What is the Value of Security of Supply for Households and Business Consumers? An Assessment Accounting for Trade-offs and Psychological Drivers

BY ALESSANDRA MOTZ

Abstract

The damage that households and businesses suffer because of a blackout may be influenced by psychological traits, and may as well reflect the perceived trade-offs between security and environmental sustainability of the electricity supply. Two analyses conducted in Switzerland provide an example on the role and impact of these drivers.

The prolonged and unexpected blackout that hit Texas at the beginning of 2021 brought the issue of security of electricity supply back in the spotlight. This topic has indeed become increasingly important in the context of the energy transition, that implies both a deep restructuring of the energy and electricity systems, with growing contributions from intermittent renewables, and the electrification of a larger share of final energy consumptions.

Security of supply and the energy transition: supply-side and demand-side approaches

Over the past decade the measures adopted in several European countries to safeguard the continuity of electricity supply along with the progress in the energy transition have witnessed an interesting shift from a predominantly supply-side approach to an approach increasingly accounting for demand-side factors. In the early 2010s, indeed, several European countries introduced capacity payment mechanisms in order to protect the profitability of the programmable generation plants that were often displaced in the merit order of the wholesale market by the new renewable generation capacity, but were still necessary for security reasons. Over time, however, the distortions induced by these measures on the electricity markets became visible, and several researchers and institutions suggested that wholesale electricity markets should have been cleared from artificial price caps and floors that hindered the formation of effective scarcity signals over the relevant time horizons. Wholesale electricity markets should instead have been designed taking into account the value that consumers actually place on security. This kind of reasoning gradually informed the European legislation for the energy markets: Regulation (EU) 2019/943, for example, states that the maximum and minimum clearing prices adopted for technical reasons on the wholesale electricity markets should be determined taking into account "the maximum electricity price that customers are willing to pay to avoid an outage", i.e. the so-called Value Of Lost Load (VOLL). According to the same Regulation, the VOLL should also be used for assessing the reliability standard desired in each country, and thus for evaluating the real need for capacity payment mechanisms; the VOLL should moreover be computed based on a transparent and coordinated methodology.

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What is then the value of security? And what are its determinants?

The growing importance of a demand-side approach leads us to the crucial question: what is then the value that consumers place on security? What are the drivers that may affect this value? And what are the preferences of consumers toward the alternative options to ensure security?

Most of the existing analyses concerning the value of security rely either on macroeconomic data, or on survey data. Macroeconomic data are used to compute the VOLL as a ratio between the contribution of each consumption segment to the gross domestic product on the one hand, and the electricity consumption of the same segment on the other hand. Survey data are instead used for detailed and customized assessments of the magnitude and kind of damage that a blackout with different characteristics may cause to specific consumption segments. The uniform VOLL methodology adopted in the European Union pursuant to Regulation (EU) 2019/943 is mostly based on survey data complemented with information on electricity consumption profiles, and allows the exploitation of a triangulation of methods to better evaluate the consequences of blackouts for different consumption segments. The main problems observed in the existing analyses lie in the extreme variability of the estimates across countries, consumption segments, and economic sectors, as well as in the low comparability of several studies based on survey data. When considering the possible drivers of the value of security, the evidence provided in the literature converges in suggesting that longer and more frequent blackouts harm more, whereas the availability of advance blackout notice helps reducing blackout damage. Next to these intuitive results, however, these is a series of conflicting findings as regards the role of the typical demographic determinants.

Two studies on the residential and business segments provide interesting hints on the role of psychological drivers

Two analyses we conducted by between 2015 and 2019 in Switzerland may help understanding what lies behind these scattered estimates and, most importantly, what may drive consumer preferences with respect to security. The two studies are particularly interesting as they investigate the perceptions and preferences of households and business consumers toward the security of electricity supply with a focus on behavioural, attitudinal, and cognitive drivers, that are often neglected in analyses based on macroeconomic data or exploiting less detailed information concerning individual behaviour. Both studies exploit original survey data and state-of-the-art econometric techniques from the field of discrete choice modelling, a tool that is already widely used in environmental, transport, and energy economics.

