values (i.e. concern for pleasure, comfort and reducing effort), egoistic values (i.e. concern for personal resources and power), altruistic values (i.e. concern for the welfare and fair treatment of others) and biospheric values (i.e. concern for nature and the environment) respectively. These variables range between 1 and 7, with 1 indicating that a person weakly endorses that particular value and 7 strongly endorses that value.

The results show that for EE and PT these additional variables do not help explaining WTP. However, for the Netherlands, Hed and Ego are negative and significant, and Alt is positive and significant, indicating that a high score for hedonic and egoistic values decrease WTP, while a high score for altruistic values increase WTP.

Table 10. Double bounded estimates for the Weibull distribution: Effect of personal values on WTP

	Estonia		The Netherlands		Portugal	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
intercept	-2.3305***	0.9214	-0.4887	0.9308	-3.4296***	1.0151
AGE	0.0029	0.0041	0.0079*	0.0042	-0.0022	0.0048
FEMALE	-0.297***	0.1103	-0.2674**	0.1175	-0.3223***	0.1245
HSIZE	-0.0684***	0.0456	-0.0157	0.0533	-0.0448	0.0572
LINCOME	0.4475	0.0647	0.3195***	0.0754	0.54***	0.08
INCMISS	1.0243	64.2416	0	.	1.2374	30.7846
BIGCITY	-0.0857	0.1716	0.1393	0.1486	0.1161	0.1905
VILLAGE	-0.1987	0.1779	-0.0316	0.2379	-0.1466	0.1918
COUNTRYSIDE	-0.1965	0.2011	-0.2534	0.4309	0.3923	0.3916
TOWN	-0.0832	0.1623	-0.0232	0.1493	-0.1455	0.1704
QA2_1	0.0158	0.0574	-0.0183	0.0584	-0.0117	0.0596
QA2_5	-0.1691	0.1048	0.0215	0.1116	-0.2215**	0.0908
QA2_13	0.3676**	0.1466	-0.2592	0.1751	0.283**	0.1155
QA2_15	-0.0508	0.0979	-0.1072	0.1463	0.0029	0.1367
QA2_16	0.2367**	0.1014	0.2385	0.1668	0.001	0.1376
UNPLDURM3	0.3052	0.1805	0.0942	0.2385	-0.0141	0.2952
Q56_56	-0.0446	0.0345	-0.0253	0.0476	-0.0891**	0.0388
Q56_57	0.1921***	0.0385	0.1986***	0.0715	0.0835	0.0532
Q56_58	0.0016	0.0372	0.1597**	0.0747	0.2519***	0.0544
HED	-0.0232	0.0605	0.0053	0.0675	-0.1223*	0.0716
EGO	-0.0744	0.0543	-0.026	0.0512	-0.1147**	0.0558
ALT	0.0001	0.0799	-0.0793	0.0935	0.177*	0.0931
BIO	-0.0503	0.0621	0.0187	0.0775	0.0952	0.0708
Scale	1.3012***	0.0492	1.3424***	0.0537	1.4895***	0.0595
Weibull shape	0.7685***	0.0291	0.7449***	0.0298	0.6714***	0.0268
Loglikelihood	-1014		-909		-970	
AIC	2077.962		1864.738		1989.491	
observations	820		757		804	

Source: own elaborations

This latest model specification is also the preferred model for M: in terms of goodness-of-fit, as shown by the Akaike Information Criterion (AIC), but not for the other two countries for which the previous model is the preferred one.

8 Conclusions

The survey data showed differences among the three samples regarding the residence and the choices over energy technologies. For example, the main energy source for space heating is wood biomass in Estonia (50 % of the sample), natural gas in the Netherlands (77 %), and electricity in Portugal (56 %).

Regarding the expenditures for different types of fuels, the data indicates the importance of natural gas for space heating, which is also reflected in the higher levels of expenditure for the fuel (especially in NL). On the contrary, the dominant use of electricity from PT respondents does not correspond to a higher expenditure.

The most 'rural' energy users have been found in EE and the least in PT. The highest share of consumers resident in a highly urbanized area of a big city was in fact found in the sample for PT (with only 7 % living in rural areas of sparse houses), while in NL and EE the share of rural respondents was respectively 29 % and 23 %.

The fuel mix for residential energy users emerging from the survey data exhibit some differences with regard to the electrification of heating and cooling, i.e. very low in EE and very high in PT. Counterintuitively, electricity plays a key role for cooking and warming water in EE, while natural gas appears crucial for NL for space heating, cooking and water heating.

Consequently to the highest level of penetration of electricity, respondents from NL stated the most energy services that could not be supplied in case of a blackout, e.g. indoor lighting, cleaning floors, cooking, showering, talking on the phone, using internet, warming rooms, washing clothes and washing dishes.

Respondents in EE declared to be most adverse to the damages of food in fridges/refrigerators, and the inability to recharge mobile phones. The respondents from PT were also concerned on being trapped in elevators, telecommunications interruptions, the loss of data from computers and damages to appliances.

The section of the questionnaire used to collect data on the values of respondents (altruistic, egoistic, biospheric and hedonic) was used to inform the statistical analysis of the preferences. We tested the role of values as predictors of:

- the willingness of respondents to invest in energy technologies
- the acceptability of strategies to improve security of energy supply

The survey placed emphasis to the reliability and affordability of energy supplies, asking respondents to assess the importance of securing these two aspects for them their family, their country, other EU countries and the future generations. Our results suggest that the concerns with this respect appear more limited in the NL sample. A special concern for future generations has been stated mainly by the sample from PT. Respondents in EE highlighted the relevance for their direct circle, with a minor role of the country wide and EU benefits.

