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Giaccaria S., Longo A., Efthimiadis T., Bouman T.

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Contact information
Name: Tilemahos EFTHIMIADIS
Address: Westerduinweg 3, 1755 LE Petten, the Netherlands
Email: tilemahos.efthimiadis@ec.europa.eu
Tel.: +31 22456 5003

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Contents

Foreword

This report was developed in the framework of the joint Structural Reform Support Service – Joint Research Centre project entitled *Greek electricity market design (GEMD).*

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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Authors

Sergio Giaccaria, European Commission, DG JRC

Alberto Longo, Queen's University of Belfast

Tilemahos Efthimiadis, European Commission, DG JRC

Thijs Bouman, University of Groningen

Executive summary

This report presents the results of a study on the Value of Lost Load (VoLL) in Greece for various scenarios of interruptions of power supply. The VoLL is the value of unserved energy, and quantifies the value of damages perceived by energy users, in case of a blackout. The VoLL is used as a proxy of the economic value of reliability or alternatively of the social costs of power outages.

The study involved two surveys: one on a random sample of 1500 households, completed via web and telephone interviews, and a second on a random sample of 750 non-residential customers included industrial, commercial and small medium enterprises participating in telephone interviews.

VoLL is a latent unobservable variable and is influenced by characteristics of the consumers. In the literature on the monetary valuation of VoLL, a common approach is to consider the variation in wellbeing of consumers comparing the two conditions (with/without electricity supply). The value of the damage, in this methodological framework, is represented by the consumers' willingness-to-pay (WTP) to avoid the interruptions, and by the willingness-to-accept (WTA) compensations for the inconveniences of the interruptions.

Policy context

The VoLL serves as a benchmark for the functioning of spot markets, as peaks in electricity prices should not exceed the value of the marginal damage, otherwise consumers would be better off accepting power cuts. The VoLL can also be applied in all the cases of ex ante evaluation of cost and benefits of policy measures or investments affecting the reliability of electricity networks, as in the modernization and enhancement of power grids.

Key conclusions

In the study for residential consumers for Greece, we assessed a mean WTP of €6.15 for a hypothetical interruption of 90 minutes. The estimate of the mean WTA is €14.29 for the same scenario. Assuming 0.86 kWh as average consumption during the event, this generates a VoLL of 7.1 €/kWh and 16.5 €/kWh respectively for WTP and WTA.

The same approach is employed for the study on non-residential customers. For a 24h blackout the 800 firms belonging to industrial, commercial and SMEs revealed a mean WTP expressed as the 5.67 % of their bi-monthly electricity bill, and a mean WTA of the 23.37 % of their electricity bill.

The study presents also direct assessments of production losses provided by the industrial, commercial and SME customers. The monetary losses change considerably with the size of the firm: looking at the median amounts declared in the survey, the loss per one hour of blackout worth €25 for firms with up to 5 employees, €100 for firms from 6 to 9 employees, €200 for firms from 10 to 19 employees, €400 for firms from 20 to 49 employees and from 50 to 249 employees, and €10000 for firms with more than 250 employees.

Both residential and non-residential customers provided information on their experience of past blackouts, on the relevance of the inconveniences suffered and on actual consumption and expenditures for electricity supply, which are included in the form of descriptive statistics.

Related and future JRC work

This volume is a part of a collection of reports within the framework of the project Societal Appreciation on Security of Energy Supply that focus on the monetization of Value of Lost Load in different EU countries. The previous volumes focus on Estonia, the Netherlands and Portugal. This work will continue to include more member states.

Quick guide

The methodology used is the Contingent Valuation, a structured approach to elicit the preferences of consumers, to determine the value they assign to a specified good or service, in this case, the reliability of electricity supply.

During the survey, respondents expressed their preferences on alternative blackout scenarios. The econometric analysis of interval data is based on a maximum likelihood estimator and a Weibull distribution. The sample entails data provided by respondents from 1500 households, targeting individuals older than 25 years with a distribution by age, sex and geographical location that is statistically representative of the Greek population.

1 Introduction

The use of electricity plays a crucial role in modern economies. In particular in Europe the concern for granting adequacy and quality of supply has received a strong emphasis. In balancing the supply and demand of electricity on the grids, monopolistic and centralized decisions tailored on predictable demands are gradually substituted by decentralised decisions and actions determined by a multitude of suppliers, consumers, and eventually prosumers, and financial costs of providing security are likely to sensibly grow in the future.

Furthermore, the decarbonisation of the economies will increase the contribution of renewable energy sources to the electricity mix. This implies decentralised and intermittent generation of electricity, demanding additional flexibility to electricity grids and interconnection capacities both at the distribution and transmission level.

Additionally, innovation processes allow economies to obtain new energy services from electricity supply. The electrification of transport and/or the digitalisation of the economy are examples of drivers that are likely to influence the reliance on electricity and the relative appreciation of security of supply.

In this context, benefits of continuity of electricity supply can be assessed by evaluating the potential economic consequences of disruptions of electricity supply, which depend more on the value of the energy service obtain through electricity, rather than from the costs of the electricity itself. The Value of Lost Load (VoLL) is a proper indicator assessing the value of unserved energy, i.e. the damage by blackouts perceived by final customers.

In today's electricity markets, the value that final electricity customers place on security is not fully revealed by price mechanisms. Electricity prices, under liberalised and competitive markets, reflect more the cost structure of the supply chain, that is, the cost of generating electricity, the costs of managing and balancing transmission and distribution networks, fiscal and regulatory cost components etc.

The applications of the VoLL are typically (i) the applications of cost benefit analyses to develop new infrastructure project; (ii) the setting of price caps in the regulatory design of wholesale markets, (iii) the design of incentives to improve the quality of supply by distributors and (iv) measures of compensation measures of damages from supply disruptions.

The Agency for the Cooperation of Energy Regulators (ACER) released an assessment of the VoLL, for all the EU member states (Cambridge Economic Policy Associates, 2018). That recent study follows a production function approach. Under such framework the value of unserved energy equals to the amount of lost economic production per unit of energy consumed.

The VoLL, calculated as lost value added per unit of energy consumed, can have high values especially for economic sectors as constructions, where the use of electricity per unit of economic output is particularly low. However, such an approach does not allow investigating the influence of individual/firm level factors on the perceived damage from blackouts. The present study focuses instead on an analysis of the preference of the customers, basing the analyses on survey data. This allows testing whether customers' characteristics and subjective components play a role in the assessment of the damage from blackouts. For further descriptions of the set of techniques for the assessment of the VoLL, see (Schroder & Kuckshinrichs, n.d.; Longo, et al., 2018).

For the current assessment, two surveys were designed to estimate the VoLL for the Greek electricity market. The first targeted households, and the second survey non-residential energy actos. The content of the questionnaire(s) was substantially built on the experience of previous surveys implemented in the framework of a joint DG Energy – Joint Research Centre project[1], and an extensive literature review (Baarsma & Hop, 2009), (Bertazzi, et al., 2005), (Carlsson & Martinsson, 2008) (Longo, et al., 2008) (Damigos, et al., 2009) (Goett, et al., 2000) (Reichl, et al., 2013). The questionnaire used was defined to collect data to support the econometric analysis for the monetization of the perceived damage from unserved energy.

After the preliminary plan of the work and completion of the questionnaires, the survey company Focus Bari S.A. has implemented the sampling, the selection of contacts for both web and telephone interviews and the execution of all the fieldwork for data collection. These steps are presented in Section 1. Sections 2 and 3 concern with the descriptive and the econometric analyses conducted on the survey data on residential customers. Sections 4 and 5 provide the same assessments for the case of the non-residential actors. Section 6 concludes.

[1] Societal Appreciation of Security Of energy Supply (SASOS) (Longo, et al., 2018).

1.1 Survey on residential customers

For this survey, the target population is represented by respondents older than 25 years, as informed and competent subjects for the purpose of the study. Similar surveys financed by utility companies alternatively target the customers of a single utility (Sanghvi, 1990). However, the scope of the present analysis is instead to explore the social value of reliability and the heterogeneity of preferences at the country-wide level. The uneven geographical distribution of population in Greece, along with different levels of internet access, suggested to mix two different methods for the interviews: computer assisted web interviews (CAWI), and computer assisted telephone interviews (CATI). The main features of the sample design are as follows:

- *Method of data collection:* mixed methodology, CAWI via Online Panel & web-CATI
- *Sampling universe:* overall population of households in Greece, with at least one member of 25 years old or older
- *Sample type:* a standard probabilistic, two-stage sampling process (Stage 1: Household level, Stage 2: Individual level), representative of each sampling universe
- *Sample size (n):* 1500 interviews
- *Selection procedure:* random selection from the list of units from each pre-defined sub-group as a result of stratification. Quota by Region, Age Group, Gender based on data from the Hellenic Statistical Authority (ELSTAT) on 25+ years old [2011 Census]. Additional Quotas by Household size x Urbanity were also based on ELSTAT data.

The stratification structure is detailed in **Error! Reference source not found.** (household level) and **Error! ference source not found.** (individual level).

Table 1. Sample stratification at the household level

	1 member		2 members		3 members		4+ members		Grand total	
	Pop%	Target	Pop%	Target	Pop%	Target	Pop%	Target	Pop%	Target
Attica	26.5	147	28.7	159	21.1	116	23.7	131	36.9	553
Thessaloniki	23.9	37	28.8	44	21.1	32	26.3	40	10.2	153
Urban areas (50,000 +)	23.5	39	29.0	49	21.3	35	26.1	43	11.1	166
Urban/semi-urban areas (2,000-50.000)	20.9	61	29.2	86	21.1	62	28.8	84	19.5	293
Rural areas (<2,000)	22.7	76	33.4	112	17.5	59	26.3	88	22.3	335
	24.0	360	30.0	450	20.3	304	25.7	386	100.0	1,500

Source: Focus Bari S.A.

Table 2. Sample stratification at the individual level

Region	Population of age 25+ (%)	Target (n=1,500)
East Macedonia / Thrace	5.5	81
Attica	35.8	553
North Aegean islands	1.8	27
Western Greece	6.1	90
West Macedonia	2.6	38
Epirus	3.2	47
Thessaly	6.8	100
Ionian islands	2	30
Thessaloniki & Central Macedonia	17.2	101
Crete	5.5	81
South Aegean	2.8	41
Peloponnese	5.5	81
Central Greece	5.2	77
		GENDER
Men	48.2	723

Women	51.8	777
		AGE GROUP
25 – 34	19.2	288
35 – 44	20.4	306
45 – 54	18.3	275
55 - 64	15.9	239
65 - 74	13.0	195
75+	13.1	197
Total	100.0	1,500

Source: Focus Bari S.A.

To ensure consistency and uniformity, one master questionnaire for both CAWI and Web-CATI was designed (Voxco Online module) and was common for all interview conduction methods. Sample quotas were applied and monitored on total sample, irrespective of method of interview conduction. Thus, “centralized” control over quotas was achieved. The questionnaire was designed to be compatible for CAWI self-completion from respondents of the FocusOnline panel and the same time being web-CATI friendly for interviewers. In particular:

- CAWI targets the segments with higher access to internet: mainly from urban areas, within the ages 25-44.
- Web-CATI targets internet and non-internet users, from urban and rural areas, mainly aged 45+.

For the sampling, the following steps are followed:

Step 1. At the first stage of stratification the sampling is distributed proportionally based on interlocked quota of urbanity x household size.

Step 2. At the second stage of stratification the sampling is distributed proportionally on the regions, gender and age groups.

Step 3. Random selection from the list of units from each pre-defined sub-group as a result of stratification. For CAWI, an invitation is sent by email to all panel members with up to 3 reminders, every 3 days from the initial invitation. For the selection via CATI, the Random Digital Dial (RDD) methodology is used; with up to 7 call backs per number on different time and days.

Step 4. Selection of respondent from total number of 25+ aged household members. CAWI: Self-completion by the recipient of the email if eligible or screened out if not eligible. CATI: Appointment with the suitable member of the household if eligible respondent not available.

Error! Reference source not found. reports an overview of the fieldwork, in terms of number of completed nterviews and of other outcomes for the respondents contacted for the survey. Data were weighted according to the real population proportions to eliminate any deviations from real population data. Specifically, data were weighted according to real population data of households and individuals 25+ years old provided by ELSTAT.

Table 3. CATI sample and fieldwork statistics

Statistic	Count	
Total contacts (calls made)	34.787	Total %
Completed sample	800	100.0
Eligible - non interview	18.032	2.3
Refusal	10.070	51.8
Respodent never available - Appointment	7.949	28.9
Break off	13	22.9
Unknown eligibility	15.511	0.04
Busy	345	44.6
No reply	15.166	1.0
Not eligible	444	43.6
Quota filled (shared with CAWI)	444	1.3

Source: Focus Bari S.A.

In the provided raw data, two different weightings can be found:

- **Household level:** Households with at least one member 25+ years old
  4.011.000 Households (ELSTAT 2011 Census)
  Weighting Factors: Household members x Urbanity
-
- **Individual level:** Individuals aged 25+
  8.064.000 Individuals (ELSTAT 2011 Census)
  Weighting Factors: Gender | Age group | Area

1.2 Survey to industrial, commercial customers and SMEs

The survey to non-residential customers has been designed by the authors and carried-out by the Focus Bari S.A. survey company. The main choices and characteristics of the design are briefly illustrated in the following list:

Method of data collection: web-CATI

Sampling universe: Corporate executives responsible in taking decisions regarding the supply of energy within their organizations

Sample size (n): 800 interviews segmented into subsamples targeting different profiles of electricity consumer, as follows:

- 100 interviews to industrial consumers
- 250 interviews to commercial consumers
- 450 interviews to Small and medium Enterprises (SME)

Methodological approach: It was decided in cooperation with Focus Bari S.A. to approach the three different target groups (industrial, commercial and SME) **under a single common questionnaire**. The main reason for this common approach was the inability to define and "target" the commercial and industrial sectors, mainly due to lack of complete relevant data for companies in Greece. Additional reasons of preference of the common approach, were the similarities in the characteristics of the three target groups and the common research objectives, as well as the creation of economies of scale, through cost and resources effective advantages.

Sample type: Due to the lack of updated official directories in Greece, professional contact lists of the Focus Bari's own resources were used for the purpose of the study. Focus Bari acquired a thorough business contact list (5+ employees) with 25.000 entries, including both SMEs and large companies in all sectors. The initial contact list was enriched through contacts through previous business-to-business studies and through desk research on the directories of Hellenic Chambers of Commerce and Industry, along with professional telephone catalogues. These auxiliary sources aimed at enriching the contact list for Very Small and Small Businesses. In total, 59.478 contacts of various businesses constituted the final contact list, which was developed proportionally in terms of business size and region, based on ELSTAT and Eurostat data. Subsequently, these contact lists were imported in Focus Bari's own random dial software.

Sampling: Quota sampling based on incomplete and not fully updated ELSTAT data (last update was in 2010) and Eurostat. Therefore, no strict quotas were set per target. About 95 % of SMEs fall within the very small to medium size companies with only 5 % being considered as large SMEs (50-249 employees, see Figure 3).