Swiss households and the risk of blackouts: three consumption segments with different attitudes toward security and environmental sustainability

The first study focussed on the residential segment and was developed based on an original survey distributed in January and February 2019 on a sample of 1006 households, representative of the Swiss population. Next to the questions concerning the typical demographic variables, the survey investigated the respondents' energy consumption habits, as well as the respondents' attitudes toward environmental issues and specific primary energy sources available for electricity generation in Switzerland. Finally, the survey also included a "discrete choice experiment", i.e. a series of questions where the respondents were was asked to choose one out of five alternative electricity supply options for their own household, differing in terms of origin of the electricity, price in CHF/kWh, and probability of incurring in a short (5 minutes) or long (4 hours) blackout over the upcoming year. Discrete choice experiments allow the researcher to measure the importance that the respondents place on each of the characteristics of the available alternatives, compute the perceived trade-offs across characteristics, and assess whether the observed preferences vary depending on specific characteristics of individual respondents. Within our setting, the comparison between the perceived impact of an additional blackout and the perceived impact of a higher electricity price allowed us to compute the marginal Willingness To Accept (WTA) for blackouts, i.e. the discount an average household would require in order to accept a higher blackout frequency. We found that the WTA for blackouts varies substantially both depending on the primary energy source used for generation, and depending on the attitudes and energy consumption behaviour of individual respondents.

More in detail, we identified within our sample three consumption segments, so-called "latent classes", showing different attitudes toward both the risk of blackouts, and the evolution of the Swiss electricity system. Table 1 below collects our estimates for the WTA of each consumption segment: the values are expressed in centCHF/kWh, and can be compared to an average final price of electricity for the residential segment around 21 centCHF/kWh over the previous months.

The first consumptions segment, identified as Class Alpha, comprises around 47% of the sample and expresses a relatively low and stable WTA for blackouts, and a mild dislike for blackouts associated to renewable-based generation. Our estimates suggest that the respondents belonging to this group are more likely to be men, with a low awareness about their own energy consumption pattern, slightly older, and worried about the economic impact of blackout on households. The second segment, Class Beta, comprising again around 47% of the sample, shows a very low aversion to short blackouts from renewable-based supplies, a stronger aversion to long blackouts from the same sources, and a very high aversion to short and long blackouts from nuclear-based supplies,

Table 1 – Estimated Willigness To Accept (WTA) values for short and long blackouts from selected primary energy sources

Class Alpha, WTA in cent CHF/kWh	
Short blackouts	
Hydro	3.49***
Mix	-1.52***
Nuclear	0.62
Sun	8.03***
Wind	5.45***
Long blackouts	
Hydro	5.92***
Mix	1.93***
Nuclear	2.15***
Sun	9.08***
Wind	6.55***

Class Beta, WTA in cent CHF/kWh	
Short blackouts	
Hydro	0.98*
Mix	6.01***
Nuclear	26.12***
Sun	0.84*
Wind	1.71***
Long blackouts	
Hydro	11.78***
Mix	10.42***
Nuclear	117.98***
Sun	12.16***
Wind	7.12***

Class Gamma, WTA in cent CHF/kWh	
Short blackouts	
Hydro	20.6**
Mix	8.24***
Nuclear	97.59***
Sun	-9.87***
Wind	7.21**
Long blackouts	
Hydro	46.13***
Mix	7.47***
Nuclear	254.3***
Sun	-7.06***
Wind	34.98***

* p-value ≤ 0.1, ** p-value ≤ 0.05, *** p-value ≤ 0.01. Confidence intervals computed via Delta method.

with WTA values reaching, in turn, 124% and 561% of current electricity prices. Our estimates suggest the respondents belonging to Class Beta are more likely to be men, of slightly younger age, with a low awareness of their own energy consumption patterns, worried about the risk of nuclear accidents in Switzerland, and strongly in favour of the nuclear phase-out envisaged in the Swiss long-term energy strategy. The third and last consumption segment, Class Gamma, shows a very mild aversion to short and long blackouts from sun- and wind-based supplies, and an extreme dislike for short and long blackouts stemming from a nuclear supply, with WTA values for blackouts in the nuclear option skyrocketing to 464% and 1210% of current electricity prices depending on blackout length. The comparison with the Alpha and Beta segments suggests that Class Gamma, collecting around 6% of the sample, is more likely to be made up of women with a high energy literacy.

While the assessment of the WTA values obtained in this study is specific to the Swiss case, our findings suggests that, generally speaking, household electricity consumers may well perceive strong trade-offs between the reliability and the environmental sustainability of the national electricity supplies. Depending on their stance toward specific primary energy sources or, more generally, toward change in the electricity system, they might indeed be ready to trade a slightly lower security level for a slightly greener supply, or for a larger reliance on technologies that are perceived as less dangerous, or finally for the safeguarding of traditional generation technologies such as, in the Swiss case, hydroelectric plants and nuclear generation. Attitudinal drivers such as risk aversion or environmental sensitivity may indeed play a large role in shaping class membership and hence the preferences with respect to blackouts: all in all, these psychological traits may contribute to a substantial share of the variability observed in in individual responses.