The study also compared the perceptions of the residential customers regarding power cuts with actual data, showing that the planned interruptions may have been remarkably overstated in duration by 15 – 18 % of respondents. For the unplanned blackouts the gap between the perception and measurements is sensibly higher in the case of the respondents in NL, largely overestimating the experienced insecurity of the last 12 months. However, these discrepancies may also be due to localised blackouts.

In the survey the respondents have been presented with possible strategies to improve the environmental sustainability and security of electricity supply, via the integration of renewables, electric mobility, storage and other smart home technologies. This exercise aimed at describe the openness of energy users to future evolution of the distribution networks and the level of aversion/acceptance of a role of prosumer. The landscape emerging from the analysis suggest that the openness to the energy technologies is country specific and relatively low. The acceptance of smart meters is even and high in the three countries, while the openness to electric mobility is of particular interest in Portugal. A further analysis has been devised to explore the relationship between the willingness to invest in these technological options, and individual characteristics of respondents. Two different econometric approaches were applied to test the robustness of the results: an ordered logit and a negative binomial model. More traditional individual characteristic as Age, gender, education and family size play a key role in explaining the acceptance toward these energy technologies.

Personal values also contribute to improve the explanatory power of the models. The openness to the technological options is related ina special way to the interest for the environmental implications, as the Biospheric component of personal values plays a key role in terms of size and sign of the coefficient, and of statistical significance. The orientation toward an environmental awareness is not the only component resulting statistically associated to the openness to the investments in these technologies. Ceteris paribus, respondents with a higher interest for their own wellbeing and utility (hedonic and egoistic) are also associated to a higher openness, while the altruistic component does not explain the stated/current choices of respondents.

Testing whether the same drivers also explain the acceptability and orientation to support strategies for improving the security of energy supply on a long run horizon, it emerged the trade-off between egoistic and biospheric values. While the first are positively associated to higher acceptance of centralized fossil energy production, the latter are clearly associated to integration of decentralized small scale renewables. The willingness to reshape the consumption behaviour, for example voluntarily rescheduling the usage of energy demanding appliances to limit the demand and improve the performances of the grid is shown to be positively correlated (for the three countries) with biospheric and altruistic values. The same result holds for the automated load control options, under which the network operator may limit the capacity allocated to the user.

Finally, the study offers an estimation of the perceived monetary benefits of a long-term strategy for energy security, in the form of an application of contingent valuation. The respondent to the survey have provided their own evaluation of a hypothetical strategy as a willingness to support through an increase in their electricity bill for the implementation of such a strategy.

The perceived benefit of a long-term strategy for energy security differs by country. More specifically, the willingness-to-pay through increases in the energy bill is 39.04 euros in Estonia, 50.97 euros in the Netherlands, and 42.14 euros in Portugal.

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List of abbreviations and definitions

AIC	Akaike Information Criteria
BIC	Bayesian Information Criteria
CAIDI	Customer Average Interruption Duration Index
CAIFI	Customer Average Interruption Frequency Index
CV	Contingent Valuation
DAF	Dispersion accounted for
EE	Estonia
kW	Kilowatt
PT	Portugal
RPL	Random Parameter Logit
SAIDI	System Average Interruption Duration Index
SAIFI	System Average interruption Frequency Index
SP	Stated Preferences
VoLL	Value of Lost Load
WTA	Willingness-to-accept
WTP	Willingness-to-pay

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Annex A: Questionnaire to households

Socio-demographics: this section is a generic example which is then adapted to the specific country with the help of local experts, e.g. the classes of age or family size should fit the classification of national statistics if used for checking the match between the structure of the population and the one of the sample.

Section A: the respondent

Please tell us about yourself:

1. Level of education:

   ☐ Postgraduate

   ☐ Graduate

   ☐ Undergraduate

   ☐ Secondary

   ☐ Other

2. Age: __ years old

3. Gender:

   ☐ Male

   ☐ female

4. Job role: ____________________

5. How many people live in your household including you?

   What is the age composition of the household?

Member 1 :	☐ 0-18	☐ 19-30	☐ 31-45	☐ 46-60	☐ Over 60
Member 2 :	☐ 0-18	☐ 19-30	☐ 31-45	☐ 46-60	☐ Over 60
Member 3 :	☐ 0-18	☐ 19-30	☐ 31-45	☐ 46-60	☐ Over 60
Member 4 :	☐ 0-18	☐ 19-30	☐ 31-45	☐ 46-60	☐ Over 60
Member 5 :	☐ 0-18	☐ 19-30	☐ 31-45	☐ 46-60	☐ Over 60

Section B – Personal values

1. Below you will find brief descriptions of different persons. For each person we describe what is very important to [him/her]. Please read each description carefully and indicate how much this person is like you. The meaning of the scores is as follows: 1 means that the person is entirely not like you, 7 means that the person is entirely like you.