Figure 1. Synaptic table of companies in Greece and Small Medium Enterprises

		Greece				EU28			
	Size	2009	2011	2013	2015	2009	2011	2013	2015
Number of companies	very small	792604	717221	655572	682798	19334419	20235009	20461528	20809502
	small	26775	21925	19603	20516	1369464	1374750	1362960	1382322
	medium	3221	3134	2429	2485	227082	225393	222757	226937
	large	482	362	391	408	43187	43630	43552	43755
	total	823084	742644	677991	706208	20974163	21878771	22090790	22462522
	total sme	822600	742280	677604	705799	20930965	21835152	22047245	22418761

number of employees	very small	1480726	1341076	1201446	1249835	39898319	39520499	38764424	39478458
	small	497099	398173	353090	369679	27504631	27512477	27178051	27660681
	medium	314828	296208	226507	231560	22931182	23038696	22949237	23529791
	large	338470	283552	268006	279183	43225396	44042548	44001297	44614907
	total	2631124	2319011	2049050	2130256	133559519	134114033	132892998	135283843
	total sme	2292653	2035457	1781043	1851074	90334132	90071673	88891712	90668929
Added value	very small	26101	21086	18424	18515	1195838	1319106	1316629	1397994
	small	16889	11904	10280	10395	1045920	1114299	1132192	1205466
	medium	11689	10408	8171	8152	1027533	1138603	1149625	1233159
	large	18129	15065	12412	12429	2309567	2605665	2629234	2785990
	total	72808	58463	49287	49492	5578859	6177703	6227680	6622608
	total sme	54679	43398	36875	37063	3269290	3572007	3598446	3836618

Source: European Commission, SME Performance Review, Annual Report 2015, through data from Eurostat SBS database

Therefore, based on assumptions with the help of the above data, the following “soft” quotas were set to have, as much as possible, a realistic representation between industrial, commercial and SMEs, and the same time ensuring adequate sample for statistical analysis (Table 4).

Table 4. Share of observations by type of contract across the three subsamples

Type of contract	%	N
Industrial	13	100
Commercial	31	250
SME	56	450

Source: Focus Bari S.A.

Additionally, 'soft' quotas, mainly for monitoring purposes as to ensure adequate representation of different SMEs categories were established for the subsample of 450 SMEs (Table 5).

Table 5. Shares of different SME by sector

Type of SME	%
SME – Industrial sector	24 %
SME – Commercial sector	28 %
SME – Services sector	48 %

Source: Focus Bari S.A.

The shares for a subsample of 100 industrial consumers are reported in Table 6.

Table 6. Shares of industrial consumers by size

Size of SME	Recorded as	%
1-5	very small	90-95 %
6-9	small	
10-19		
20-49	medium	5-10 %
50-249	large SME	

Source: Focus Bari S.A.

Finally, additional monitoring was ensured per detailed sector of activity, to ensure representation of all sectors of activities. The list of activities was segmented in two main sub-categories, a) so as to verify and control the “stated” sector (i.e. industrial, commercial, services) and b) to facilitate selection of the appropriate sector by respondents in the course of the interview (Table 7).

Table 7. Detail of the classification of sectorial activities to be chosen by respondents during the interview

COMMERCE / SERVICES	COMMERCE / INDUSTRY
Entertainment	Food products
Government	Drink products
Telecommunication	Smoking products
Hospitality Industry/tourism	Fabrics & materials

Mass media	Clothing
Healthcare/hospitals	Leather products
Public health	Wood products
Information technology	Paper-related products
Waste disposal	Printing / reproductions
Consulting	Coke & refinement
Retail sales	Chemical products
Franchising	Pharmaceutical products
Real estate	Plastic & elastics
Education	Non-metallic mineral products
Financial services	Basic metals
Fast moving consumer goods	Metallic products
Professional services – accounting	Electronics & PCs
Professional services – legal services	Electrical equipment
Professional services – Management consulting	Machinery
Motor vehicles	
Transport equipment	
Furniture	
Other manufacturing products	
Repairs / installations	

Source: Focus Bari S.A.

Based on the fact that SMEs of large size may have the same type of electricity contract as industrial and commercial customers in terms of contracted power, the area of activity of the firm was also defined as below:

- One master questionnaire was designed, in the Voxco Online module, so as for a uniform "environment" to be ensured, both within each sub-sample, as well as through these 3 sub-samples [which address broader b2b energy customers, further divided according to their energy supply and utilities].
- Sample quotas were applied and monitored on total sample, irrespective of the category of customer. Thus, "centralized" control over quotas was achieved.
- To ensure participation of the eligible respondent, a separate "filter" questionnaire was designed. This questionnaire verified the enterprise's sector and line of activity, while ensuring eligibility of the respondent in terms of: job role and responsibility related to issues regarding the electricity needs/use of the company/institution. Once eligibility was ensured, the interview continued on the main questionnaire.

In a corporate environment, especially in SMEs, it is often difficult to ensure the eligibility of participants, especially in cases where more than one employee are involved. To be able to "pinpoint" the eligible respondents and ensure their participation, a filter-questionnaire was used [see above] to ensure that their job role or responsibility is directly related to issues regarding the electricity needs/use of the company/institution.

Beyond this, to ensure participation of eligible respondents, the following processes and measures were implemented:

- Initial contacts: Initial contacts were addressed on a secretarial level, so as to acquire information on the subject that is eligible to participate via a short questionnaire to identify eligible respondents, scripted in Converso [licensed software for telephone number administration, offering an atomized rotation plan, arrangement of appointments, and up to 7 re-dials].
- Invitation to participate: Once the respondent was identified and accessed, a telephone appointment was arranged, if the eligible respondent wasn't available to participate in the survey right away
- Main interview: The main interview was conducted via the questionnaire designed on the Voxco online platform; filter questions included in the initial filter questionnaire were included in this one, as well, for verification of eligibility, company profile, etc.

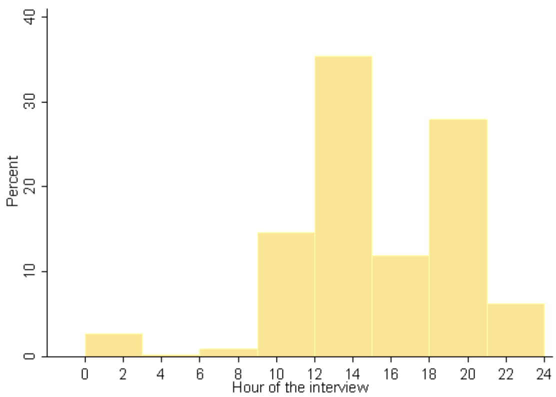
Furthermore, in an effort to improve response rate and participation, respondents were informed at the initial stage that survey was conducted on behalf of the European Commission. In particular, a text explaining the scope of the survey, the head authority etc., was developed and distributed to potential respondents.

2 Residential sector: descriptive statistics

This section illustrates the results from the descriptive analyses of the survey data. It provides qualitative and quantitative insights on the experienced insecurity of supply and the profile of energy users. It also characterizes perceptions and opinions of residential energy users on the possible impacts and inconveniences created by blackouts.

The *time at which the interview has taken place is used* as explanatory variable in the econometric analysis and is provided in Figure 2. It is important *when* the interview has been completed, because it enters in the definition of the blackout scenarios proposed to the respondent for the monetary evaluation.

Figure 2: Distribution of the hour of the interview

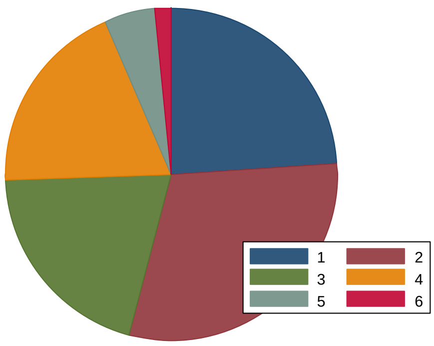


Source: own elaborations

The unit of analysis is the consumer and her preferences at an individual level, but the questionnaire collects as well further information about the household to control in the econometric analysis for the influence of households' characteristics on the preferences over the Value of Lost Load.

Figure 3 presents the composition of the sample, in terms of number of people living in the residence of the respondent. In particular, 24 % of residences are single occupancy and 30 % have double occupancy. Residences with 4, 5, 6 and more than 6 persons represent respectively the 20 %, 19 %, 5 % and the 2 % of the sample data (Figure 3).

Figure 3: Number of people in the residence



Source: own elaborations

The presence of children is a factor that may increase the reliance on electricity to ensure the wellbeing of the household. Respondents in 24 % of cases live with minors younger than 14 years old.

Concerning the responsibility in paying the electricity bills, 8 % declares to not be involved in payments, while the rest have some role, solely (54 %) or in collaboration with other family members (38 %) (Table 8).

Table 8: Role of the respondent concerning payments

Role	Freq.	Percent	Cum.
You are the sole person responsible for paying electricity bills	816	54.4	54.4
You and a partner, spouse or member jointly pay the electricity bill	570	38.0	92.4
I am not involved in the payment of the electricity bill	114	7.6	100.0
Total	1,500	100.0	

Source: own elaborations

The geographical distribution of the population is highly uneven, with the region of Attica covering 38 % of the resident population. As reported in **Error! Reference source not found.**, the geographical distribution of he sample match closely the census data.

Table 9. Geographical and sample distribution of population, by NUTS 2 regions

Region	ELSTAT share	Sample share
East Macedonia / Thrace	5.5	5.33
Attica	35.8	36.87
North Aegean islands	1.8	1.8
Western Greece	6.1	6.07
West Macedonia	2.6	2.53
Epirus	3.2	3.13
Thessaly	6.8	6.67
Ionian islands	2	2
Thessaloniki & Central Macedonia	17.2	16.93
Crete	5.5	5.4
South Aegean	2.8	2.73
Peloponnese	5.5	5.4
Central Greece	5.2	5.13

Source: own elaborations

Respondents assess the population of the village/town/city they live in (Table 10). Figure 4 and Table 11 summarise how the respondent declared the size of the house in square meters (excluding garages, attic and basement).

Table 10: Size of the population [ER8]

	Freq.	Percent	Cum.
More than 50,000 inhab.	168	21.16	21.16
2,000-50,000 inhab.	296	37.28	58.44
Less than 2,000 inhab.	330	41.56	100.00
Total	794	100.00	

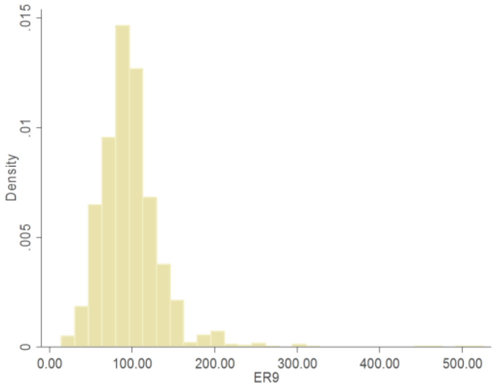
Source: own elaborations

Table 11: summary statistics for size of house [ER9]

Percentiles	Value (m^2)	Smallest	Obs	1,449
1 %	33	14	Sum of Wgt.	1,449
5 %	50	18	Mean	96.20
10 %	56	20	Std. Dev.	40.56
25 %	72	22		
50 %	90			
		Largest	Variance	1645.29
75 %	110	450	Skewness	3.360
90 %	135	460	Kurtosis	28.394
95 %	150	500		
99 %	236	525		

Source: own elaborations

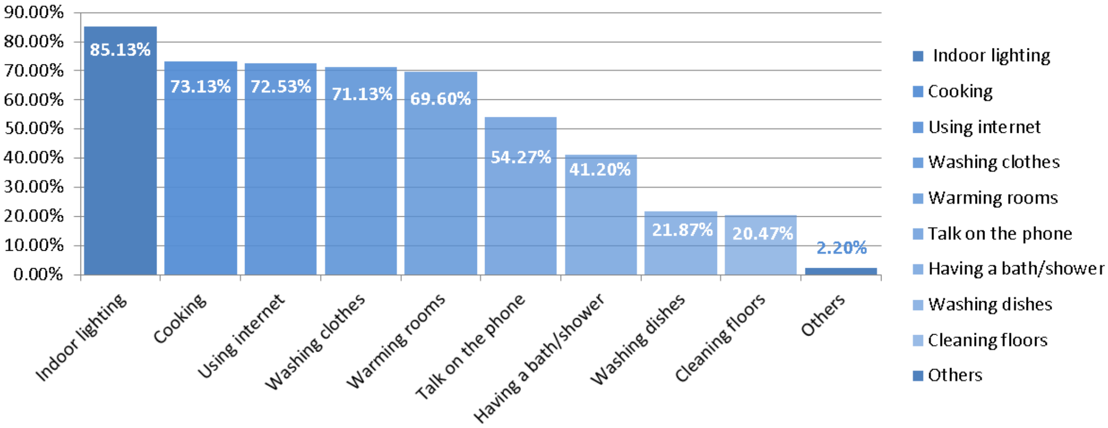
Figure 4: Histogram of size of the house [ER9]



Source: own elaborations

In case of a power cut, indoor lighting is impossible for the 85 % of respondents. Cooking, space heating and internet are hindered for approximately 70 % of the sample. The absence of electricity excludes the possibility of telephone calls for the 54 % of the respondents. This share decreases below the 50 % for activities as having a bath, washing dishes, cleaning floors and other energy services.

Figure 5: Frequencies of responses



Source: own elaborations

The median assessment for the monthly expenditure for electricity is €65 (details of quantiles and summary statistics in Table 12). The distribution is skewed similarly to the one of the variable of the size of the house declared by the respondent. A moderate but statistically significant correlation between size of the house and expenditure in electricity is confirmed. We calculated a simple correlation coefficient (0.32).

The expenditure data (values declared by respondent, in euros) are illustrated by geographical regions, in order to check whether the sample offers information over differentials in electricity consumption over various locations. The boxplot of Figure 7 does not point out at relevant disparities in the median expenditures or in the dispersion of the data.

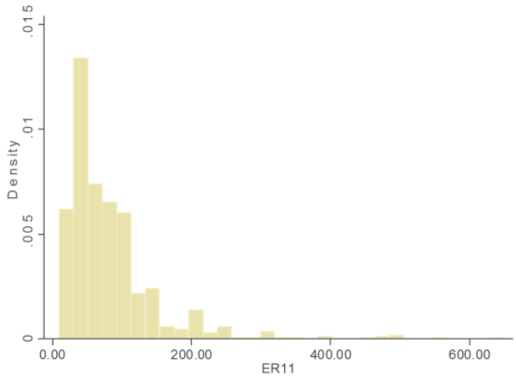
Table 12. Monthly expenditure for electricity (Euros) [ER11]

Percentiles	Euro	Smallest	Obs	1,500
1 %	15	10	Sum of Wgt.	1,500

5 %	25	10	Mean	84.43
10 %	30	10	Std. Dev.	69.43
25 %	42.5	10		
50 %	65			
		Largest	Variance	4821.39
75 %	100	500	Skewness	3.14
90 %	150	550	Kurtosis	17.44
95 %	200	564		
99 %	400	650		

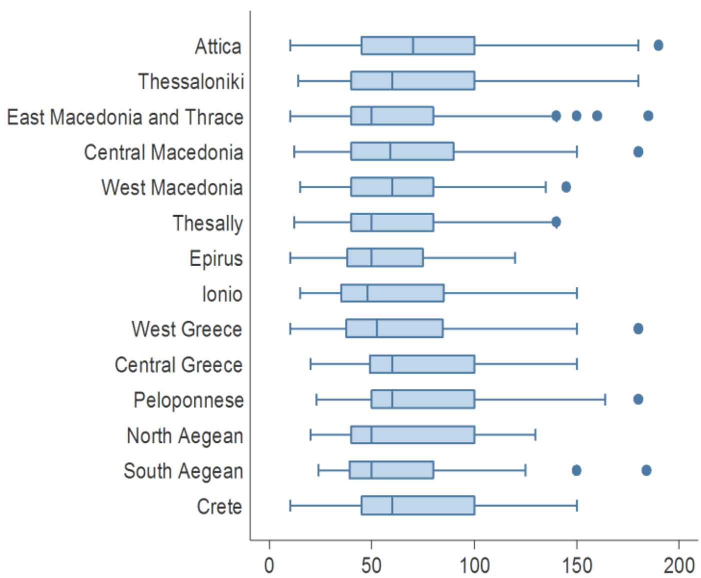
Source: own elaborations

Figure 6. Histogram last electricity bill [ER11]



Source: own elaborations

Figure 7. Boxplot of sample values electricity bill, by geographic area



Source: own elaborations

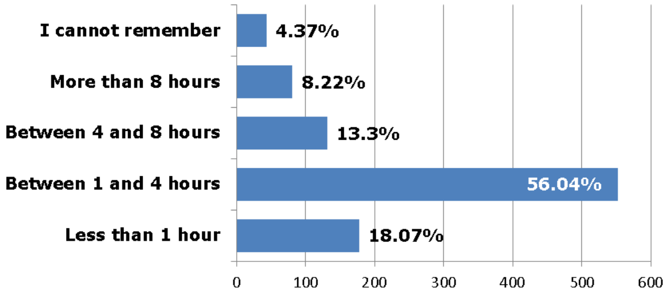
Approximately 61 % of respondents declared to have experienced power cuts (Table 13). From the total 920 providing an assessment of longest power cut experienced, 18 % recalls the longest event lasting less than 1 hour while the 56 % declaring between 1 and 4 hours (see figure 9 and the regional breakdown in figure 10). Latest available measurements on interruptions in Greece (Council of European Energy Regulators, 2018) report a System Average Interruption Duration Index (SAIDI) of planned and unplanned events of about 250 minutes, and a value of the planned and unplanned System Average Interruption Frequency Index (SAIFI) of about 3 events per year. Therefore we can observe that the responses reasonably match the observed data regarding power cuts.