The business segment: heterogeneous responses due to different tastes and different decision-making strategies

The second study analysed instead the reactions of business consumers, and was conducted through an original survey distributed between December 2018 and January 2019 on a sample of 543 firms representative of the economy of Canton Ticino, one of the Italian-speaking regions of Switzerland. Next to some questions regarding the size of each firm, its activity, its electricity consumption profile, the availability of back-up devices, and the subscription of an insurance covering blackout damage, the survey investigated the magnitude and kind of damage that a blackout lasting one hour might cause to each firm. The survey also included a discrete choice experiment in which each respondent was asked to choose one out of two blackout scenarios, differing in terms of blackout duration (from 0 to 12 hours), availability of an advance blackout notice, and finally provision of a compensation for blackout damage from the local electricity supplier (from 0% to 25% of the monthly electricity bill paid by the consumer).

The data suggest that the median damage caused by a blackout lasting one hour is around 501-1'000 CHF, and decreases to 0-500 CHF if the blackout is announced with a 24 hour notice. This relatively small figure should be interpreted in light of the composition of the sample, largely made up of small firms with less than 50 employees, and considering that magnitude of blackout damage tends to increase with electricity consumptions. Indeed, the blackout damage hovers around 10%-20% of the yearly electricity bill for firms with bills below 100'000 CHF/year, and around 10% of the yearly electricity bills for firms with higher consumption levels. The heaviest consequences of blackouts display in terms of cost of labour (inactive workers), damages to information and communication technologies and data privacy and availability, lost turnover, and finally damaged machinery. More than half of the respondents own at least one back-up device, such as a UPS, a generator, or a back-up connection to the distribution grid. More than one third is moreover insured against the adverse impacts of blackouts.

The discrete choice experiment included in the survey provides instead interesting hints as regards the preferences of business consumers with respect to blackout duration, availability of advance notice, and provision of a monetary compensation for blackout inconvenience. Longer blackouts harm more, but the negative impact of any additional minute of blackout is decreasing with blackout length; moreover, business consumers having a back-up connection to the distribution grid are less impacted by blackout duration. Receiving advance blackout notice helps reducing the blackout damage substantially, but there is a large heterogeneity among consumers in this respect. Finally, only 65% of the survey participants evaluate positively the availability of a monetary compensation for the blackout inconvenience; the impact of receiving a compensation is however rather small and varies substantially across respondents.

Interestingly, the results collected through the discrete choice experiment show that almost 40% of the respondents always chose the blackout scenario with the shortest blackout duration, disregarding the availability of both advance blackout notice, and monetary compensation. This kind of behaviour, called "lexicographic preferences" among economists, may either witness an extreme importance of blackout duration for consumers, or reveal the use of "heuristics", i.e. a simplified decision-making procedure, when completing the survey. This finding suggest that any analysis concerning the behaviour of businesses should carefully consider the way in which these kind of consumer reach their final decisions as regards their own energy supplies and consumption patterns: individual behaviours display a sizeable heterogeneity and the assumption of a profit maximising behaviour is not necessarily the most appropriate in all contexts.

Electricity: a homogeneous good eliciting heterogeneous reactions strongly impacted by psychological traits

All in all, the two studies suggest that even if electricity is a homogeneous good often absorbing a relatively small share of the monthly budget, the perceptions of households and businesses as regards the impact of blackouts are also driven by the perceived trade-off between security and environmental sustainability of the own electricity supply. Individual preferences are moreover very heterogeneous, and often driven by behavioural, attitudinal, and cognitive drivers.

Electricity suppliers may use this kind of information for designing supply contracts meeting the needs and preferences of each consumption segment, with customized security levels, variable shares of renewable-based generation, and increasing or decreasing contractual complexity. Policy makers, on the other hand, should be aware that disregarding the behavioural, attitudinal, and cognitive drivers of consumer behaviour might lead to biased estimates of the value of security, and ultimately to investments that might be sub-optimal with respect to the trade-offs that citizens and firms perceive among security, sustainability, and affordability.

Behavioural and attitudinal drivers are often specific to the context and evolve over time. The analyses including this kind of drivers may be seen as too detailed to be included in the uniform methodology adopted in the European Union for the functioning of wholesale electricity markets and the evaluation of the national reliability standards. Nonetheless, they can provide useful hints to complement this methodology, detect the aspects of security that are more important for each consumption segment, and finally provide suggestions as regards the strategies that could best meet the expectations of the citizens and local economic activities.

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