Try to distinguish as much as possible in your answering by using different scores. The person that is most like you should thus receive the highest score. The person that is the least like you, the lowest.	**Entirely not like me**						**Entirely like me**
a) It is important to [him/her] that every person has equal opportunities.	1	2	3	4	5	6	7
b) It is important to [him/her] that every person is treated justly.	1	2	3	4	5	6	7
c) It is important to [him/her] to take care of those who are worse off.	1	2	3	4	5	6	7
d) It is important to [him/her] that there is no war or conflict.	1	2	3	4	5	6	7
e) It is important to [him/her] to be helpful to others.	1	2	3	4	5	6	7
f) It is important to [him/her] to protect the environment.	1	2	3	4	5	6	7
g) It is important to [him/her] to be in unity with nature.	1	2	3	4	5	6	7
h) It is important to [him/her] to respect nature.	1	2	3	4	5	6	7
i) It is important to [him/her] to prevent environmental pollution.	1	2	3	4	5	6	7
j) It is important to [him/her] to have fun.	1	2	3	4	5	6	7
k) It is important to [him/her] to enjoy the life's pleasures.	1	2	3	4	5	6	7
l) It is important to [him/her] to do things [he/she] enjoys.	1	2	3	4	5	6	7
m) It is important to [him/her] to be influential.	1	2	3	4	5	6	7
n) It is important to [him/her] to have control over others' actions.	1	2	3	4	5	6	7
o) It is important to [him/her] to have authority over others.	1	2	3	4	5	6	7
p) It is important to [him/her] to work hard and be ambitious.	1	2	3	4	5	6	7
q) It is important to [him/her] to have money and possessions.	1	2	3	4	5	6	7

Thinking about energy security for your country of residence in the next five years you, how important it is <u>for you…</u>	Extremely unimportant	Somewhat unimportant	Neither important nor unimportant	Somewhat important	Extremely important
…To have a **secure supply of oil, gas, coal and uranium**	☐	☐	☐	☐	☐
…To promote **trade** in energy products, technologies, and exports	☐	☐	☐	☐	☐
…to **minimize depletion** of domestically available energy fuels	☐	☐	☐	☐	☐
…to **have stable, predictable, and clear** price signals	☐	☐	☐	☐	☐
…to have **affordably priced energy services**	☐	☐	☐	☐	☐
…to have **small scale, decentralized** energy systems	☐	☐	☐	☐	☐
…to have a **low energy intensity** (unit of energy required for unit of economic output)	☐	☐	☐	☐	☐
…to conduct **research and development** an new and innovative energy technologies	☐	☐	☐	☐	☐
…to assure **equitable access** to energy services to all its citizens	☐	☐	☐	☐	☐
…to ensure **transparency and participation** in energy permitting, siting and decision making	☐	☐	☐	☐	☐
…to inform consumers and promote social and community **education** about energy issues	☐	☐	☐	☐	☐
…to minimize the destruction of forests and the degradation of **land** and soil	☐	☐	☐	☐	☐
…to provide available and clean **water**	☐	☐	☐	☐	☐
…to minimize **air pollution**	☐	☐	☐	☐	☐
…To minimize the impact of **climate change** (i.e. adaptation)	☐	☐	☐	☐	☐
…to reduce the **greenhouse gas emissions** (i.e. mitigation)	☐	☐	☐	☐	☐

18. Given the sixteen dimensions of energy security discussed here, select the five that you think are the most important for your country of residence, and rank them from 1 (the most important) to 5 (5th most important), without allowing for ties. Please rank only 5 dimensions

☐	Secure supply of oil, gas, coal, and uranium	☐	Equitable access
☐	Bolstering trade	☐	Transparency and participation in siting and decision making
☐	Minimizing rate of depletion	☐	Education and information
☐	Predictable and clear price signals	☐	Preservation of land
☐	Affordably priced energy services	☐	Availability and quality of water
☐	Decentralization and small scale supply	☐	Minimal air pollution
☐	Low energy intensity	☐	Responding to climate change (adaptation)
☐	Research and development	☐	Reducing greenhouse gas emission (mitigation)

19. Did we miss any dimension that you consider important for the energy security of your country of residence in the next five years? Please enter below:

____
____
____

I don't miss anything <go to Q21>

<show Q20 on same page as Q19 in case respondents mentioned something in the open text box at Q19>

20. When you think about energy security for your country of residence in the next five years, how important is the above dimension?

☐ Extremely important

☐ Somewhat important

☐ Neither important nor unimportant

☐ Somewhat unimportant

☐ Extremely unimportant

Section B – Household energy use, expenditures and perceived risks of damages from power cuts

21. **Which of the following options best describes the area where you live?**

☐ A big city

☐ The suburbs or outskirts of a big city

☐ A town or a small city

☐ A country village

☐ A farm or home in the countryside

22. **What is approximately the size of your house (excluding garages attic and basement)?**

____________________ square meters

23. **Please indicate whether you own or you intend to purchase the following:**

	I have this	**I do not have this but I intend to buy it in the near future**	**I do not have this and have no intend of buying it in the near future**	**I do not know**
Solar panels for electricity	☐	☐	☐	☐
Electric/hybrid car	☐	☐	☐	☐
Solar panels for heating water	☐	☐	☐	☐
Woodchip heaters	☐	☐	☐	☐
Micro wind generator	☐	☐	☐	☐
Smart meters	☐	☐	☐	☐
Applications to automatize operation of electric appliances at home	☐	☐	☐	☐

24. **Which is the main fuel you use in your home to**

	Electricity	Gas	Wood	Other (specify)
Heat the house	☐	☐	☐	☐
Cook	☐	☐	☐	☐
Heat the water	☐	☐	☐	☐

25. **Which of the following activities cannot be done in your house <u>in any way</u>, if electricity is not available (in case you use gas to heat your home, heating is likely to stop as well without electricity)**

☐ Cooking	☐ Warming rooms	☐ Washing dishes
☐ Indoor lighting	☐ Talk on the phone	☐ Washing clothes
☐ Using internet	☐ Having a bath/shower	☐ Cleaning floors
Others:	______________________	____________________

26. **A – Can you estimate how much you pay on a monthly basis for the following utilities?**

<answers are empty allowed>

	euros
Electricity	_____
Gas	_____
Water	_____
Combined gas and electricity	_____
Wood	_____

B – Could you tell when you pay for the following utilities?