Table 13. Experience of power cuts during the last 5 years

	Freq.	Percent	Cum.
Yes	920	61.33	61.33
No	515	34.33	95.67
Do not know	65	4.33	100
Total	1,500	100	

Source: own elaborations

Figure 8. Perceived duration of the longest power cut in 5 years



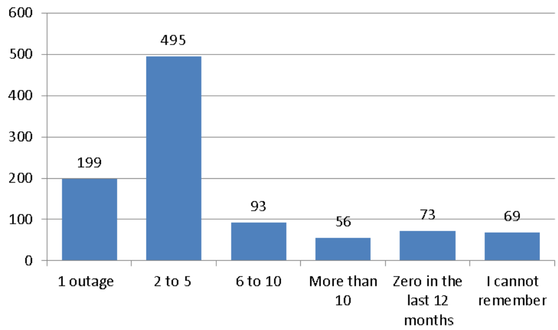
Source: own elaborations

Table 14. Frequencies of responses [ER13]

ER13	Freq.	Percent	Cum.
Less than 1 hour	178	18.07	18.07
Between 1 and 4 hours	552	56.04	74.11
Between 4 and 8 hours	131	13.3	87.41
More than 8 hours	81	8.22	95.63
I cannot remember	43	4.37	100
Total	985	100	

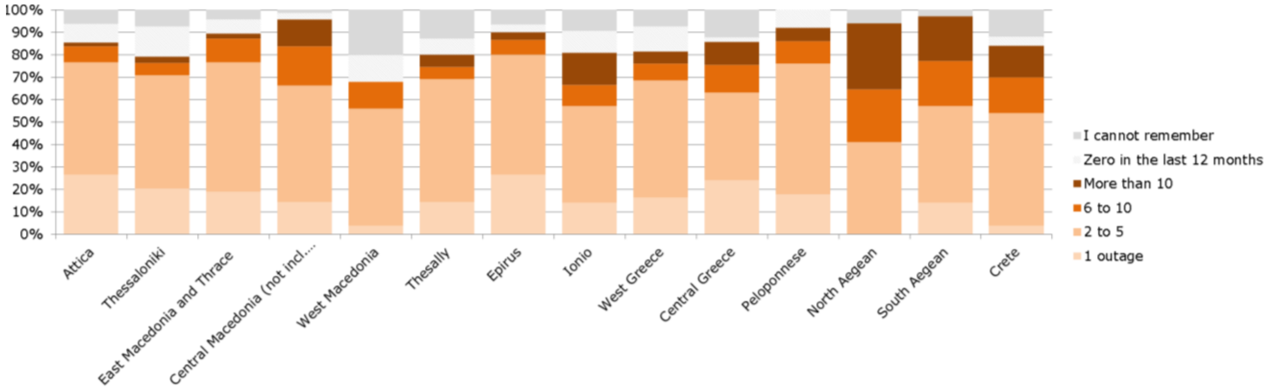
Source: own elaborations

Figure 9. Number of power cuts in the last 12 months



Source: own elaborations

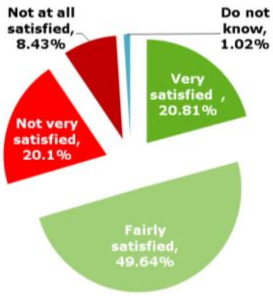
Figure 10. Number of power cuts in the last 12 months breakdown by geographical area



Source: own elaborations

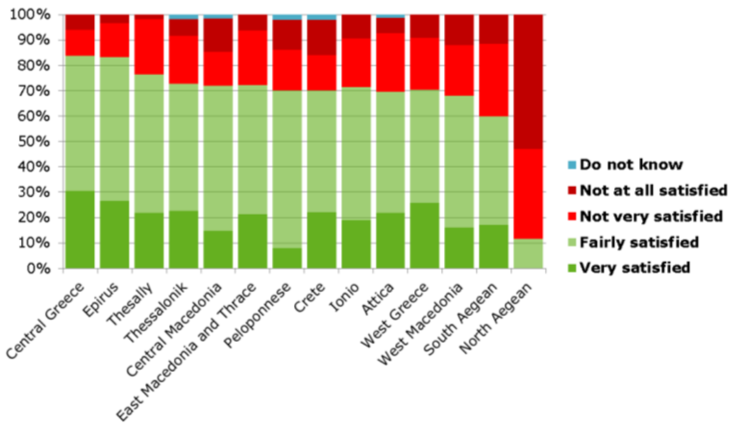
In terms of general satisfaction concerning the reliability, 21 % of the respondents is very satisfied, while the 50 % declares to be "fairly satisfied", and only 8 % are "not satisfied at all" (Figure 11). Regarding the location of the unsatisfied, we can note they are particularly concentrated in in the North Aegean area, while they are evenly distributed over the other areas (Figure 12).

Figure 11. Shares of the different level of satisfaction on continuity of supply



Source: own elaborations

Figure 12. Satisfaction on continuity, breakdown by geographical area

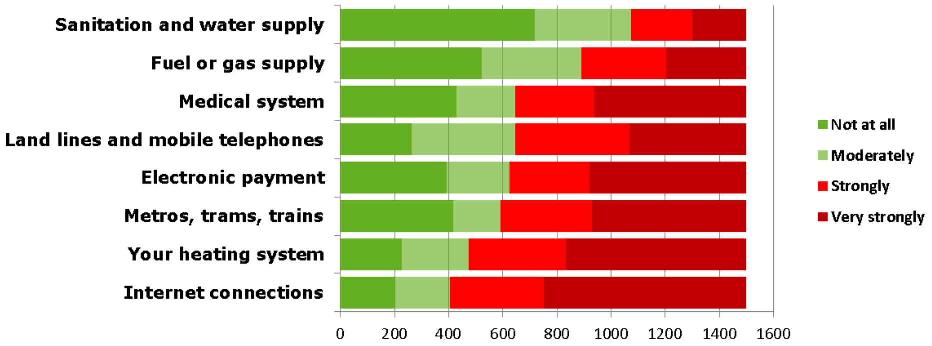


Source: own elaborations

A blackout scenario of 4 hours have been presented to the respondent, asking to qualify to which extent (some) services would be affected. Respondents are asked to agree on the level of the impact (choosing among 'Not at all', 'Moderately', 'Strongly' and 'Very strongly'). Figure 13 shows that the respondents' opinions highlight the function of internet communications. Heating system is the second most frequently chosen (cooling is included), while electric public transportation modes (tram, trains and metros) is the third most chosen service that is expected to be strongly or very strongly affected.

Water sanitation and supply, as well as fuel or gas supply were not considered as affected by an interruption of electricity. Medical system, landlines telephones, electronic payments and public transports have been assessed in a similar manner.

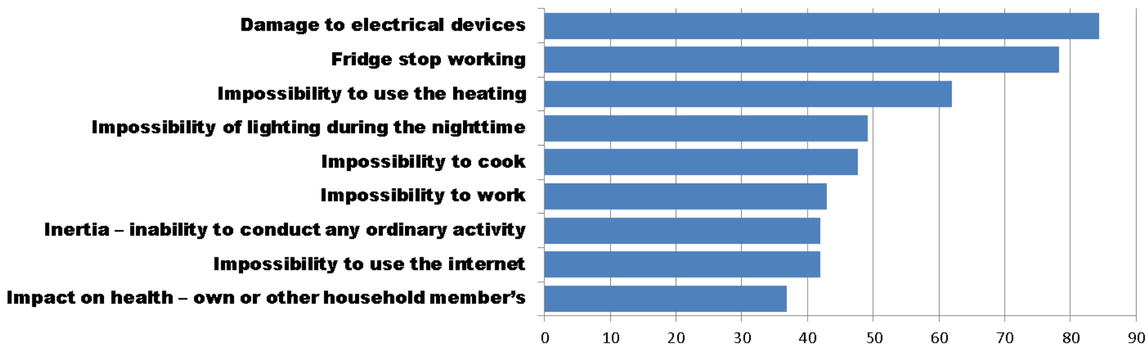
Figure 13. Impact on services after 4 hours of power cut



Source: own elaborations

The residential customer consider the most annoying inconveniences from blackouts to be the damage to electrical devices, followed by the damage/spoiling of food in the fridge/refrigerator, and the impossibility to use heating and cooling (Figure 14) including gas heating depending by electricity.

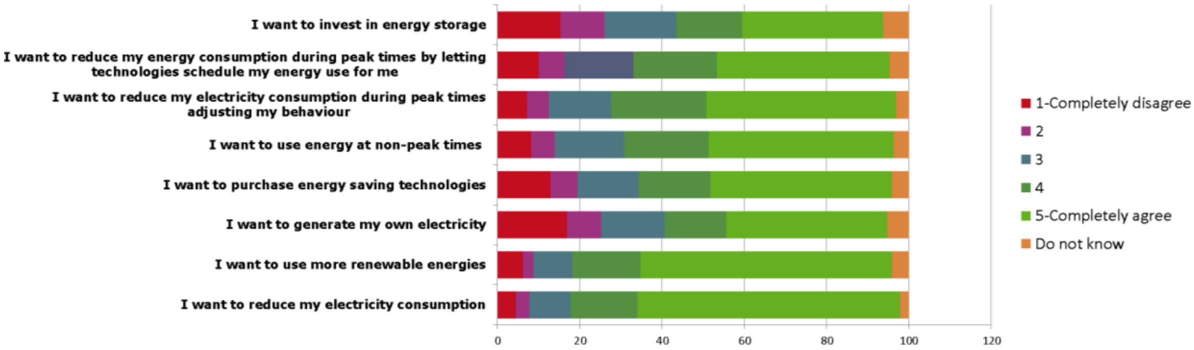
Figure 14. Worse consequences if the power cut would occur at home (% of respondents)



Source: own elaborations

As suitable measures to improve the performances of the electricity system, more than 80 % of the sample agrees with energy savings strategies (stating availability to voluntarily contain their own consumption) and increasing the use of renewable energy sources (Figure 15). Nearly 50 % of respondents agreed or tend to agree with buying energy saving technologies. Approximately 40 % of the sample does not agree with generating their own electricity and potentially supplying excesses to the grid ("prosumer "). 30 % favourably sees adjusting their consumption voluntarily postponing in time the use of appliances to moderate peak demands. The acceptance of automatic load control is, as expected, lower but still covering a share of about 50 % of respondents.

Figure 15. Attitudes toward potential changes in the use of electricity introduced in the interview



Source: own elaborations

3 Residential sector: econometric analysis

Contingent Valuation (CV) is a technique belonging to the family of stated preference methods, and is often used to define a monetary value typically for non-market goods and services, or for those that are not yet on a market. The scenarios presented and the choices stated by the respondents are collected through a structured format in a questionnaire, and the elicitation sections aim at inferring from stated choices, the implicit assessment that consumers make. The theoretical framework of neoclassical economics and Random Utility theory is used to formulate a specification of the choice process in the form of utility functions. Such utility functions model the change in the experienced wellbeing/comfort of consumers, when they pass from a reference condition (the status quo) to an alternative state of the world (with alternative levels of reliability of power supply).

Under this framework, choices are determined both by stochastic and unobservable factors, and by deterministic drivers, the variables whose effect on the probability of choosing, and the econometric analysis tests checks the existence of relationships and regularities in the values of the parameters of the utility functions. This offer statistical evidence that can corroborate, through hypothesis testing, the definition of average values for the WTPs and WTAs.

Following the "double bounded" CV approach (Alberini, et al., 2005), respondents were presented with two closed-ended CV questions, where they are asked whether they would be willing to:

- pay to secure additional reliability (WTP);
- accept compensations for a loss of reliability (WTA)

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. 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[2,3]. Mean WTP is equal to $\sigma \cdot \Gamma(1/\theta + 1)$, whereas median WTP is $\sigma[-\ln(0.5)]^{1/\theta}$.

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' willing to pay 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:

$$WTP_i^* = \mathbf{z}_i \gamma + \varepsilon_i \quad (8)$$

where WTP* represents the WTP amount,[4] and **z** is an m×1 vector of individual characteristics of the respondents. γ is a vector of unknown coefficients, and ε is the econometric error term. Specifically, we explore whether WTP/WTA varies with respondents' socio-economic characteristics and other factors, listed in the table of variables description. Two symmetric exercise have been implemented, one for the estimation of WTP for improvements in reliability and one for the acceptance of worse levels of reliability with WTA. The bid values implemented are reported in Table 15 and the percentage of acceptance to the first bid is in Table 16.

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

[3] The estimates based on likelihood function are often referred to as "double-bounded" in the contingent valuation literature, with the implicit assumption that respondents refer to the same underlying WTP amount when answering both payment questions.

[4] 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 15. Values of the bids proposed to the respondents in the WTP and WTA tasks

WTP task			**WTA task**		
Initial value (€)	**If "yes" at the initial value (€)**	**If "no" or "don't know" at the initial value (€)**	**Initial value (€)**	**If "yes" at the initial value (€)**	**If "no" or "don't know" at the initial value (€)**
2	5	1	2	1	5
5	10	2	5	2	10
10	20	5	10	5	20
20	40	10	20	10	40

Source: own elaborations

Table 16. Frequencies of responses in the WTP and WTA tasks

WTP task		**WTA task**	
Percentage of people willing to pay the initial bid (n=1208)		**Percentage of people willing to pay the initial bid (n=1172)**	
Initial value (€)	**% yes**	**Initial value (€)**	**% yes**
2	45.4 %	10	66.9 %
5	24.4 %	20	53.9 %
10	25.4 %	50	39.5 %
20	15.9 %	100	34.0 %

Source: own elaborations

The average value of reliability, measured by WTP is then €6.15 for a 90 minute blackout, with a payment vehicle that is an increase on the bi-monthly electricity bill. The corresponding WTA mean value is €14.29 (Table 17 reports expected values and standard errors calculated with delate method).

Table 17. Mean WTP and WTA for a 90 minute blackout (€)

WTP task		**WTA task**	
Mean WTP	**s.e.**	**Mean WTA**	**s.e.**
6.15	**0.34**	**14.29**	**0.67**

Source: own elaborations

3.1 Conversion to value per unit of unserved energy

Assuming a hypothetical blackout lasting 90 minutes adopted in the CV exercise, and an annual consumption per capita of 5063 kWh, we get an estimated per capita consumption of 0.88 kWh. This leads the mean WTP to a value of 7.1 €/kWh and the mean WTA to 16.5 €/kWh. This final conversion is sensitive to the assumption about the load curves and a more accurate distinctions about consumption profiles are beyond the boundaries of this work

3.2 Extended models

A further exploration is dedicated to research with extended models for the WTPs and WTAs may enhance the explanatory power of the analysis, adding covariates to the base model. Table 18 lists the set of explanatory variables that have been tested in extended models. The results presented in Table 19 show that among the socioeconomic traits of the respondents, income and age increase the explanatory power of the models, while the perceived damage from blackout is not found to depend on the gender of the respondent.

