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Consumer Valuation of Energy Supply Security: An Analysis of Survey Results in Three EU Countries

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Introduction

There is a decided movement in EU energy markets towards a deregulated framework. This framework, however, might lack the necessary incentive structure for generators to maintain high service reliability, thus increasing the risk of generation and transmission outages.[1] Faced with such a challenge, it is crucial for policy-makers to envisage consumer valuation of service reliability in the future so that an acceptable combination of regulatory and economic tools can be applied to maintain adequate security of energy supply that is socially optimal and economically efficient.

This study investigates consumer valuation of the security of various types of energy supply, namely electricity, natural gas and transport fuels (oil). Moreover, whilst the majority of previous studies of this kind focused on electricity supply, this study contributes to the literature by expanding the scope of research to two other types of energy supplies which, we believe, are increasingly important in people's lives. Our research objectives were two-fold: 1) to derive monetary estimates of the welfare impacts of energy insecurity and 2) to assess the willingness to pay (WTP) to improve security of supply. Surveys were implemented in three EU countries – France, Italy and the United Kingdom – to collect primary data, and were carried out via face-to-face interviews with heads of households. The final raw data concern 200 households in France, 222 in Italy and 303 in the UK.

[1] D. F. Layton and K.Moeltner (2004), "The cost of power outages to heterogeneous households – An application of the mixed gamma-lognormal distribution", in *Applications of Simulation Methods in Environmental and Resource Economics*, A. Alberini and R. Scarpa (eds), Kluwer Academic Press.

secure — Security of Energy Considering its Uncertainty, Risks and Economic implications

SEVENTH FRAMEWORK PROGRAMME

Research for this paper was carried out in the context of the SECURE project (Security of Energy Considering its Uncertainties, Risks and Economic Implications), funded by the European Commission under the Seventh Framework Programme. The project develops appropriate tools for evaluating the vulnerability of the EU to the different energy supply risks, and for promoting the optimisation of EU energy insecurity mitigation strategies, including investment, demand side management and dialogue with producing countries.

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1. Survey findings on WTP

1.1 Reliability of electricity supply

Four attributes were selected to characterise the security (reliability) of electricity supply to household consumers. They represent how often power cuts take place, how long on average a power cut lasts, and when power cuts occur (during which months and at what time of the day).

The results show that domestic users in different countries demonstrate notably different preferences for the characteristics ascribed to the reliability of electricity supply. For example, respondents in France are willing to pay for the certainty of knowing the seasons during which a power cut would take place and to avoid power cuts occurring in the evening. But French respondents are not willing to pay to reduce the frequency or the duration of power cuts. By contrast, respondents in the UK and Italy are willing to pay to reduce the number of power cuts and their average duration. UK households are willing to pay to avoid a cut during the daytime whilst those in France are willing to pay to avoid a cut in the evening. Respondents in Italy, however, prefer knowing in which season a blackout would occur, whilst the time of day at which it occurs is not important. Table 1summarises our principal WTP results.

Table 1. Reliability of electricity supply: Key WTP results

	Annual WTP per household*		
	UK (£)	**France (€)**	**Italy (€)**
To avoid one power cut over a period of five years	10.09	-6.43	6.0
To avoid a one-hour interruption	19.23	-25.17	17.14
Having power cuts in April-September			
To avoid not knowing the season of power cuts	-8.85	80.14	44.71
To avoid October-March	-9.40	-115.0	0.0
Having power cuts at any time during the day			
To avoid daytime (6:00-18:00)	4.87	0.0	0.0
To avoid evening (18:00-6:00)	0.0	24.07	0.0

*"0" represents statistically insignificant results at the 10% significance level.

1.2 Reliability of gas supply

To determine the reliability of gas supply to homes, this study considered the number of one-day and three-day disruptions during each of two halves of the year: April to September and October to March.

In general, we find that households in the three countries are not willing to pay to avoid a supply disruption during the warm months (April-September), though in Italy there is a positive WTP to avoid a one-day cut without a warning. When it comes to a supply disruption during the cold months (October-March), the associated negative impact is evident in all three countries. The difference between a one-day cut with warning and a one-day cut without warning is considered the willingness to pay to avoid the uncertainty, and a positive WTP can be observed in France and Italy. Contrasting the one-day cut (no warning) with the three-day cut (no warning) shows that the impact of a supply disruption appears non-linear with the duration time. Note, however, that households in France are willing to pay to avoid one-day cuts during the cold months, but not to avoid a three-day cut. This may be because they judged such a prolonged cut unlikely and hence they were unwilling to pay to prevent it. UK households are willing to pay to avoid a three-day cut during the winter months, whereas the results suggest that a one-day cut during the cold months will have no impact on welfare. Results are summarised in Table 2.

Table 2. Reliability of gas supply: Key WTP results

	Annual WTP (per household)*		
	UK (£)	**France (€)**	**Italy (€)**
During April-September			
One-day cuts, no warning	0.0	0.0	3.63
Three-day cuts, no warning	0.0	0.0	0.0
During October-March			
One-day cuts, no warning	0.0	3.22	3.74
One-day cuts, with warning	0.0	2.28	2.95
Three-day cuts, no warning	22.0	-24.69	43.42

*"0" represents statistically insignificant results at the 10% significance level.