< empty answers allowed>

	Monthly	Every two months	Every three months	Every 4 months
Electricity	☐	☐	☐	☐
Gas	☐	☐	☐	☐
Water	☐	☐	☐	☐
Combined gas and electricity	☐	☐	☐	☐
Wood	☐	☐	☐	☐
Other	☐	☐	☐	☐

1) **In case of a power outage ("blackout"), what are the inconveniences that you are more concerned about?**

____ (open question)

Section D: Planned power cuts

Sometimes, the electricity network operator undertakes planned maintenance work on the network. When this happens, they will inform customers in advance of the planned power cut so that customers can adapt their activities accordingly and be prepared for the power cut.

When, if at all, did you last have a planned power cut to your home?

<If the answer is (Q27:1) "In the last 12 months" then go to question Q28. Otherwise go to Q30>

In the last 12 months	1
More than 1 year but less than 5 years ago	2
More than 5 years but less than 10 years ago	3
More than 10 years ago	4
Do not recall having a planned power cut	5
Had had a planned power cut but cannot recall when it took place	6

Thinking about the last 12 months how many times have you experienced a planned power cut?

<If the answer is (Q28:1) "Once" or (Q28:2) "Twice" or (Q28:3)"Three times" or (Q28:4)"More than three times" or (Q28:6)"Not sure" then go to Q29. If the answer is (Q28:5) "Never" go to Q30>

Once	1
Twice	2
Three times	3
More than three times	4
Never	5
Not sure	6

In the last 12 months, what was the longest time you were without power during a planned power cut?

Less than 4 hours	1
More than 4 hours	2
Not sure	3

Section E: Unplanned power cuts

Sometimes the electricity network suffers an unplanned power outage. This may happen because of unpredictable damages, faults in the network. Customers cannot be informed in advance of an unplanned power outage.

When, if at all, did you last have an unplanned power cut to your **home**?

<If the answer is (Q30:1) "In the last 12 months" then go to the Q31. Otherwise go to infoQ33>

In the last 12 months	1
More than 1 year but less than 5 years ago	2
More than 5 years but less than 10 years ago	3
More than 10 years ago	4
Do not recall having a unplanned power cut	5
Had had an unplanned power cut but cannot recall when it took place	6

Thinking about the last 12 months how many times have you experienced an unplanned power cut?

<If the answer is (Q31:1) "Once" or (Q31:2) "Twice" or (Q31:3) "Three times" or (Q31:4) "More than three times" or (Q31:6) "Not sure" then go to Q32. If the answer is (Q31:5) "Never" then go to infoQ33>

Once	1	
Twice	2	
Three times	3	
More than three times	4	______________
Never	5	
Not sure	6	

In the last 12 months, what was the longest time you were without power due to an unplanned power cut?

Up to 1 hour	1
1 to 3 hours	2
3 to 10 hours	3
More than 10 hours – please specify	4

Section F: Hypothetical questions on electricity scenarios

In this section, we will ask you to consider some hypothetical scenarios on power outages.

The most recent data on power outages[9] show that, under the current levels of investments in the electricity network, over the next five years we should expect to have 4 planned power outages lasting 10 hours and 10 unplanned power outages lasting 10 hours.

Suppose that no new investments are made to the electricity network during the next five years. As a result, the number and the duration of both planned and unplanned power outages will increase. Households will be compensated for the inconvenience caused through a reduction in their electricity bill.

You will see now 5 hypothetical choice cards, with each card showing the current situation, and two alternative hypothetical scenarios of power outages in the next 5 years resulting in cost reductions during the same 5 year period. Before choosing your favourite option in each card, consider the effect that an increase in power outages would have on you and the discount on your electricity bill.

27. Choose your preferred option

	Option A	Option B	Current situation
Number of **planned** power outages in the next 5 years	6	4	4
Duration of **planned** power outages in the next 5 years	18 hours	10 hours	10 hours
Number of **unplanned** power outages in the next 5 years	10	10	10
Duration of **unplanned** power outages in the next 5 years	15 hours	18 hours	10 hours
Electricity bill	€1 discount on electricity bill per year	€3 discount on electricity bill per year	No change
Which option would you choose?	☐	☐	☐

28. Choose your preferred option

	Option A	Option B	Current situation
Number of **planned** power outages in the next 5 years	6	5	4
Duration of **planned** power outages in the next 5 years	15 hours	10 hours	10 hours
Number of **unplanned** power outages in the next 5 years	18	10	10
Duration of **unplanned** power outages in the next 5 years	18 hours	15 hours	10 hours
Electricity bill	€10 discount on electricity bill per year	€3 discount on electricity bill per year	No change
Which option would you choose?	☐	☐	☐