The analysis also reveals that the presence of minor younger than 14 do not imply higher WTP or WTA. Also, the expenditures in electricity, the households' size and the house size did not provide statistically significant estimates of parameters. Table 20 reports the estimates of WTP and WTA models tested as explanatory variables the experienced planned and unplanned disruptions. Past experiences of blackouts do not appear to determine variability in the perception of damage from blackouts.

Table 18. Variables description

Name	Description
hhsize	Number of members of the households
hosize	Surface of the house where respondents live
monthbill	Household' s expenditure for electricity for month
Fridge	Worst consequences of a power cut: fridge stop working
Appliances	Worst consequences of a power cut: Destruction of electrical devices
NoLighting	Worst consequences of a power cut: Impossibility of lighting during the night-time
Nowork	Worst consequences of a power cut: Impossibility to work
Nocook	Worst consequences of a power cut: Impossibility to cook
Noheat	Worst consequences of a power cut: Impossibility to use the heating
Nointernet	Worst consequences of a power cut: Impossibility to use the internet
Health	Worst consequences of a power cut: Impact on health – own or other household member's
Ordactivity	Worst consequences of a power cut: Inertia – inability to conduct any ordinary activity
RedCon	Availability to reduce her own consumption of electricity
Renewable	Willingness to use more renewable energy
Autoproduction	Willingness to adopt auto generation technologies
Esavtech	Willingness to adopt energy saving technologies
Nopeak	
Loadshift	Manually adjusting behaviour reducing electricity consumption in peak times
Loadcontrol	Automatically reducing electricity consumption in peak times
Estorage	Willingness to adopt energy storage
You	Importance of reliable and affordable energy supply for the following people: for the respondent
Family	How important is having reliable and affordable energy supply for the following people: Your family
Country	How important is having reliable and affordable energy supply for the following people: Your country
EU	How important is having reliable and affordable energy supply for the following people: European Union
Future	How important is having reliable and affordable energy supply for the following people: Future generations
EUstrategy	How important is to increase the reliability and the affordability of energy supply implementing the EU Energy Security Strategy

Source: own elaborations

Table 19. Double bounded estimates for the Weibull distribution: effect of socio economic variables

	WTP		WTA	
Parameter	Estimate	Standard Error	Estimate	Standard Error
Intercept	0.6827**	0.3087	1.5382	0.2730
male	-0.0372	0.1135	0.0022	0.0982
age	0.0095***	0.0039	0.0089***	0.0035
child	0.2499	0.1538	-0.1744	0.1371
university	-0.0755	0.1363	0.0752	0.1196
income	0.0002**	0.0001	0.0001	0.0001
hhsize	-0.07	0.0553	0.0778	0.0479
hosize	0.0011	0.0015	0.0006	0.0014
monthbill	0.0003	0.001	0.0006	0.0009
Scale	1.6271***	0.0648	1.3319***	0.0442
Weibull Shape	0.6146***	0.0245	0.7508***	0.0249
Loglikelihood	-1147.98845		-1317.55672	
Observations	1022		969	

Source: own elaborations

Table 20. Double bounded estimates for the Weibull distribution: effect of past experienced power cuts

	WTP		WTA	
Parameter	Estimate	Standard Error	Estimate	Standard Error
Intercept	1.1002***	0.4311	2.5663***	0.3428

onlypayer	0.0477	0.2491	-0.1924	0.2249
twopayers	0.0284	0.2549	-0.0999	0.2291
powercut	0.2346	0.3796	0.1085	0.3108
dpower	-0.0069	0.0345	-0.0201	0.0290
npower	0.0159	0.0276	0.0075	0.0225
Scale	1.6449***	0.0773	1.3137***	0.0521
Weibull Shape	0.608***	0.0286	0.7612***	0.0302
Loglikelihood		-828.683		-921.599
Observations		719		679

Source: own elaborations

Table 21. Double bounded estimates for the Weibull distribution: effect of attitudes towards energy

	WTP		WTA	
Parameter	**Estimate**	**Standard Error**	**Estimate**	**Standard Error**
Intercept	0.6255	0.5166	2.6992***	0.4458
Fridge	0.2867**	0.1437	-0.0801	0.1229
Appliances	-0.1281	0.1597	-0.0793	0.1359
NoLighting	-0.0014	0.1242	-0.1442	0.1112
Nowork	-0.108	0.1301	0.088	0.1146
Nocook	0.0232	0.1274	0.0348	0.1151
Noheat	0.3469***	0.1302	0.058	0.1104
NoInternet	-0.109	0.1294	0.1679	0.1162
Health	-0.1598	0.1208	-0.1309	0.1035
Ordactivity	0.2128*	0.1258	0.2066*	0.1096
EnSavings	-0.0984	0.0604	-0.083*	0.0493
Renewable	-0.0285	0.0581	0.0346	0.0501
Autoproduction	-0.0751*	0.0437	0.0292	0.0376
Esavtech	0.0056	0.0508	-0.1042***	0.0424
Nopeak	-0.0931*	0.0529	0.0069	0.0463
Loadshift	0.077	0.0578	-0.0275	0.0494
Loadcontrol	-0.0023	0.0517	0.0367	0.0451
Estorage	0.1219***	0.0472	0.0132	0.0391
You	-0.0621	0.1231	0.1812*	0.1104
Family	-0.1915	0.1248	-0.1991*	0.1108
Country	-0.083	0.1315	0.0991	0.1126
EU	0.0175	0.0739	-0.0514	0.0682
Future	0.4214***	0.1391	0.049	0.0995
EUstrategy	0.0956	0.0604	-0.0572	0.0507
Scale	1.6165***	0.0612	1.3157***	0.0423
Weibull Shape	0.6186***	0.0234	0.7601***	0.0244

	WTP	WTA
Loglikelihood	-1255.990529	-1409.490106
Observations	1103	1044

*** statistically significant at the 1 % level
** statistically significant at the 5 % level
* statistically significant at the 10 % level

Source: own elaborations

4 Industrial, commercial and SMEs: descriptive statistics

Taking into consideration the "professional" role of the participants being demanding and difficult-to-reach, it was important that the main questionnaire won't exceed a total duration of 15'-17' per interview. The length of the interviews is reported in Table 22.

Table 22. Length of interviews

	Mean	Minimum	Maximum
Length of interview	16,32"	14,15"	28,31"

Source: Focus Bari S.A.

The questionnaire consisted mainly of closed-end questions with some semi-open questions for further clarifications if needed. The questionnaire was structured as following:

- Intro: Introductory statement and respondent details: Explaining to respondents the scope of the study | gaining their permission for participation | checking eligibility of respondent
- Section A: Sector of activity and size of organization (soft quota monitoring)
- Section B: Energy profile: energy consumption, experience with power cuts, concerns, importance of reliable energy supply
- Section C: Self-assessment of expected damages from power outages
- Section D: Hypothetical scenarios on electricity scenarios. Two different routes appearing to respondents in rotation.

The total number of contacts used for the scope of the study was 19.759. The refusal rate was **24.6 %.** 800 interviews were completed through web-CATI (see details of successes and refusals in Table 23).

Table 23. Sample and fieldwork statistics

	Total N	**Total %**
Total Contacts (Calls made)	19,759	100.0
Completed sample	800	4.0
Eligible - Non interview	10,134	51.3
Refusal	4,853	24.6
Respondent never available - Appointment	5,281	26.7
Break off	36	0.2
Unknown eligibility	8,789	44.5
Busy	218	1.1
No Reply	8,571	43.4
Not Eligible	39	0.2
Quota filled	39	0.2

Source: Focus Bari S.A.

The opening of the interview is a question about the respondent, to qualify their involvement in the choice of energy supplies. As the responses are considered to be on the behalf of the organization, it is crucial to know the competence of the respondent. In the sample, 57 % of the interviewed declares to be the sole decision-maker regarding the supply of energy within his/her organization, while the remaining 43 % are sharing responsibility with other colleagues in the organization.

A third option for the respondent is this first question was "I do not decide, nor do I participate in such decisions". When this option was chosen, the interview would not go further.

Various results are presented in Figures 16-19. From these, we find that the consumers do not seem to see a nexus between prices and security of power supply. They declare of not having experienced any price increase as a consequence of a shortage of supply or malfunctioning of the networks (93 % of cases).

Self-generation capacity is used as a source of electricity by the 12 % of the respondents.

On the level of importance of reliability, the 90 % of the organizations responding to the questionnaire considers that reliability of electricity supply is *very important*, and 9 % (just) *important*.

Figure 16. size of the organization, by number of employees (labels in percent values)

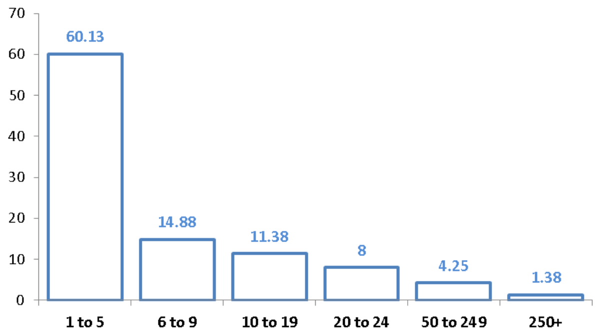


Figure 17. Type of contract (percent shares)

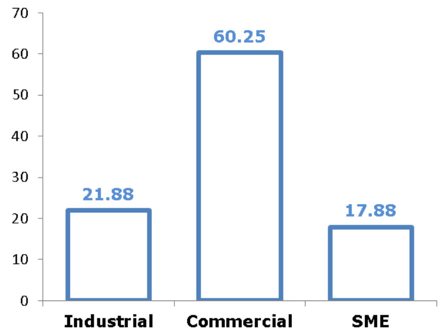


Figure 18. Type and contract type

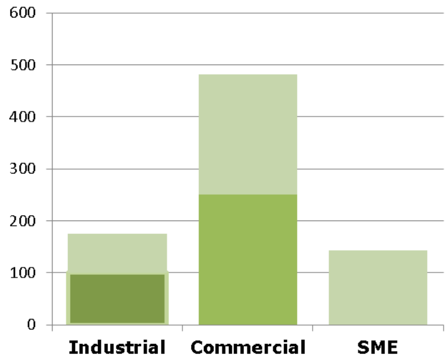
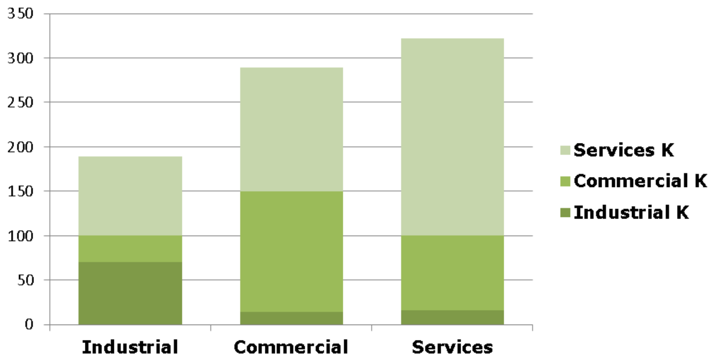


Figure 19. Field of activity



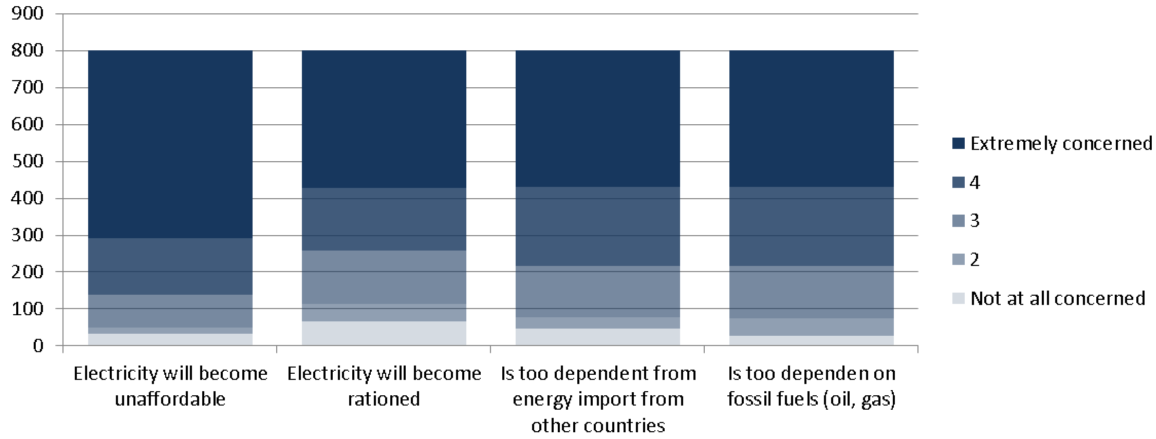
Source: own elaborations

During interview participants were presented with some possible threats that could affect the future Greek electricity market/system. We asked the level concern that the organization has each of these sources of risk. We find that affordability of electricity prices is the most relevant, compared to concerns over potential restrictions (rationing of supply) or on the dependency on foreign energy sources or fossils, as shown in Figure 20.

Similarly, the organization were also asked to assess the likelihood of bad events determined by different sources of risk (Figure 21). Tehcnical failures are seen as the most likely source of power cuts, while terrorist attacks are considered as the most unlikely. The respondent have assigned a subjective degree of likelihood on events negative for the security of power supply. They have been asked to evaluate how likely outages will be occurr by insufficient electricity being generated, by insufficient renewable electricity being generated, by natural disasters and extreme weather, by technical failures, terrorist attacks, by national political instability and by international political instability.

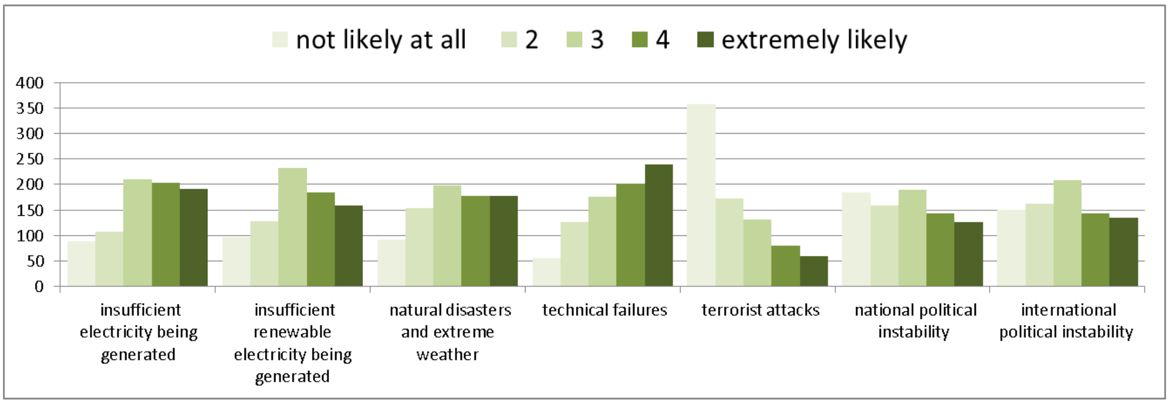
While the sources of geopolitical risk are evaluated evenly across the different levels (Figure 21), respondents have assigned increasingly higher likelihood to techincal failures, and also the generation adequacy has been considered as a likely driver of interruptions of power supply. Recoding the ordinal scale of likelihood as a score from 1 to 5, mean values and standard deviations of the scores are reported in Table 24.