1.3 Quality of transport fuels

This study looked at two issues relating to the insecurity of transport fuel supply. One is the dependence on crude oil that makes consumers constantly vulnerable to fluctuations in oil prices. The second concerns climate change impact caused by greenhouse gas emissions. Two attributes are adopted in the survey design to address these two dimensions of insecurity. The first refers to the share of substitute fuel used by consumer vehicles; it is presumed that higher shares of substitute fuel reduce the impact of oil price fluctuations, given the implied reduced reliance on oil. The second attribute defines the levels of CO_2 in gram per kilometre emitted by consumer vehicles when in motion. This represents the extent of climate change impact as a result of using transport fuels. Therefore, rather than consider fuel supply disruptions, we consider differences in the qualities of the good linked to reduced vulnerability and environmental concerns.

Table 3 below summarises the preferences for the two aspects of security associated with transport fuels – environmental impact and the reliance on fossil fuels. Households in Italy demonstrate a willingness to pay for an increase in the shares of substitute fuels and for a reduction in the level of CO_2 emissions of a fuel mix. By contrast, households in the UK are willing to pay for a reduction in CO_2 emissions but evaluate negatively an increase in substitute fuels. Those in the France provide a negative valuation of a decrease in CO_2 emissions and show, at the 90% confidence level, no preferences for an increase or a decrease in substitute fuels. These results suggest that the total welfare gain/loss at a national level, as a result of implementing an energy policy that combats CO_2 emissions by increasing shares of substitute fuels, might be inconclusive across Europe.

Table 3. Quality of transport fuels: key WTP results

	Annual WTP (per household)*		
	UK (£)	France (€)	Italy (€)
To have 1% increase in substitute fuel[a]¶	-9.5	0.0	8.0
To avoid 1 gram CO_2/kilometre[b]	2.5	-3.89	4.33

[*] "0" represents statistically insignificant results at the 10% significance level.

[a] For example, to blend more biofuel (from 1% to 2%) into fossil fuels.

[b] A passenger car that emits 160 g of CO_2/kilometre and has annual mileage of 10,000 miles produces 2.575 tonnes of CO_2 per year. The reduction of 1 g of CO_2/kilometre leads to a reduction of 0.016 tonne of CO_2 per year.

2. Policy implications

Domestic user preferences for the reliability of electricity supply are not identical across the three countries. The current levels of reliability of supply in each country do not seem to explain many of the observed differences in household preferences for the attributes of supply reliability. When it comes to a decision on improving a given aspect of reliability of supply, the implication is therefore that policy-makers in different countries should have different priorities.

The extent of the economic impact of a disruption on gas supply depends on its duration and the season in which it takes place. Household preferences for the level of supply reliability vary from country to country. To obtain an aggregate economic impact of a given type of supply disruption, one can multiply the associated estimated price by the total number of households that are currently dependent on gas supply in each of the three countries, or regions within the countries. Such aggregate measures would then constitute a valuable indicator of the costs of supply unreliability, or benefits of supply reliability, based on which policy-makers/energy suppliers should make decisions on the amount of economically justifiable further investment required to secure a certain level of reliability of supply to domestic users.

The welfare measures for five hypothetical policies[2] related to transport fuels are shown in Table 4. In France the welfare measures for these five policies are negative and this can suggest that no benefits would be gained from introducing any of them. In Italy positive welfare measures for all five policies suggest that applying any of them would have positive benefits. The results for the UK suggest that a policy that only sets a target for biofuels without encouraging improvement in motor technologies has negative benefits, whereas one that mainly promotes technological development has positive welfare impacts. These results strongly imply that, despite an existing EU-wide policy framework/directive promoting the use of biofuels or the cutting of CO_2 emissions related to transport fuels, country-specific strategies in the process of compliance are crucial.

[2] These policies are closely in line with the European Union's attempts to promote the use of renewable fuels and to reduce CO_2 emissions in the transport sector.

Table 4. Policy preferences: Key WTP results

	Policy A (low carbon fuels)	**Policy B** (Improvement in motor technology)	**Policy C** (low carbon fuel + improvement in motor technology)	**Policy D** (high & low carbon fuels + improvement in motor technology)	**Policy E** (high & low carbon fuels + advanced improvement in motor technology)
Specifications					
Share of alternative fuels (e.g. biofuels)	5.75%	1%	5.75%	10%	10%
CO_2 emissions (gram/km)	150	130	120	120	95
Welfare measures					
France (€/household/year)	-38.89	-116.67	-155.56	-155.56	-252.78
Italy (€/household/year)	81.33	130	211.33	245.33	353.67
UK (£/household/year)	-20.13	75	54.88	14.50	77.00

3. Conclusion

In this study, the estimated value of the security of electricity supply can be considered a lower bound because the sample households rely jointly on electricity supply and gas supply in their homes. It is believed that households that rely only on electricity are likely to have a higher WTP for the reliability of electricity supply. A future study that attempts to derive a nation-wide valuation of electricity supply security should account for this explicitly.

Future research should also attempt to explore preferences across the EU for other, perhaps more radical, changes in the degree of supply security. Whilst we have found some resistance to changes – on the grounds that they are unrealistic or undesirable because unknown – paying more attention to the development of plausible future energy supply scenarios might make them more appealing.

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