29. Choose your preferred option

	Option A	Option B	Current situation
Number of **planned** power outages in the next 5 years	4	6	4
Duration of **planned** power outages in the next 5 years	10 hours	18 hours	10 hours
Number of **unplanned** power outages in the next 5 years	15	18	10
Duration of **unplanned** power outages in the next 5 years	15 hours	10 hours	10 hours
Electricity bill	€5 discount on electricity bill per year	€20 discount on electricity bill per year	No change
Which option would you choose?	☐	☐	☐

30. Choose your preferred option

	Option A	Option B	Current situation
Number of **planned** power outages in the next 5 years	5	6	4
Duration of **planned** power outages in the next 5 years	18 hours	10 hours	10 hours
Number of **unplanned** power outages in the next 5 years	10	15	10
Duration of **unplanned** power outages in the next 5 years	18 hours	10 hours	10 hours
Electricity bill	€5 discount on electricity bill per year	€1 discount on electricity bill per year	No change
Which option would you choose?	☐	☐	☐

31. Choose your preferred option

	Option A	Option B	Current situation
Number of **planned** power outages in the next 5 years	5	4	4
Duration of **planned** power outages in the next 5 years	15 hours	18 hours	10 hours
Number of **unplanned** power outages in the next 5 years	15	10	10
Duration of **unplanned** power outages in the next 5 years	10 hours	15 hours	10 hours
Electricity bill	€20 discount on electricity bill per year	€3 discount on electricity bill per year	No change
Which option would you choose?	☐	☐	☐

Suppose that to reduce the number and duration of power outages, new investments are needed for the electricity network. These investments would have to be funded through an increase in the electricity bill.

I am going to show you 5 hypothetical choice cards showing various options for investment over the next 5 years and associated cost to you. Each card will have the current situation, and two alternative improved options with different costs in the form of an increase in your annual electricity bill. Before choosing your favourite option in each card, consider your household's budget and the impact that your choice would have on your household's budget.

32. Choose your preferred option

	Option A	Option B	Current situation
Number of **planned** power outages in the next 5 years	4	3	4
Duration of **planned** power outages in the next 5 years	5 hours	10 hours	10 hours
Number of **unplanned** power outages in the next 5 years	10	2	10
Duration of **unplanned** power outages in the next 5 years	2 hours	2 hours	10 hours
Electricity bill	€20 increase in annual electricity bill	€5 increase in annual electricity bill	No change
Which option would you choose?	☐	☐	☐

33. Choose your preferred option

	Option A	Option B	Current situation
Number of **planned** power outages in the next 5 years	4	3	4
Duration of **planned** power outages in the next 5 years	5 hours	2 hours	10 hours
Number of **unplanned** power outages in the next 5 years	10	5	10
Duration of **unplanned** power outages in the next 5 years	5 hours	5 hours	10 hours
Electricity bill	€3 increase in annual electricity bill	€10 increase in annual electricity bill	No change
Which option would you choose?	☐	☐	☐

34. Choose your preferred option

	Option A	Option B	Current situation
Number of **planned** power outages in the next 5 years	3	2	4
Duration of **planned** power outages in the next 5 years	5 hours	2 hours	10 hours
Number of **unplanned** power outages in the next 5 years	2	10	10
Duration of **unplanned** power outages in the next 5 years	2 hours	10 hours	10 hours
Electricity bill	€1 increase in annual electricity bill	€3 increase in annual electricity bill	No change
Which option would you choose?	☐	☐	☐

35. Choose your preferred option

	Option A	Option B	Current situation
Number of **planned** power outages in the next 5 years	2	4	4
Duration of **planned** power outages in the next 5 years	10 hours	5 hours	10 hours
Number of **unplanned** power outages in the next 5 years	2	5	10
Duration of **unplanned** power outages in the next 5 years	2 hours	2 hours	10 hours
Electricity bill	€20 increase in annual electricity bill	€1 increase in annual electricity bill	No change
Which option would you choose?	☐	☐	☐

36. Choose your preferred option

	Option A	Option B	Current situation
Number of **planned** power outages in the next 5 years	2	3	4
Duration of **planned** power outages in the next 5 years	2 hours	10 hours	10 hours
Number of **unplanned** power outages in the next 5 years	5	5	10
Duration of **unplanned** power outages in the next 5 years	10 hours	2 hours	10 hours
Electricity bill	€5 increase in annual electricity bill	€3 increase in annual electricity bill	No change
Which option would you choose?	☐	☐	☐

Section G: Long term Security of Energy Supply

The European Union (EU) imports more than half of all the energy it consumes. Its import dependency is particularly high for crude oil (more than 90 %) and natural gas (66 %). The total import bill is more than €1 billion per day.

Many countries heavily rely on a single supplier, including some that rely entirely on Russia for their natural gas. This dependence leaves them vulnerable to supply disruptions, whether caused by political or commercial disputes, or infrastructure failure.