Figure 20. Levels of concern on possible threats to energy security for the organization



Source: own elaborations

Figure 21. Likelihood of interruptions of electricity supply for different causes (number of observations)



Source: own elaborations

Table 24. Summary statistics for likelihood scores of interruptions in electricity supply

Source of interruptions	Mean	Std. Dev.
insufficient electricity being generated	3.38	1.282637
insufficient renewable electricity being generated	3.225	1.273343
natural disasters and extreme weather	3.2475	1.304174
technical failures	3.555	1.258553
terrorist attacks	2.13875	1.287078
national political instability	2.83625	1.379062
international political instability	2.93625	1.345157

Source: own elaborations

5 Industrial, commercial and SMEs: econometric analysis

The analysis of the non-residential data for Greece is based on 800 organizations. The majority (60 %) comprises small organizations with no more than five employees each. The type of electricity contract is industrial for 22 %, commercial for 60 %, and SME for the remaining 18 % of organizations.

As small organizations with no more than 5 employees comprises the majority, we look in detail at the characteristics of this subsample (SMALL). The type of electricity contract for small organizations is industrial for 10 %, commercial for 66 %, and SME for the remaining 24 %. The mean monthly average expenditure for electricity for the last 12 months is €331.73, while the median is €180. The average consumption of electricity for small organizations is 81.24 kWh/day, or 2,437.2 kWh per month, with a median consumption of 26.66 kWh/day. Only 5 % of these small organizations is equipped with an electricity generator for self-production. We notice that small organizations are mostly composed by activities supplied with a commercial or SME electricity contract, have a much smaller electricity consumption and bill, and are quite unlikely to have an electricity generator. However, similarly to the full sample, 76 % of small organizations have experienced at least one power outage in the last 12 months.

The analysis of the value of lost load has investigated three separate but related issues: the effect of unplanned power outages on production losses, organizations' willingness-to-pay (WTP) in terms of percentage increase in their electricity bill for avoiding a 24hr power cut during a two-month period, and organizations' willingness-to-accept (WTA) in terms of percentage decrease in their electricity bill for accepting a 24hr power cut during a two-month period.

A direct assessment of the economic losses in terms of production has been requested to the organizations participating to the survey for selected blackout scenarios. The respondents have been asked to assess the losses caused by different lengths of unplanned power outages, starting at 10am, and lasting 1 hour, 6 hours, 12 hours and 24 hours. The exercise of assessment has been requested in terms of monetary losses and as a percentage of total production. We report both mean and median values, with the latter indicating more conservative estimates of the value lost, as the mean is affected by few organizations reporting large losses.

For the full sample, for a 1hr power outage the mean is €943 and the median €40 per organization. This loss increases rapidly to €3,908 (mean) and €450 (median) for a 6hr power outage, increases less rapidly to €7,646 (mean) and €75 (median) for a 12hr power outage, and then to €11,720 (mean) and €1,000 (median) for a 24hr power outage (Table 26).

A similar trend can be noticed by looking at the percentage lost in terms of productivity. A short term power outage of 6 hours affects 30 % of the production for the median company, and both a 12hr and a 24hr power outage affect the median production by 50 %. A similar trend for both losses is found in small organizations, with considerable smaller monetary values, but generally larger losses in percentage terms.

Table 25. Economic loss caused by unplanned power outages (only SMALL organizations up to five employees)

	Duration of unplanned power outage, starting at 10am	**mean**	**median**	**st dev**	**min**	**max**	**n**
Monetary loss in €	1hr	268.55	25	2395.93	0	50000	481
	6hr	1222.23	200	6726.48	0	100000	481
	12hr	2019.87	400	11259.59	0	200000	481
	24hr	3872.18	500	22472.14	0	300100	481
Monetary loss in % of production	1hr	10.86	5	18.38	0	100	404
	6hr	35.70	30	30.62	0	100	387
	12hr	56.75	50	37.53	0	100	394
	24hr	65.32	85	38.55	0	100	398

Source: own elaborations

Table 26. Economic loss caused by unplanned power outages (full sample)

	Duration of unplanned power outage, starting at 10am	**mean**	**median**	**st dev**	**min**	**max**	**n**
Monetary loss in €	1hr	942.85	40	5879	0	100000	800
	6hr	3908.07	450	14867.67	0	200000	800
	12hr	7646.96	725	32413.23	0	500000	800
	24hr	11720.43	1000	49707.61	0	600000	800
Monetary loss in % of production	1hr	11.59	5	19.10	0	100	689
	6hr	33.95	30	29.58	0	100	665
	12hr	50.15	50	37.09	0	100	675
	24hr	57.42	50	38.99	0	100	682

Source: own elaborations

Table 27. Economic loss caused by one hour of unplanned power outage by size of the organization

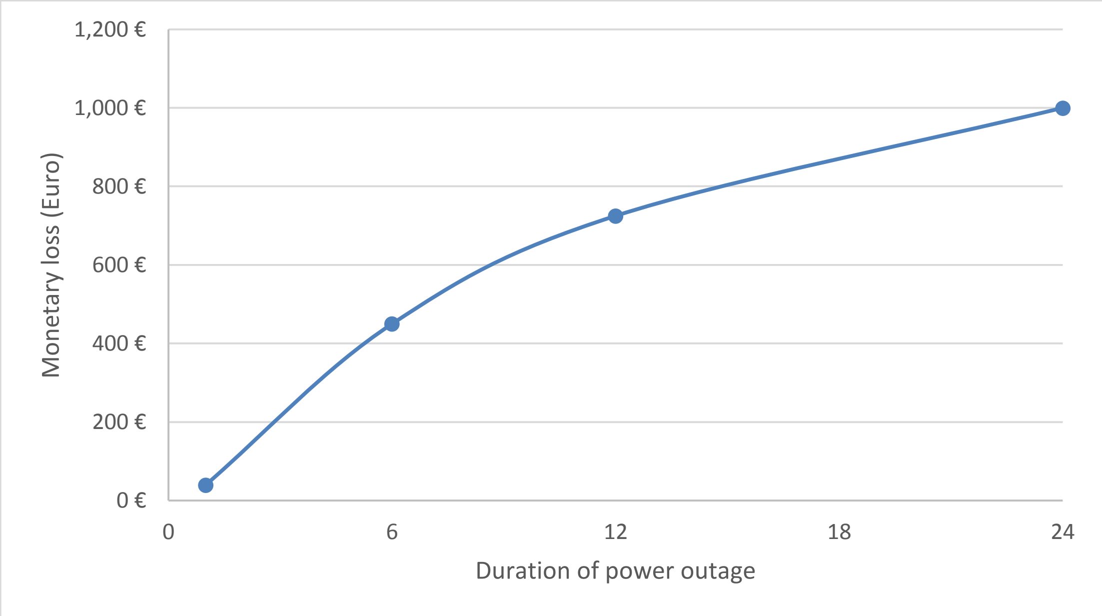
Employees	Median value (Euro)	Observations
1 to 5	25	481
6 to 9	100	119
10 to 19	200	91
20 to 24	400	64
50 to 249	400	34
250+	10000	11

Source: own elaborations

Looking at the assessment done by the industrial, commercial and SME customers, we notice that one hour of interruption of electricity supply induces an economic loss that is changing considerably with the size of the firm: looking at the median amounts declared in the survey, it worth €25 for firms with up to 5 employees, €100 for firms with 6-9 employees, €200 for firms with 10-19 employees, €400 for firms with 20-24 and 50-249 employees, and €10000 for firms with more than 250 employees (the number of observations in the sample is reported in Table 27).

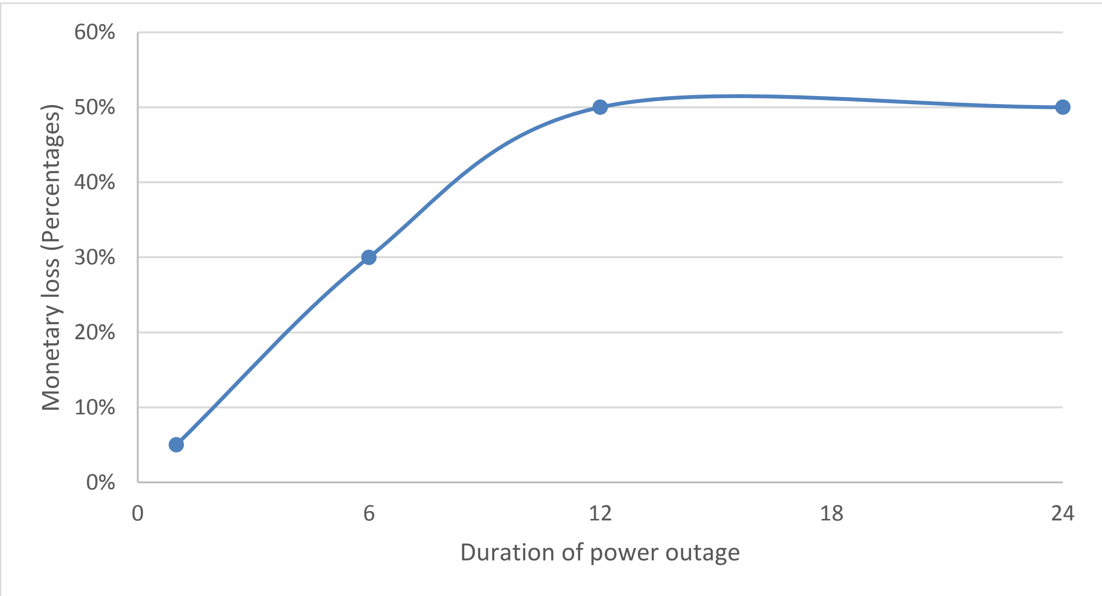
Figures 22 and 23 show that the economic loss increases at a slightly decreasing rate with the duration of the power outage for unplanned power cuts. By taking the economic loss for a 24hr power outage starting at 10am and dividing it by the number of kWh consumed per day, we derived a first assessment of the VoLL given by the direct assessment of the respondent. The median value of this variable is 20 €/kWh. For the organizations with less than 5 workers, such median worth 19.2 €/kWh.

Figure 22. Median monetary loss in euros vs hours of power outage, starting at 10am, full sample



Source: own elaborations

Figure 23. Median monetary loss in percentages per hours of power outage, starting at 10am, full sample



Source: own elaborations

We investigate non-domestic organizations' monetary loss from the different duration of power outages using Tobit models, to consider that losses are only reported when non-negative. We first run four separate models, where the dependent variables are the logarithm of the monetary loss for the different durations of power outages – 1hr, 6hrs, 12hrs, 24hrs – and the independent variables are whether an organization has no more than five employees (SMALL), whether their electricity contract is industrial, or commercial (with SME contract being the reference dummy variable), whether they have experienced a power outage, either announced or unannounced, in the last 12 months (BLACK), whether they have their own electricity generator to face a power outage (GENERATOR), and the logarithm of their electricity bill (BILL).

We then run a panel model, where our dependent variable is the ratio between the logarithm of the monetary loss from the different duration of power outages divided by the duration of the power outage. This panel model captures the information that each respondent reported four separate data on the monetary losses arising from different power outages. We then repeat this analysis using as dependent variable the percentage productivity loss, rather than the monetary productivity loss, and the ratio between the percentage productivity loss and the duration of the power outage for the panel data analysis.

The results show that organizations with industrial electricity contracts have higher monetary losses from power outages compared to organizations with a commercial or an SME electricity contract. As power outages become longer, differences across organizations that have different electricity contracts still exist, but decrease. Small organizations with no more than 5 employees suffer less from power outages of at least 6hrs compared to other organizations with more employees. Having had experience with power outages increases the monetary loss from power outages of at least 12hrs, but not for shorter power outages. The presence of a power generator does not seem to affect an organization's monetary loss from power outages, irrespectively of the duration of the power outage. The higher the logarithm of the electricity bill, the greater the monetary damage suffered by organizations from power outages. We can also calculate the effect of different electricity bills on the monetary loss from power outages. For example, an organization that has 10 % higher electricity bill than a second organization will be associated with a 5.8 % increase in monetary losses from a 1hr power outage (Table 28).

Table 28. Results from Tobit models to analyse the monetary loss due to different power outages starting at 10am.

	Tobit model, dep variable Log monetary loss for 1hr power outage		Tobit model, dep variable Log monetary loss for 6hr power outage		Tobit model, dep variable Log monetary loss for 12hr power outage		Tobit model, dep variable Log monetary loss for 24hr power outage	
	Coeff	st. err.	Coeff	st. err.	Coeff	st. err.	Coeff	st. err.
Intercept	-2.8002***	1.0878	2.6276***	0.6478	2.9341***	0.5828	3.0345***	0.5744
small	0.1247	0.4114	-0.8302***	0.2487	-0.7102***	0.2240	-0.6411***	0.2209
industrial	2.0471***	0.5547	1.3823***	0.3371	0.9739***	0.3032	0.8845***	0.2990
commercial	0.6739	0.4361	0.4709*	0.2608	0.3455	0.2340	0.3443	0.2307
black	0.4569	0.3801	0.3621	0.2301	0.6582***	0.2070	0.7287***	0.2041
generator	0.3917	0.5150	-0.4183	0.3207	-0.2705	0.2888	-0.1068	0.2847
Bill	0.5922***	0.1439	0.4484***	0.0871	0.5046***	0.0784	0.5286***	0.0773
Sigma	4.1791***	0.1501	2.6849***	0.0740	2.4220***	0.0646	2.3895***	0.0632
AIC	3323		3686		3614		3611	
Obs	800		800		800		800	

*** statistically significant at the 1 % level
** statistically significant at the 5 % level
* statistically significant at the 10 % level

Source: own elaborations

When we focus on the analysis of the percentage productivity loss due to power outages, the Tobit models show that for a short power outage of one hour, the percentage loss increases if an organization is small and the greater the electricity bill. For small organizations, the percentage of production lost increases as the power outage duration increases. We find little evidence that the electricity contract type affects the productivity loss from power outages, except for long power outages of 24 hours where we notice that organizations with a commercial electricity contract suffer a 9 % reduction in productivity compared to organizations with an industrial or an SME electricity contract. Having had some experience with power outages in the last 12 months lead to our respondents reporting higher productivity losses for 12 and 24 hours power outages. Having a generator of electricity reduces the productivity loss by about 9 % for power outages lasting 24 hours.

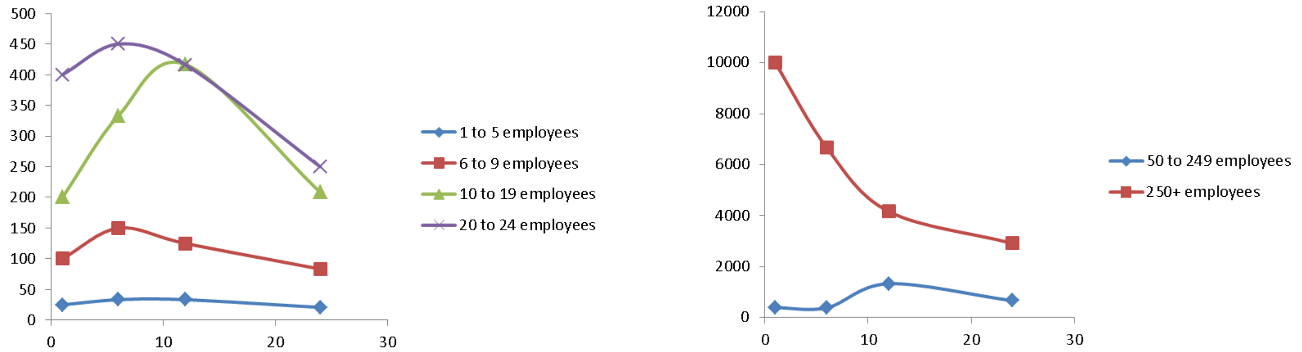
Table 29. Results from Tobit models to analyse the percentage productivity loss due to different power outages starting at 10am.

	Tobit model, dep variable percentage productivity loss for 1hr power outage		Tobit model, dep variable percentage productivity loss for 6hr power outage		Tobit model, dep variable percentage productivity loss for 12hr power outage		Tobit model, dep variable percentage productivity loss for 24hr power outage	
	Coeff	st. err.	Coeff	st. err.	Coeff	st. err.	Coeff	st. err.
Intercept	-22.8436***	7.8664	17.9214**	8.7272	29.0850***	10.178	27.8667***	10.305
Small	5.1642*	3.0099	6.7337**	3.3732	15.4593***	3.9132	19.1332***	3.9735
industrial	5.1180	3.9936	6.9472	4.5294	0.3637	5.2328	3.2607	5.3509
commercial	-0.4280	3.1815	0.1879	3.5901	3.7641	4.1152	9.0461**	4.2073
Black	3.0356	2.8588	4.7224	3.2275	10.6723***	3.7036	13.1403***	3.8109
generator	0.7193	3.8265	-5.0883	4.4329	-8.0471	5.0551	-8.9088*	5.1472
Bill	3.1291***	1.0177	0.7650	1.1574	0.1052	1.3597	0.2634	1.3727
Sigma	27.8563***	1.0530	33.2221***	1.0165	38.9343***	1.1374	39.9716***	1.1525
AIC	4249		5826		6386		6550	
Obs	689		665		675		682	

*** statistically significant at the 1% level
** statistically significant at the 5% level
* statistically significant at the 10% level

Source: own elaborations

Figure 24. Median values of declared outage cost/hour of interruption by different firm size



Source: own elaborations

The outage costs declared by respondents, expressed ad monetary loss per hour of interruption, are illustrated in the two graphs of Figure 24. An inverse U-shaped curve with damages is initially increasing up to six or twelve hours, then reducing in magnitude the marginal hourly loss.

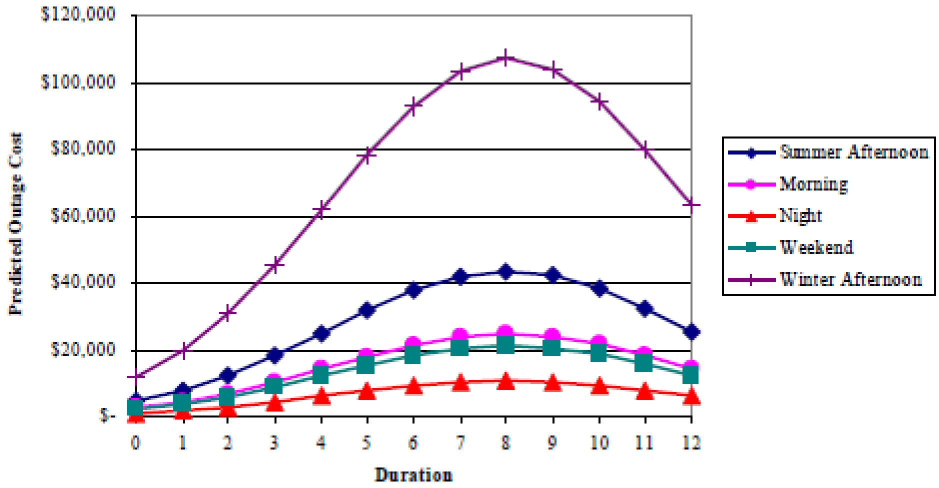
Such shape obtained by assessment of hypothetical outage scenarios is consistent with the results of predictive models of customer damage function, as the one reported in Figure 25.

The same result is not present for the biggest companies in the sample, who declared extremely high values for the initial hour of blackout scenario, with decreasing marginal values for all the other scenarios with longer durations.

Finally, Table 30 presents the results from two Tobit models:

- Model 1: dependent variable ratio between the Log of the monetary loss from power outages and the duration of the power outage
- Model 2: Random effects Tobit model, dependent variable is the ratio between the percentage loss in productivity from power outages and the duration of the power outage

Figure 25. Example of customer damage functions obtained by modelling applications (model for large industrial and commercial customers, varying season and time of day)



Source: (Lawton, et al., 2003)

Table 30. Tobit regressions with dependent variable given as a ratio between production losses and duration

	Model 1		Model 2	
	Coeff	st. err.	Coeff	st. err.
Intercept	0.3013	0.5375	-1.9838	2.3029
small	-0.6652***	0.2030	1.4680*	0.8812
industrial	0.8766***	0.2745	1.2920	1.1646
commercial	0.3865*	0.2118	-0.1706	0.9099
black	0.3198*	0.1805	0.8139	0.8048
generator	0.2265	0.2801	-1.1270	1.1834
bill	0.5273***	0.0729	0.7886**	0.3072
AIC	9963		14401	
Obs	2504		2142	

Source: own elaborations

5.1 WTP and WTA estimates through analysis of interval data

In the CV exercise, respondents were asked to a hypothetical scenario of extreme crisis with shortage of electricity supply, where the price of electricity may have exceptional increases. Additionally, to warrant the service to protected customers the operator may selectively interrupt the service to others imposing a power cut to some economic activities, or imposing a higher price that would mean an increase on the next electricity bill to avoid the power cut.

Respondents were then asked two dichotomous choice contingent valuation questions to assess their WTP to avoid a 24hr power cut. Respondents were randomly allocated to one of five possible levels of increase in electricity bill: 2 %, 5 %, 7 %, 10 % or 20 %. If their answer to the initial question was positive, then they were asked for a second higher value (5 %, 7 %, 10 %, 20 % or 40 %), and if their initial answer was lower, they were asked for a lower WTP value (1 %, 2 %, 5 %, 7 % or 10 %).

Respondents were further asked about their WTA for a symmetric hypothetical scenario where they were asked how much they were willing to accept for a 24hr power cut. We used the same bid values across the WTP and WTA questions. The order of the WTP and WTA contingent valuation questions was randomly varied across respondents to minimize any order effects.

An initial analysis of the WTP and WTA questions shows that at the lowest variation in the electricity bill, only about 33 % of respondents were WTP an increase in their electricity bill, indicating that more than 66 % of respondents have a WTP lower than a 2 % increase in their electricity bill. Similarly, looking at the WTA responses, we find that for the highest initial bid value, a 20 % discount in the electricity bill, only 33 % of respondents were willing to accept the power cut. These results highlight how the reliability is a very valuable good for non-residential customers, with the majority of organizations not willing to accept a power cut at the proposed variation in electricity bill.

Table 31. Share of acceptance of the first bid on the WTP and WTA exercises

	WTP	WTA
Initial bid value	% yes	% yes
2%	33.5	24.6
5%	30.5	30.4
7%	31.3	28.6
10%	19.3	25.7
20%	11.4	33.3

Source: own elaborations

Next, we report the results of the econometric models using the interval data model to estimate mean WTP and WTA for the hypothetical scenario of a 24hr power outage. To obtain estimates of mean WTP for the proposed policy, we assume that WTP is distributed as a Weibull with scale σ and shape parameter θ. Respondents' answers to the initial and follow-up payment questions can be combined to form intervals around the respondent's willingness-to-pay, and to estimate σ and θ using the method of maximum likelihood. Given our assumptions, for WTP data, 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. Mean WTP is equal to $\sigma \cdot \Gamma(1/\theta + 1)$. For the WTA data, the model is identical, with the only difference that the WTP^L and WTP^U are replaced by WTA^L and WTA^U representing the lower and upper bounds of the interval around the respondent's WTA amount. We run separate models for different subsamples to estimate WTP and WTA values for different groups of organizations, to consider their type of electricity contract (industrial, commercial, or SME) for organizations that have up to five employees (SMALL) as they comprise about 60% of organizations in the sample, for organizations that own an electricity generator, and to capture the experience with a power outage (unannounced or announced) in the previous 12 months. Standard Errors (S.E.) are calculated with the delta method.

Table 32. Estimates WTP/WTA for the full sample and subsamples

	mean WTP	S.E.	n	mean WTA	S.E.	n
full sample	5.67%	0.48	793	23.37%	1.09	799
industrial	6.24%	1.01	172	26.05%	2.36	175
commercial	5.77%	0.66	472	23.59%	1.41	481
SME	4.70%	0.95	140	19.45%	2.44	143
SMALL	4.36%	0.48	469	21.98%	1.38	480
owning generators of electricity	7.15%	1.68	90	23.62%	3.88	93
had a power outage in last 12 months	5.57%	0.53	605	24.13%	1.30	615

Source: own elaborations

The results show that, on average, non-domestic organizations are willing to pay an increase of 5.7 % in their next electricity bill to avoid a 24hr power cut, while they are willing to accept a 23.4 % reduction in their electricity bill to accept a 24hr power outage. Small variations in WTP and WTA exist across the sub-samples.

Organizations with an industrial electricity contract are willing to pay more, about 6.2 %, compared to organizations with commercial electricity contracts (5.8 %) and SME electricity contracts (4.7 %). When we look at the WTA results, the differences increase across the three subsamples, with organizations with industrial electricity contracts willing to accept on average a price cut of about 26 %, about 2.5 % more than organizations with commercial electricity contracts and 6.5 % more compared to non-domestic customers with SME electricity contracts. Small organizations value a 24hr power outage about 2 % less in terms of their electricity bill compared to the full sample mean values, both in terms of WTP and WTA, indicating that they are less affected by a power outage shock compared to larger organizations. Interestingly, non-domestic customers that have their own generator of electricity place an important value to the reliability of the electricity supply, as they are willing to pay 7.15 % more in their electricity bill to avoid a power cut. Finally, having had a power outage in the last 12 months does not seem to affect much organizations' WTP and WTA for a 24hr power cut.

We explore heterogeneous preferences in WTP and WTA for a 24hr power outage by running models that add covariates to the interval data models, using the full sample. The first model, Model 1, adds dummy variables to take into account the effect of whether the respondent to the survey is the sole decision-maker regarding the supply of energy within his/her organization (decisionmaker), whether the organization has no more than 5 employees (small), the type of electricity contract – industrial or commercial – with SME being the reference dummy variable, whether the respondent is the owner, director or president of the organization (boss), the logarithm of the electricity bill (bill), and whether the organization is based in the Attica region, where more than half of our organizations are located (attica). Both the WTP and WTA models show that there are no differences in WTP or WTA according to the different type of electricity contract – commercial, industrial or SME – and whether the respondent of the survey was responsible for the electricity contract or had a managerial position in the organization. The WTP model shows that small organizations and organizations that are located in the Attica region have a lower WTP for avoiding power outages. The WTA model further shows that organizations with a higher electricity bill require a higher compensation to accept an increase in power outages.

Model 2 adds variables that capture the activity of the organizations, with dummy variables capturing whether the sector of business is entertainment, tourism, fast moving consumer goods (fastmovinggoods), management consulting, food, drink, and whether they had experienced a sudden increase in electricity price due to shortage of electricity or a failure in the network (suddenincrease), and if they own a power generator (generator). We do not find evidence of heterogeneous preferences in all these different characteristics of organizations, except for organizations that operate in the food industry that have a higher WTP to avoid power outages, organizations that operate in the drink industry and in the tourism sector that have a higher WTA to accommodate an increase in power outages. Model 3 adds further dummy variables to explore the effect of attitudes towards energy security, experience with and opinions about power outages, and one variable that measures the logarithm of the monetary production loss suffered from a 24hr power outage (ler20a).

Stating that having energy security is very important (es_vimp) has no effect on WTP or WTA. Being very concerned that electricity becomes unaffordable (unaffordable_vconc), or rationed (rationed_vconc) has no impact on WTP or WTA. On the one hand, being very concerned that electricity needs to be imported (import_vconc) reduces respondents' WTP but has no impact on WTA. On the other hand, being very concerned that electricity needs to rely on fossil fuels (fossil_vconc) increases WTP and has no impact on WTA. On a 1 to 5 Likert scale, where 1 means very unlikely and 5 very likely, the effect on WTP of respondents considering that the likelihood that outages are caused by not enough electricity generated is equal to 4 or 5 (outages_noelec) is not statistically different from zero. Conversely, the effect of outages_noelec on WTA is negative.

Considering very likely (equal to 4 or 5) that the likelihood that power outages are caused by not enough renewable energy (outages_noren) has a negative effect on WTP, but does not impact WTA. We then explore the effect of four 1 to 5 Likert Scale questions, and build dummy variables equal to 1 when the answers are either 4 or 5 to the Likert Scale questions, on the likelihood that power outages are caused by natural disasters (outages_dis), technical failures (outages_tec), terrorist attacks (outages_ter), national political instability (outages_nat), international political instability (outages_int). Only a high rating for believing that power outages are caused by technical failures negatively affects WTA, and a high rating for deeming power outages being caused by international political instability leads to a decrease in WTP.

Having had a planned power outage in the last 12 months (plast12) negatively affects WTP but has no effect on WTA. Considering not acceptable to be without power for any length of time (notacceptable) leads an increase in both WTP and WTA, indicating that non-domestic customers that consider very important a continuous supply of power have high WTP and WTA for changes to the quality of the supply of electricity. Interestingly, compared to those who state that it is not acceptable to be without power for any length of time, respondents who consider acceptable a power outage of maximum 1 hour (pless1), or 4 hours (pless4), have a similar WTP for avoiding a deterioration in the quality of the electricity supply, and a positive but lower WTA for accepting a deterioration in the service.

The next set of dummy variables pick the effect of whether respondents consider as zero (pn0), one (pn1), or two (pn2) respectively the maximum acceptable number of planned power outages per year. While these variables have no effect on WTA, considering acceptable zero planned power outages negatively affects WTP. Next, we focus on unplanned power outages, and we find that having had at least one unplanned power outage in the last 12 months (unplast12) has a negative effect on WTA, but no effect on WTP. Unpn0, unpn1, and unpn2 are dummy variables capturing the effects on WTP and WTA of considering that the maximum number of unplanned power outages is zero (unpn0), one (unpn1) and two (unpn2) respectively. We find that those that consider as zero the maximum acceptable number of unplanned power outages have a higher WTA, and those that think that the maximum acceptable number of unplanned power outages is one have a lower WTP. Finally, the higher the logarithm of the monetary production loss from a 1hr power outage stated by our respondents (ler20a), the higher their WTA for accepting a 24hr power outage.