37. How important is having reliable and affordable energy supply for the following people? Please tick the box that best represents your view

	Very important	Important	Moderately Important	Slightly Important	Not Important
	1	2	3	4	5
You	☐	☐	☐	☐	☐
Your family	☐	☐	☐	☐	☐
Your country	☐	☐	☐	☐	☐
European Union	☐	☐	☐	☐	☐
Future generations	☐	☐	☐	☐	☐

The EU Energy Security Strategy describes a roadmap to 2030 that EU member states need to follow to increase their energy security, that is, to have more reliable and affordable energy and be less dependent on imports of energy. In particular, the strategy aims to reduce imports of oil by 3 %, gas by 14 % and coal by 12 % compared to the business as usual scenario by 2030. These goals will be achieved by:

- saving energy,
- producing more local renewable energy
- making it easier to transport gas and electricity around Europe,
- finding different ways and routes to import energy,
- building good relationships with suppliers and distributers, and
- having common goals when negotiating with other countries.

The implementation of the strategy will require an increase in energy prices now for EU Member States to be able to undertake all the investments needed for a more reliable and affordable energy in the future. If the strategy is not implemented, sudden prolonged energy disruptions could occur in the future, as well as huge fluctuations in electricity prices.

38. How important do you think it is to increase the reliability and the affordability of energy supply implementing the EU Energy Security Strategy?

Very important	Important	Moderately Important	Slightly Important	Not Important
1	2	3	4	5

Suppose that an **increase in the electricity bill for the next 5 years** was used to fund the EU Energy Security Strategy. You will see higher and a lower increase in the electricity bill and will be asked whether you would be willing to pay it to guarantee the reliability and the affordability of energy until 2030. Before answering, please think carefully about the consequences of paying the increase in the electricity bill as your disposable income for other expenditure would decrease. If you decide that you are not willing to pay, you should consider that if EU Energy Security Strategy would not be implemented, sudden prolonged energy disruptions, as well as huge fluctuations in the price of electricity may occur.

You should present the question 45 treating 25 % of the sample putting the monetary value of 10, 25 % with the value 20, 25 % with 50 and the last 25 % with 100.

In question 46 (not 36 as specified in brackets!) we repeat the request of a willingness-to-pay asking a higher value

If 45 is a YES with a value of 10 euros in 46 you should ask 20 euros

If 45 is a YES with a value of 20 euros in 46 you should ask 50 euros

If 45 is a YES with a value of 50 euros in 46 you should ask 100 euros

If 45 is a YES with a value of 100 euros in 46 you should ask 200 euros

With answer NO to 45 the respondent should always go to 47. Here we ask lower values

If 45 is a NO or Don't know with a value of 10 euros in 47 you should ask 5 euros

If 45 is a NO or Don't know with a value of 20 euros in 47 you should ask 10 euros

If 45 is a NO or Don't know with a value of 50 euros in 47 you should ask 20 euros

If 45 is a NO or Don't know with a value of 100 euros in 47 you should ask 50 euros

39. Would you be willing to support the implementation of the EU Energy Security Strategy to guarantee the reliability and the affordability of energy until 2030 if your annual electricity bill was €[10, 20, 50, 100] more expensive for the next five years?

☐ YES [go to question 46]

☐ NO [go to question 47]

☐ Don't know [go to question 47]

40. [bidhigh] Would you be willing to support the implementation of the EU Energy Security Strategy to guarantee the reliability and the affordability of energy until 2030 if your annual electricity bill was € [20, 50, 100, 200] more expensive for the next five years?

☐ YES [go to question 48]

☐ NO [go to question 48]

☐ Don't know [go to question 48]

41. [bidlow] Would you be willing to support the implementation of the EU Energy Security Strategy to guarantee the reliability and the affordability of energy until 2030 if your annual electricity bill was €[5, 10, 20, 50] more expensive for the next five years?
☐ YES
☐ NO
☐ Don't know
What is the highest increase in your annual electricity bill for the next five years that you would be willing to pay to implement the EU Energy Security Strategy to guarantee the reliability and the affordability of energy at least until 2030?
€________
Which reasons best describe your choices to pay or not to pay for the implementation of the EU Energy Security Strategy? [Tick all that apply]
☐ The reliability and the affordability of energy are important
☐ I cannot afford to pay more for my electricity bill
☐ I am not interested in the reliability and the affordability of energy supply
☐ I don't believe that the Energy Security Strategy can be implemented
☐ I don't believe the hypothetical scenario of an increase in electricity bill
☐ Others, such as the government and industry, should pay for the Energy Security Strategy.

Section H: Options for energy security and personal preferences

We ask you to say if you agree or disagree with the following statements:

	Completely disagree					Completely agree	
I want to reduce my energy consumption	1	2	3	4	5	6	7
If I don't support the implementation of the EU Energy Security Strategy, and then I will be restricted with the use of energy, I will later wish that I had	1	2	3	4	5	6	7
If I don't support the implementation of the EU Energy Security Strategy, and then my family will be restricted with the use of energy, I will later feel bad for my family	1	2	3	4	5	6	7

45. **There are different ways in which the security of the supply of energy could be improved. How do you evaluate the following options?** (1 = very unacceptable to 7 = very acceptable & 1 = very negative to 7 = very positive)

Increase centralized energy production (as nuclear, coal and gas fired power plants)

Very unacceptable	1	2	3	4	5	6	7	Very acceptable
Very negative	1	2	3	4	5	6	7	Very positive

Increase decentralized, more local, energy production (e.g. private solar panels, wind turbines)

Very unacceptable	1	2	3	4	5	6	7	Very acceptable
Very negative	1	2	3	4	5	6	7	Very positive

Use less energy during peak times by adjusting your energy behaviour: You yourself decide which devices you will use during non-peak times making decisions yourself about which devices you will wait to use until there is a large supply of energy (for example the washing machine). You have control over which devices will be turned on at non-peak times.