Table 33. Explorative extended WTP models for explain further heterogeneity in preferences

	WTP models					
	MODEL 1		MODEL 2		MODEL 3	
	Coeff	St. err.	Coeff	St. err.	Coeff	St. err.
Intercept	1.3487**	0.5626	1.4646**	0.5764	1.2765**	0.7136
decisionmaker	0.0743	0.1862	0.0448	0.19	0.085	0.1856
small	-0.4794**	0.2041	-0.5012**	0.2106	-0.3317	0.2117
industrial	0.0239	0.2798	0.0994	0.2918	0.2357	0.2917
commercial	0.1779	0.2175	0.2103	0.2212	0.2962	0.2243
boss	-0.1014	0.199	-0.0894	0.2006	-0.0903	0.1978
bill	0.0523	0.0725	0.0119	0.0773	0.0298	0.0773
attica	-0.3595**	0.1622	-0.311*	0.1656	-0.0417	0.1792
entertainment			-0.0193	0.3286	0.075	0.3256
tourism			0.5372	0.375	0.6359*	0.3688
fastmovinggoods			0.0937	0.3186	0.2222	0.3111
consulting			-0.0133	0.3883	0.0986	0.3964
food			0.4585*	0.2666	0.584**	0.2642
drink			-0.0657	0.3344	0.0571	0.3306
suddenincrease			0.0308	0.3276	-0.2372	0.3326
generator			0.0274	0.2846	0.2943	0.2793
es_vimp					-0.2484	0.27
unaffordable_vconc					-0.1212	0.1888
rationed_vconc					0.0338	0.1807
import_vconc					-0.5838***	0.1969
fossil_vconc					0.6171***	0.1928
outages_noelec					0.0987	0.1993
outages_noren					-0.4814**	0.1973
outages_dis					-0.2134	0.1733
outages_tec					0.0087	0.1809
outages_ter					0.1658	0.2461
outages_nat					0.2838	0.2168
outages_int					-0.4122*	0.2148
plast12					-0.3081*	0.1674
notacceptable					0.6458*	0.3592
pless1					0.6376**	0.3077
pless4					0.6478**	0.2923
pn0					-0.5448*	0.2848
pn1					-0.005	0.2492
pn2					-0.1715	0.2201
unplast12					0.0528	0.1776
unpn0					-0.1075	0.2644
unpn1					-0.5736**	0.2735
unpn2					-0.1574	0.2727
ler20a					0.0357	0.0294
Scale	1.7798***	0.0945	1.7698***	0.0942	1.6582***	0.0885
Weibull Shape	0.5619***	0.0298	0.565***	0.0301	0.6031***	0.0322
AIC		1396.84		1407.88		1411.66
BIC		1436.64		1483.05		1592.94
Loglikelihood		-689.42		-686.94		-664.83
Obs		615		615		615

*** statistically significant at the 1 % level
** statistically significant at the 5 % level
* statistically significant at the 10 % level

Source: own elaborations

Table 34. Explorative extended WTA models for explain further heterogeneity in preferences

	WTA models					
	MODEL 1		MODEL 2		MODEL 3	
	Coeff	St. err.	Coeff	St. err.	Coeff	St. err.
Intercept	2.4674***	0.3642	2.385***	0.3791	1.8771***	0.4564
decisionmaker	-0.1788	0.1225	-0.1639	0.1244	-0.0581	0.1221
small	-0.0242	0.1372	-0.0219	0.1409	0.0947	0.1416
industrial	0.2451	0.182	0.3085*	0.1886	0.3385*	0.1935
commercial	0.1503	0.1408	0.1648	0.1441	0.1067	0.1419
boss	0.0213	0.1339	0.0175	0.1359	-0.0177	0.1346
bill	0.0784*	0.0471	0.0813*	0.0499	0.0629	0.0502
attica	0.1587	0.1041	0.1622	0.1053	0.3529***	0.1142
entertainment			0.0316	0.2096	-0.0014	0.2038
tourism			0.3821	0.2427	0.5367**	0.2394
fastmovinggoods			0.0295	0.2068	0.0405	0.1986
consulting			0.1083	0.2431	0.2594	0.2393
food			0.09	0.1752	0.0314	0.1721
drink			0.2516	0.2158	0.4589**	0.2133
suddenincrease			-0.1096	0.2156	-0.2086	0.2125
generator			-0.1904	0.1886	-0.124	0.1863
es_vimp			-0.1904	0.1886	0.0344	0.1691
unaffordable_vconc					-0.0516	0.1217
rationed_vconc					-0.026	0.1179
import_vconc					-0.0531	0.1209
fossil_vconc					0.0975	0.1201
outages_noelec					-0.2364*	0.1295
outages_noren					-0.1675	0.1261
outages_dis					0.1319	0.1121
outages_tec					-0.2205*	0.1158
outages_ter					0.1603	0.1536
outages_nat					-0.1466	0.1376
outages_int					-0.1279	0.1394
plast12					-0.1154	0.1078
notacceptable					0.6774***	0.2302
pless1					0.5112***	0.1887
pless4					0.3295*	0.1794
pn0					-0.3053	0.1935
pn1					-0.1141	0.1637
pn2					-0.161	0.1456
unplast12					0.2405**	0.11
unpn0					0.4208**	0.1689
unpn1					0.0175	0.1733
unpn2					0.1728	0.1749
ler20a					0.0412**	0.0189
Scale	1.0585***	0.0406	1.0501***	0.0406	0.9794***	0.0391
Weibull Shape	0.9447***	0.0363	0.9523***	0.0368	1.021***	0.0408
AIC		1635.72		1645.97		1635.51
BIC		1675.67		1721.44		1817.52
Loglikelihood		-808.86		-805.98		-776.75
Obs		626		626		626

*** statistically significant at the 1 % level
** statistically significant at the 5 % level
* statistically significant at the 10 % level

Source: own elaborations

5.2 Conversion of results in monetary value per unit of unserved energy

We now convert the CV estimates of WTP/WTA in to a monetary amount per unit of energy is then a crucial step. The results provided through the analyses of the survey data are not immediately usable for any specific policy purpose, as they are provided in the previous parts of the report. As the payment vehicle assumed in the elicitation question is a variation on a bi-monthly electricity bill, we provided as estimates, monetary amounts associated to the costs of a 24h blackout, referred to a bi-monthly time span.

We then calculate a measure of VoLL normalized to kWh for each firm in the sample, as follows:

$$VoLL_i = \frac{\hat{E}(WT\dot{P})_t * B_i}{C_{ti}}$$

$\hat{E}(WTP)_t$ is the estimated expected value of the WTP expressed as a share of the bill, referred to the duration of the event (24 hours). The duration of 24h is chosen to reduce the cognitive burden of the evaluation. The economic production loss of a day is a frame for the assessment that can be easily managed. Within this time span the respondents can also consider with accuracy the possibilities to substitute of electricity with other fuel (operatively justified for a long disruption) or the possibility to reduce damages shifting to activities that do not require electricity.

B is the value of the bi-monthly bill,

C is the consumption of electricity in kWh,

t is the duration of the interruption of electricity supply, and

i is the firm (observation in the sample).

C_{ti} from the sample data can be obtained from the monthly consumption declared by respondent i.

B_i is obtained doubling the monthly expenditure declared by respondents, as they provided information about the average monthly expenditure over the last year, to avoid biases due to seasonal variations. It is important to note that B and C have the subscript i as we computed the value of the damage for kWh over the sample of firms under observations.

Different measurement approaches can be used depending on the purpose of the use. We opted for an averaging approach to provide a single value for the non-residential sector. Then, for specific customers the term $\hat{E}(WTP)_t$ can be combined with customer specific information not coming from a survey. A suitable extension of this exercise can be the use of load profiles and consumption data measured in an accurate way to characterize the normalization by kWh. On the pooled sample, the median WTP is 0.68 €/kWh and the WTA is 2.80 €/kWh.

The corresponding sample distribution of the computed $VoLL_i$ are in presented in the boxplot of Figure 25.

The results of the VoLL from the CV, for different size of non-residential consumers are reported (median values) in Table 35.

Table 35. Estimates of the VoLL per unit of energy (€/kWh)

Employees	Median WTP	Median WTA
1 to 5	0.68	2.80
6 to 9	0.64	2.64
10 to 19	0.90	3.74
20 to 24	0.68	2.80
50 to 249	0.61	2.52
250+	0.57	2.38

Source: own elaborations

Figure 26. Distribution of VoLL from CV data for non-residential customers, by firm size (€/kWh)

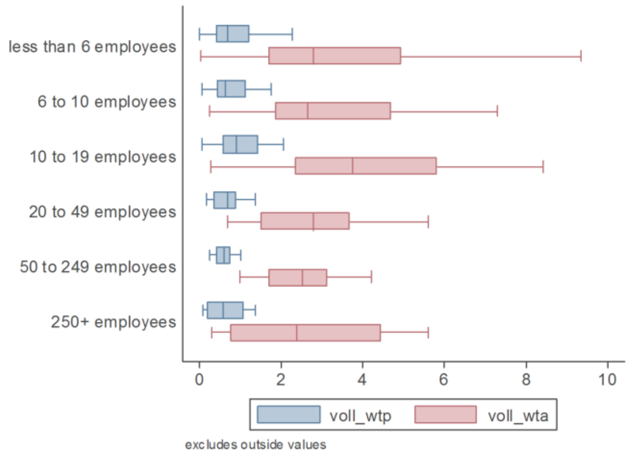


Table 36. Comparison of the survey results with other available studies (€/kWh)

Survey	Study context	Sector	€/kWh
Fischer (1986)	USA, summer, afternoon	Trade	23.00
Woo & Gray (1987)	USA, summer, afternoon	Industry	79.30
Woo & Train (1988)	USA, summer, afternoon	Trade	11.30
Caves et al. (1990)	USA (maximum value)	Firms	29.80
Doane et al. (1990)	USA, winter, evening	Industry	8.90
Sullivan et al. (1996)	USA	Firms	50.80
Bertazzi et al. (2005)	Italy	Firms	143.90
Bliem (2007)	Austria	Firms	239.30
Reichl et al. (2007)	Austria	Firms	8.60
De Nooij et al. (2007)*	Netherlands	Non-household consumers	21.20
Reichl et al, 2013	Austria, winter, morning	Non-household consumers	29.70
Doane et al. (1988)***	USA, winter, evening	Households	22.20
Sanghvi, (1983)	USA, summer, midday	Households	0.20
Bertazzi et al. (2005)	Italy	Households	4.50
Fickert (2004)	Austria	Households	2.40
Bliem (2007)	Austria	Households	6.20
Reichl et al. (2007)	Austria	Households	3.90
Reichl et al, 2013	Austria, winter, morning	Households	2.80
Our study	Greece	Households (WTP)	7.10
Our study	Greece	Households (WTA)	16.50
Our study	Greece (direct assessment)	Non-household consumers (damage evaluation of blackout scenarios)	20.00
Our study	Greece (CV)	Non-household consumers (WTP)	0.68
Our study	Greece (CV)	Non-household consumers (WTA)	2.80

Source: own elaborations on Reichl et al. 2013

6 Conclusion

In the study for residential consumers we estimated a mean WTP of €6.15 and a mean WTA of €14.29 for a hypothetical 90 minute blackout. Assuming 0.86 kWh as average consumption during the event, this generates for residential consumers a VoLL of 7.1 €/kWh and 16.5 €/kWh respectively for WTP and WTA.

The same approach is employed for the study on non-residential customers. For a 24h blackout, the 800 firms belonging to industrial, commercial and SMEs stated a mean WTP that amounts to 5.67 % of their bi-monthly electricity bill, and a mean WTA of 23.37 %.

The survey data also provided an open ended evaluation of the costs of blackout scenario directly quantified in terms of loss of economic production by respondents. Looking at these data, industrial, commercial and SME customers pointed out that one hour of interruption of electricity supply induces a monetary loss changing considerably with the size of the firm: the median values declared in the survey are €25 for firms with up to 5 employees, €100 for firms from 6 to 9 employees, €200 for firms from 10 to 19 employees, €400 for firms from 20 to 24 employees and from 50 to 249 employees, and €10000 for firms with more than 250 employees.

The non-residential customers participating to the survey assessed the loss in their economic production for four scenarios: 1, 6, 12 and 24 hour blackout. In this way, survey data have been used to draw damage curves and to run regression analyses, exploring the relationship between damage values and other variables. Adopting a panel data approach, we controlled for the fact that each respondent reported four observations for their organization's monetary loss due to different power outages lengths and four observations for the percentage loss as well. The larger an organization's electricity bill, the higher also the damage, both in absolute and percentage terms. We notice that organizations with an industrial or commercial electricity contract suffer a larger damage, everything else being equal, compared to organizations with an SME electricity contract. Organizations declaring to have experienced a power outage in the last 12 months have also higher economic losses.

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List of abbreviations and definitions

CASES	Cost Assessment of Sustainable Energy Systems
CATI	computer assisted telephone interviews
CAWI	computer assisted web interviews
CEER	Council of European Energy Regulators
ELSTAT	Hellenic Statistical Authority
ENS	energy not served / supplied
GDP	Gross Domestic Product
IEAR	Interrupted Energy Assessment Rate
kW	kilowatt
kWh	kilowatt hour
MWh	megawatt hour
SAIFI	System Average Interruption Frequency Index
SAIDI	System Average Interruption Duration Index
SME	Small Medium Enterprise
SP	Stated Preferences
VoLL	Value of Lost Load
WTA	Willingness-to-accept
WTP	Willingness-to-pay

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Annex 1 – Questionnaire to residential customers

Introductory statement

INTRO CATI. Good morning / evening. My name is……………………… and I call from FOCUS BARI research agency. We are conducting a study regarding your experience as consumer of electricity. We would like our help with some questions. The number I called is a **household** or **workplace**?

IF NEEDED SPECIFY: This study has been commissioned by the European Commission and will take place at many countries of the European Union. The number I called you has been selected randomly. Your participation in the study is very important for us, but it is not obligatory and you can refuse participation if you wish. If you need more information regarding our company you can call us at 210 7252453 - 210 7238122 or visit www.Focusbari.gr

HOUSEHOLD number and suitable person available to participate	1
WORKPLACE number	2
REFUSAL	3
COMMUNICATION ISSUE (not Greek speaker, other communication issue)	4
NOT AVAILABLE RIGHT NOW (APPOINTMENT)	5
DID NOT PASS QUOTAS CHECK	6

With this questionnaire, you will provide anonymous information to the government on how the citizens value their *experiences and opinions regarding electricity distribution. There are no correct or wrong answers, but we invite you to be accurate as* your replies will be taken into consideration to inform the future regulation on the Greek electricity market.

INTRO CAWI. Welcome to the new FOCUS BARI study. We are interested in people's views and experiences as consumers of electricity. We would be most grateful if you could spend about 20-30 minutes answering our questions.

This specific study has been commissioned by the European Commission and will take place to many countries of the European Union.

With this questionnaire, you will provide anonymous information to the government on how the citizens value their *experiences and opinions regarding electricity distribution. There are no correct or wrong answers, but we invite you to be accurate as* your replies will be taken into consideration to inform the future regulation on the Greek electricity market.

Thank you for your time, and the effort that you will put in this survey.

For the interviewer, date and hour of the interview to be recorded on a variable [datehour]

Section B – Household energy use, expenditures and perceived risks of damages from power cuts.(title not visible to the respondent)

1) Your gender : Male☐ Female☐

2) What is your date of birth?
- **(numeric – 4 digits | from 1917 till 2017)** ___

3) How many people, including yourself, live in the house the majority of the year?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ More than 5

4) Are there any children under the age of 14 living in your households?
- Yes
- No

5) Which one of the following best describes your role in your household, as far as electricity supply and payment are concerned?

☐ You are the sole person responsible for paying electricity bills
☐ You and a partner, spouse or member jointly pay the electricity bill
☐ I am not involved in the payment of the electricity bill

6) In which peripheral unit do you live in?
- East Macedonia and Thrace

- Attica
- North Aegean
- West Greece
- West Macedonia
- Epirus
- Thesally
- Ionio
- Central Macedonia
- Crete
- South Aegean
- Peloponnese
- Central Greece
-

7) What is the population of the city or village you live in?

- More than 50,000 citizens
- 2,000-50,000 citizens
- Less than 2,000 citizens

8) What is approximately the size of your house (excluding garages, attic and basement)?

____________________ square meters ☐ I do not know

9) Which of the following activities cannot be done in your house in any way, 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:	________________________	______________________

-

10) We kindly ask you to refer to your last electricity bills. How much do you pay for your monthly consumption? ________________ euros

Section D: Planned power cuts

11) During the past 5 years, have you experienced any power cut, planned or unplanned, that affected your household?

☐Yes ☐No ☐I do not know

12) How long did the longest power cut last, that you experienced during the last 5 years - whether planned or unplanned?

☐Less than 1 hour

☐Between 1 and 4 hours

☐Between 4 and 8 hours

☐More than 8 hours

☐I cannot remember

13) Please estimate the number of power cuts you experienced during the last 12 months?