Very unacceptable	1	2	3	4	5	6	7	Very acceptable
Very negative	1	2	3	4	5	6	7	Very positive

Use less energy during peak times by letting technologies schedule your energy use. Convenience technology turns on devices during non-peak times. For example, a grid in the house turns devices (for example your washing machine) on only when there is a large supply of energy, you don't have to do anything yourself. You do not have control over which devices will be turned on during non-peak times.

Very unacceptable	1	2	3	4	5	6	7	Very acceptable
Very negative	1	2	3	4	5	6	7	Very positive

46. **Among the following inconveniences created by interruptions in the supply of electricity, please select those more relevant to you in the following list**

- ☐ Non-operating security and alarm systems
- ☐ Suddenly remaining in the dark
- ☐ Interrupted telecommunications
- ☐ Inability to use the TV
- ☐ Inability to use the PC
- ☐ No heating
- ☐ Inability to recharge mobile phones
- ☐ Inability to recharge electric vehicles
- ☐ Inability to cook
- ☐ Spoiled food in the fridge
- ☐ Spoiled food in the freezer
- ☐ Remaining stuck in a closed room
- ☐ Remaining stuck in an elevator
- ☐ Damage to appliances
- ☐ Loss of data from your computer
- ☐ other ……………………………………….

47. **What was your total household income before taxes during the past 12 months?**

<question is empty allowed>

- ☐ Less than 10,000 Euros
- ☐ 10,000 to 29,999 Euros
- ☐ 30,000 to 59,999 Euros
- ☐ 60,000 to 99,999 Euros
- ☐ 100,000 to 149,999 Euros
- ☐ 150,000 or more Euros

The interview is now completed.

If you are interested, the aggregated survey results and analysis from this survey will be available at http://publications.jrc.ec.europa.eu/repository/ in the coming months (search for 'survey on VOLL').

We thank you for your kind participation.

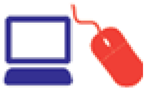
Annex B: Technical Description of the phases of the fieldwork from SSI

Kick-off call

After the project had been awarded and the questionnaire draft was ready, SSI had a kick-off call to review the project and to clarify the questionnaire, quotas and timeline details.

Questionnaire delivery and review

- Sander Ooms and Rafael de Kock (dedicated project management team) had a kick-off call with Sergio Giaccaria and Tilemahos Efthimiadis and conducted a thorough questionnaire review to ensure:
  - All skip patterns are logical and correctly point to questions in the survey
  - Question numbers and punch values are consistent, don't overlap, match with routing instructions
  - Wording, spelling, grammar is consistent for the Dutch market
  - Numeric questions have data ranges as specified



Questionnaire programming, testing and revisions

SSI expected changes and revisions to happen along the way and have developed a system to incorporate them without risking errors.

Before and during the programming of the questionnaire SSI:

- Requested and received the localized questionnaire in Dutch, Portuguese and Estonian in Word format from the European Commission.
- Requested changes via e-mail in a table and in an Excel file with question number for each change.
  - SSI compiled questions/clarifications in batches for review.
- SSI controlled each version of the questionnaire and submitted a highlighted version for the European Commission's approval after each round or revision.
  - SSI alerted the European Commission when changes were incorporated and tested.
- SSI checked the Dutch language questionnaire, as Sander Ooms is a native Dutch speaker. Sander Ooms shared his thoughts and gave feedback on wording and grammar. This was implemented upon approval by the European Commission.
- Multiple Dutch, Portuguese and Estonian language experts from the European Commission, checked the translated test links for quality and wording.
- SSI sent test links to the European Commission for final review and approval after SSI had done a thorough quality review.

Soft launch - Pilot

The soft launch gatherd 5%-10% of the required completes.

Data quality check

After soft launch completion, SSI provided the interim data and a report of incidence, length and drop rate. There were no deviations from the bid specifications.

Full launch

Once the soft launch – pilot data was approved, SSI moved to the full launch. Here, quota management was important. The SSI team carefully monitored quota and adjusted sample as needed. SSI kept the European Commission team regularly updated.

Data delivery

SSI conducted data checks to remove excessive speeders and completes showing evidence of fraud or repeated inattention. SSI used multiple checks before flagging the data based on speeding and bad open answers.

SSI delivered final cleaned SPSS and Excel data files to you within hours of fieldwork completion.

Measuring Success Rates

Please note that SSI is unable to share response rates with the European Commission. Measuring response rates in a multi-source, routed environment is practically impossible – in fact it is very difficult to calculate them in any online environment. As mentioned, SSI employs a routing environment to efficiently allocate willing participants to surveys they are best suited for and are more likely to be able to complete. This reduces the self-selection bias associated with invitation-based methods and increases participant satisfaction with the market research process. There is therefore no concept of a response rate except the conversion from being asked to do a specific survey once in the router and starting that survey.

AAPOR (the American Association for Public Opinion Research) believes that the best that can be provided for a non-probability access panel is a "participation rate" since numbers of contacts at the first stage (recruitment) are unknown. Note: since we do not send survey-specific invitations, the SSI definition of participation rate is the number of starts which did not drop out of the survey. They also recognize that panel management processes (particularly how often inactive panelists are removed from the database) has an effect on participation rates. Thus any measurement of 'response' (participation) will not be an indicator of panel quality per se nor necessarily comparable to the same panel over time, nor comparable to other panels.