☐1 outage

☐2 to 5

☐6 to 10

☐More than 10

☐Zero in the last 12 months

☐I cannot remember

14) **If you think of the number and duration of power cuts your household has experienced overall, how satisfied are you with the general reliability of your household's electricity supply?**

☐Very satisfied

☐Fairly satisfied

☐Not very satisfied

☐Not at all satisfied

☐Do not know

15) **Please think at a very long power cut. Considering that it started 4 hours ago, to what extent the following services would be affected, in your opinion? Please rate from 1 to 4 where**

	1 means	2 means	3 means	4 means
	Not at all	*Moderately*	*Strongly*	*Very strongly*
Medical system				
Fuel or gas supply				
Electronic payment				
Land lines and mobile telephones				
Your heating system				
Internet connections				
Metros, trams, trains				
Sanitation and water supply				

Section F-wta: Hypothetical questions on electricity scenarios

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

The most recent data on power cuts show that the electricity network suffers unplanned failures. In Greece, yearly, one blackout occurs with a total duration of 90 minutes. In the future the reliability of the system depends from many factors and may either worsen or improve.

Please, consider carefully the following situation. A hypothetical power cut is starting from now. Under this situation, it would be impossible for you to use electricity at home in the next 90 minutes. During the year a similar event has already occurred, and you received no notice in advance for both these events.

16) Think at the consequences of the power cut on the activities that you were expecting to do in your next 90 minutes. Do you think these inconveniences could be fully compensated by a discount on your next electricity bill of **X** euro?

- ☐ Yes
- ☐ No

17) Would the consequences of the power cut be compensated by an amount of **Y** Euro?

- ☐ Yes
- ☐ No

18) Would the consequences of the power cut be compensated by an amount of **W** euros?

- ☐ Yes
- ☐ No

19) Which reasons best describe your choices ~~to accept or~~ not accept a compensation for the inconveniences suffered from the blackout? [Tick all that apply]

- ☐ The inconveniences that my family would suffer are ~~relevant~~ too important
- ☐ I don't believe that a system of discounts can be implemented
- ☐ I don't believe the hypothetical scenario of a discount on the electricity bill
- ☐ Others, such as the government and industry, should pay for the power cuts

Section F-wtp: Hypothetical questions on electricity scenarios

Consider now the following situation. Under this scenario, the operators running the electricity networks had invested resources to improve the reliability of the electricity supply, providing additional generators and measures useful in case of peak or failures. The presence of these devices would allow managing the crisis without cutting the power supply and would require you to pay an increased amount on your electricity bill.

20) If such system could prevent a blackout starting from now and during the next 90 minutes, would you be willing to pay an increase on your next electricity bill of X1
Euros, avoiding the consequences of the power cut?

- ☐ Yes
- ☐ No

21) Would you be willing to pay if the amount to avoid the power cut would be of **Y1** euros?

- ☐ **Yes**
- ☐ No

22) Would you be willing to pay if the amount to avoid the power cut would be of **Z1** euros?

23) Which reasons best describe your choices ~~to accept or~~ not accept a compensation for the inconveniences suffered from the blackout? [Tick all that apply]

☐ The inconveniences that my family would suffer are ~~relevant too important~~

☐ I don't believe that a system of discounts can be implemented

☐ I don't believe the hypothetical scenario of a discount on the electricity bill

☐ Others, such as the government and industry, should pay for the power cuts

24) Among the possible inconvenient consequences of a power cut, which could be the worse for you, personally? (Feel free to describe the one that would make you feel more unconfortable if the power cut would occur at home or in another place)

- Fridge stop working
- Destruction of electrical devices
- Impossibility of lighting during the nighttime
- Impossibility to work
- Impossibility to cook
- Impossibility to use the heating
- Impossibility to use the internet
- Impact on health – own or other household member's
- Inertia – inability to conduct any ordinary activity
- Other_______________
- Other_______________

25) We ask you to say if you agree or disagree with the following statements: 5 POINT SCALE

	Completely disagree				Completely agree
• **I want to reduce my electricity consumption**	1	2	3	4	5
• **I want to use more renewable energies**	1	2	3	4	5
• **I want to generate my own electricity**	1	2	3	4	5
• **I want to purchase energy saving technologies**	1	2	3	4	5
• **I want to use energy at non-peak times (i.e., times when there is plenty of supply).**	1	2	3	4	5
• **I want to reduce my electricity consumption during peak times adjusting my behaviour**	1	2	3	4	5
• **I want to reduce my energy consumption during peak times by letting technologies schedule my energy use for me**	1	2	3	4	5
• **I want to invest in energy storage**	1	2	3	4	5

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.[5]

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.

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

•

	DK/NA	Very important	Important	Moderately Important	Slightly Important	Not Important
		5	4	3	2	1
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.

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.

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

DK/NA	Very important	Important	Moderately Important	Slightly Important	Not Important
	5	4	3	2	1

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.

28) 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

☐ NO

☐ Don't know

•

29) [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? **SINGLE CHOICE**

☐ YES

☐ NO

☐ Don't know

30) [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

31) 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? €________

- DK / DA

32) 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

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

	Completely disagree				Completely agree
• **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
• **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

Section I: Sociodemographics

34) What is the highest degree or level of education you have completed? **SINGLE CHOICE**

- High school graduate (includes equivalency)
- Technical, post-high-school education
- Higher education (University)
- Postgraduate / PhD

35) Could you please provide the range of the current total net monthly income of your household?

- Up to 300 EUR
- 301 – 630 EUR
- 631 – 800 EUR
- 801-1.000 EUR
- 1,001-1,220 EUR
- 1,221-1,500 EUR
- 1,501-1,800 EUR
- 1,801-2,300 EUR
- 2,301-3,700 EUR
- 3,701+ EUR
- DK/NA

Thank you for your participation in the study!

Annex 2 - Questionnaire to non-residential customers

Which are your responsibilities in the enterprise regarding the supply and consumption of energy?

- Me alone decides on issues regarding the supply and consumption of energy in the enterprise
- Me together with someone else decide on issues regarding the supply and consumption of energy in the enterprise
- I do not decide, nor do I participate in such decisions

Section A – Sector of activity (title not visible to the respondent)

First of all, some classification questions on the profile of the enterprise and your job role in it

1. Which of the following best describes your role in the organization / enterprise?
    - Owner
    - President of the Board / CEO
    - Director
    - Manager / mid-level manager
    - Employee
    - Other
2. How many employees are there in the organization / enterprise?
    - 1-5
    - 6-9
    - 10-19
    - 20-49
    - 50-249
    - 250+
3. Which type of contract / bill you have with your energy provider, industrial/commercial/residential?
    - ☐ INDUSTRIAL CONTRACT
    - ☐ COMMERCIAL CONTRACT
    - ☐ RESIDENTIAL CONTRACT

4. Which of the following best describes the activity of the enterprise / organization?
    - Manufacture
    - Retail
    - Services

- 4A. And, in which sector is your enterprise / organization operating? (if necessary, more categories can be selected, but only 1 from each list)
- LIST A

☐ Entertainment
☐ Government
☐ Telecommunication
☐ Hospitality Industry/tourism
☐ Mass media
☐ Healthcare/hospitals
☐ Public health
☐ Information technology
☐ Waste disposal
☐ Consulting
☐ Retail sales
☐ Franchising
☐ Real estate
☐ Education
☐ Financial services (banking, insurance, investment management)
☐ Fast moving consumer goods
☐ Professional services – accounting
☐ Professional services – legal services
☐ Professional services – Management consulting

- LIST B

- ☐ Food products
- ☐ Drink products
- ☐ Smoking products
- ☐ Fabrics & materials
- ☐ Clothing
- ☐ Leather products
- ☐ Wood products
- ☐ Paper-related products
- ☐ Printing / reproductions
- ☐ Coke & refinement
- ☐ Chemical products
- ☐ Pharmaceutical products
- ☐ Plastic & elastics
- ☐ Non-metallic mineral products
- ☐ Basic metals
- ☐ Metallic products

Section B – Energy profile

5. Can you provide an assessment of the average monthly consumption of electricity of the organization you work in? ________________kWh

6. What was your organizations' average electricity bill for the previous month? €___________

7. Has your organization experienced any sudden increase on electricity prices due to a shortage of production or a failure of the network?

   Yes ☐ No ☐

8. Is your organization equipped with any electricity generator for auto production?

   Yes ☐ No ☐

9. How important is having access to a reliable electricity supply for your organization?

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

10. How concerned, if at all, is your organization that … [1 not at all concerned to 5 extremely concerned]

Score (from 1 to 5)

electricity will become unaffordable	1 2 3 4 5 6 7
electricity will become rationed	1 2 3 4 5 6 7
[country] is too dependent on energy imports from other countries	1 2 3 4 5 6 7
[country] is too dependent on fossil fuels (e.g., oil, gas)	1 2 3 4 5 6 7

11. … [1 not likely at all to 7 extremely likely]

Score (from 1 to 7)

… insufficient electricity being generated	1 2 3 4 5 6 7
… insufficient renewable electricity being generated	1 2 3 4 5 6 7
… natural disasters and extreme weather	1 2 3 4 5 6 7
… technical failures	1 2 3 4 5 6 7
… terrorist attacks	1 2 3 4 5 6 7
…national political instability	1 2 3 4 5 6 7
…international political instability	1 2 3 4 5 6 7

12. When, if at all, did you last have a planned power cut to your business – that is, you were informed in advance of the power cut by the electricity provider?
    - ☐ In the last 12 months
    - ☐ More than 1 year but less than 5 years ago
    - ☐ More than 5 years but less than 10 years ago
    - ☐ More than 10 years ago
    - ☐ Have had a planned power cut but cannot recall when it took place
    - ☐ Do not recall having a planned power cut

•

13. What do you think is a **reasonable amount of time** to be without your electricity supply to allow planned maintenance work to be conducted?
    - ☐ More than 8 hours
    - ☐ 5 to 8 hours
    - ☐ 1 to 4 hours
    - ☐ Less than 1 hour
    - ☐ Not acceptable to be without power for any length of time
    - ☐ I do not know

14. What do you think is the **maximum number of planned power cuts** that is acceptable per year to your organization?
    - ☐ More than six times
    - ☐ Six times
    - ☐ Five times
    - ☐ Four times
    - ☐ Three times
    - ☐ Twice
    - ☐ Once
    - ☐ None
    - ☐ I do not know

15. When, if at all, did you last have an **unplanned power cut** to your organization – that is, you were NOT informed in advance of the power cut by the electricity provider?
    - ☐ In the last 12 months
    - ☐ More than 1 year but less than 5 years ago
    - ☐ More than 5 years but less than 10 years ago
    - ☐ More than 10 years ago
    - ☐ Have had a planned power cut but cannot recall when it took place
    - ☐ Do not recall having a planned power cut

16. What do you think is the **maximum number of unplanned power cuts** that is acceptable per year to your organization?
    - ☐ More than six times
    - ☐ Six times
    - ☐ Five times
    - ☐ Four times
    - ☐ Three times
    - ☐ Twice
    - ☐ Once
    - ☐ None
    - ☐ I do not know

17. In case of interruption of the supply of electricity to your organization, which additional sources are available and operative in your organization?
    - ☐ Generators for autoproduction of electricity
    - ☐ UPS (uninterruptible power supply) systems applied to computers
    - ☐ UPS and backups applied to other machineries (please, specify) __________________
    - ☐ Protection for data losses
    - ☐ Other (please specify)___________
    - ☐ Nothing

18. Could you provide an assessment of how much the company spent for providing the options selected in the previous question?
    - ☐ Purchase _______________ Euro
    - ☐ Annual operating and maintenance costs ___________Euro

Section C – Self assessment of expected damages from power outages

In this section, we present some hypothetical scenarios of power outages and ask you to assess the financial damage that is most likely to occur to your organization.

19. Scenario 1: Weekday, unplanned power outage lasting 1 hour, starting at 10am and finishing at 11am.
    a) What is the monetary loss to your organization? €__________
    b) What is the value added lost over that day in percentage, between 0 % and 100 %?_______%
20. Scenario 2: Weekday, unplanned power outage lasting 6 hours, starting at 10am and finishing at 4pm.
    c) What is the monetary loss to your organization? €__________
    d) What is the value added lost over that day in percentage, between 0 % and 100 %?_______%
21. Scenario 3: Weekday, unplanned power outage lasting 12 hours, starting at 10am and finishing at 10pm.
    e) What is the monetary loss to your organization? €__________
    f) What is the value added lost over that day in percentage, between 0 % and 100 %?_______%
22. Scenario 4: Weekday, unplanned power outage lasting 24 hours, starting at 10am and finishing at 10pm.
    g) What is the monetary loss to your organization? €__________
    h) What is the value added lost over that day in percentage, between 0 % and 100 %?_______%

SECTION D-WTA: Hypothetical questions on electricity scenarios

Please, consider the following situation. A hypothetical power cut starts now and for the next 24 hours your organization is not receiving the usual power supply.

23.
- Think at the consequences of the power cut on the activities that your organization should perform in the next 24 hours. In case the power cut is affecting your organization, do you think these inconveniences could be fully compensated by a discount on the next electricity bill of **X** %?
- [X CAN BE 2 % OR 5 % OR 7 % OR 10 %, IT SHOULD BE RANDOMLY ASSIGNED AND IN THE FINAL DATA THERE SHOULD BE AN EVEN DISTRIBUTION OF THESE AMOUNTS]

Yes No

24. Would the consequences of the power cut be compensated by a discount of **Y**?

Yes No

25.
- ASK IF 23) = NO
- Would the consequences of the power cut be compensated by an amount of **W** euros?

Yes No

26 Which reasons best describe your choices to accept or not to accept a compensation for the inconveniences suffered from the blackout? [Tick all that apply]

I experienced already real inconveniences and such discounts are appropriate

The damage the organization I work for will suffer from the power cut worth the discounts

I don't believe that a system of discounts can be implemented

The electricity provider would probably not accept to pay

The electricity operators are going to increase prices before apply

SECTION E-WTP: Hypothetical questions on electricity scenarios

Consider now the following situation. Under a scenario of extreme crisis with shortage of supply on the transmission system, the price of electricity may have exceptional increases, and to warrant the service to protected customers the operator may selectively interrupt the service to others imposing a power cut to some economic activities, or imposing a higher price that would mean an increase on the next electricity bill.

27.
- In case you organization would be hypothetically disconnected from the power supply from now for the next 24 hours, would you be willing to pay an increase of **X1 %** on your next electricity bill to avoid such power cut?
-
- [X1 CAN BE 2 OR 5 OR 7 OR 10 IT SHOULD BE RANDOMLY ASSIGNED AND IN THE FINAL DATA THERE SHOULD BE AN EVEN DISTRIBUTION OF THESE AMOUNTS. Please note here is in % and not in euros]

☐ Yes (if this is the option chosen, go to question 28)

☐ No (if this is the option chosen go to question 29)

28. Would you be willing to pay if the increase to avoid the power cut would be of **Y1** %?

Yes No

29. Would you be willing to pay if the amount to avoid the power cut would be of **Z1** %?

Yes No

30. Which reasons best describe your choices to accept or not to accept a compensation for the inconveniences suffered from the blackout? [Tick all that apply]

☐ I cannot afford increases in the electricity bill

- ☐ The damages from power cuts are not so relevant to my organization
- ☐ I do not believe that blackouts can be eliminated with such increases
- ☐ In any case the operator cannot be justified in requesting additional payments also in case of shortages of supply.

31. In general, why did you choose those options?

- ☐ I chose the options which would result in the least cost to my organization
- ☐ I chose the options which offered the improvements at reasonable prices
- ☐ I chose the options which offered the highest improvements, irrespective of the cost to my organization
- ☐ I was just guessing mostly
- ☐ I didn't really understand the questions
- ☐ The actual service of electricity supply has a low quality and I think that organizations should not pay any increase in the electricity bills
- ☐ Other

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