Interview Length

Please note that interview length per country can differ due to varying internet speeds.

Country	Median survey length
Netherlands	16:31 minutes
Portugal	19:26 minutes
Estonia	24:00 minutes

Quota control

SSI delivered a report link to the European Commission so that fieldwork progress and quota management could be monitored.

SSI had a quota on version per country. Please see below the completed per version (A, B, C, D and E) and per country (Estonia, Netherlands and Portugal):

PKLRVersion

hlang (Single)	hVersions (Single)	Limit	Count
Estonia	Ver-A	1	209
Estonia	Ver-B	1	208
Estonia	Ver-C	1	208
Estonia	Ver-D	1	209
Estonia	Ver-E	1	209
Netherlands	Ver-A	1	207
Netherlands	Ver-B	1	208
Netherlands	Ver-C	1	208
Netherlands	Ver-D	1	208
Netherlands	Ver-E	1	207
Portugal	Ver-A	1	211
Portugal	Ver-B	1	211
Portugal	Ver-C	1	212
Portugal	Ver-D	1	212
Portugal	Ver-E	1	213

All soft launch completes (between 109-132 for each country) were considered as version A and WTA first. That's why those numbers are a bit higher. After the soft launch / pilot SSI added the other 4 versions and the WTA First and WTP First logic.

PKLRhRandom

hlang (Single)	hRandom (Single)	hVersions (Single)	Limit	Count
Estonia	WTA - First	Ver-A	1	132
Estonia	WTP - First	Ver-A	1	77
Estonia	WTA - First	Ver-B	1	104
Estonia	WTP - First	Ver-B	1	104
Estonia	WTA - First	Ver-C	1	104
Estonia	WTP - First	Ver-C	1	104
Estonia	WTA - First	Ver-D	1	104
Estonia	WTP - First	Ver-D	1	105
Estonia	WTA - First	Ver-E	1	104
Estonia	WTP - First	Ver-E	1	105
Netherlands	WTA - First	Ver-A	1	120
Netherlands	WTP - First	Ver-A	1	87
Netherlands	WTA - First	Ver-B	1	104
Netherlands	WTP - First	Ver-B	1	104
Netherlands	WTA - First	Ver-C	1	104
Netherlands	WTP - First	Ver-C	1	104
Netherlands	WTA - First	Ver-D	1	104
Netherlands	WTP - First	Ver-D	1	104
Netherlands	WTA - First	Ver-E	1	103
Netherlands	WTP - First	Ver-E	1	104
Portugal	WTA - First	Ver-A	1	109
Portugal	WTP - First	Ver-A	1	102
Portugal	WTA - First	Ver-B	1	106
Portugal	WTP - First	Ver-B	1	105
Portugal	WTA - First	Ver-C	1	106
Portugal	WTP - First	Ver-C	1	106
Portugal	WTA - First	Ver-D	1	106
Portugal	WTP - First	Ver-D	1	106
Portugal	WTA - First	Ver-E	1	107
Portugal	WTP - First	Ver-E	1	106

Quota - Total Number of completes

quotaCountry

hlang (Single)	Limit	Count
Estonia	9999	1043
Netherlands	9999	1038
Portugal	9999	1059

In accordance with the European Commission, the target for the oldest age group for Estonia was relaxed and completes were compensated in the 55-64 age group.

quotaGender

hAge (Single)	hlang (Single)	Q3 (Single)	Limit	Count	Rem.
25-34	Estonia	Male	105	76	29
35-44	Estonia	Male	105	104	1
45-54	Estonia	Male	95	96	-1
55-64	Estonia	Male	84	86	-2
65+	Estonia	Male	84	77	7
25-34	Estonia	Female	105	105	0
35-44	Estonia	Female	95	96	-1
45-54	Estonia	Female	95	95	0
55-64	Estonia	Female	175	183	-8
65+	Estonia	Female	179	125	54
25-34	Netherlands	Male	95	91	4
35-44	Netherlands	Male	105	101	4
45-54	Netherlands	Male	116	115	1
55-64	Netherlands	Male	95	91	4
65+	Netherlands	Male	116	112	4
25-34	Netherlands	Female	95	91	4
35-44	Netherlands	Female	105	101	4
45-54	Netherlands	Female	116	112	4
55-64	Netherlands	Female	95	91	4
65+	Netherlands	Female	137	133	4
25-34	Portugal	Male	95	96	-1
35-44	Portugal	Male	105	106	-1
45-54	Portugal	Male	105	106	-1
55-64	Portugal	Male	84	85	-1
65+	Portugal	Male	116	118	-2
25-34	Portugal	Female	95	96	-1
35-44	Portugal	Female	105	108	-3
45-54	Portugal	Female	105	105	0
55-64	Portugal	Female	95	97	-2
65+	Portugal	Female	158	142	16

hlang (Single)	PKLRQ45 (Single)	Limit	Count
Estonia	10	1	261
Estonia	20	1	261
Estonia	50	1	260
Estonia	100	1	261
Netherlands	10	1	260
Netherlands	20	1	260
Netherlands	50	1	259
Netherlands	100	1	259
Portugal	10	1	264
Portugal	20	1	265
Portugal	50	1	265
Portugal	100	1	265

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