



# The value of supply security: The costs of power outages to Austrian households, firms and the public sector<sup>☆</sup>

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## ABSTRACT

This paper presents a model for assessing economic losses caused by electricity cuts as well as Willingness-to-Pay to avoid these power outages as an approximation to the value of supply security. The economic effects for simulated power cuts from 1 to 48 h, which take the affected provinces, the day of the week and the time of day into consideration, can be calculated using the assessment tool APOSTEL. The costs due to power cuts are computed separately for all sectors of the economy and for households. The average value of lost load for Austrian households and non-household consumers in the case of a power cut of 1 h on a summer workday morning was calculated to be 17.1 € per kWh of electricity not supplied.

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## 1. Introduction

In the past decades, Europe has experienced an unprecedented degree of electricity supply security.<sup>1</sup> Nevertheless, the current status of reliability should not distract from the fact that the future development of electricity supply security is uncertain as production as well as distribution experiences significant restructuring. This transformation is taking place at three levels potentially affecting security of supply:

Firstly, challenges arise due to changes in the market framework or as a consequence of deregulation and unbundling imposed by EU directive 2003/54/EC (European Commission, 2003).<sup>2</sup> Secondly, the significant growth of electricity generation from renewable energy sources implies

increasing levels of supply volatility thereby putting pressure on transmission and distribution systems (Borggreffe and Nuessler, 2009; Boxberger, 2005, or BDEW, 2011). Thirdly, the current and anticipated growth of electricity consumption in developed countries such as Austria<sup>3</sup> requires capacity enhancements and innovative solutions. From a technical and public acceptance perspective these infrastructure measures become increasingly difficult to implement (Netzentwicklungsplan, 2012).

Together, these developments represent significant challenges to the power infrastructure and to the preservation of the current level of electricity supply security in the future.<sup>4</sup>

Selection and design of the appropriate measures for addressing these challenges require knowledge about their costs and their benefits. Hogan (2008) and Eto et al. (2001) discuss issues of the electricity market structure in the United States and find the necessity to assess the economic value of supply security enhancing

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<sup>1</sup> According to CEER (2012), which periodically publishes reliability indices, the average duration of unplanned power cuts per market participant in Europe ranges from 15 (Germany) to 465 min (Slovakia) p.a.

<sup>2</sup> For a discussion of regulation and supply security see Jamasb and Pollitt (2005) or Ter-Martirosyan (2003). Generally, market structures should aim at providing sufficient investment incentives for measures aimed at improving services reliability.

<sup>3</sup> From 1970 to 2008 Austrian electricity consumption increased by about 2.9% annually. Renewable energy sources accounted for 68.2% of electricity production in 2009 (Consentec et al., 2008; Statistik Austria, 2009a).

<sup>4</sup> In line with international studies (e.g. Jamasb and Pollitt (2005) or Ter-Martirosyan (2003)), Reichl et al. (2008) concluded for Austria that liberalization and unbundling do not automatically contribute to long-term electricity supply security, and that quality-oriented regulation is needed to create incentives which lead the grid operators to focus on long-term electricity supply security.

measures as complement to the evaluation of their technological benefits. This is an essential prerequisite for regulatory policy and for the justification of investment decisions. While efficient decision making regarding security investments is hampered by the lack of precise knowledge of the benefits of potential enhancing measures, large scale failures of the power system are supposed to have increasingly serious consequences for the society. In the presence of near-perfect levels of supply reliability and increasing electricity dependence, societies are getting more vulnerable to power outages as preparation for prolonged outages becomes more difficult and less of a concern. This is known as the double paradox, researched in detail by Luijck and Klaver (2000) and De Hoo et al. (1994) for the Netherlands.

Despite their increasing dependence on uninterrupted electricity supply, consumers send hardly any signals about their valuation of energy supply security to suppliers, who thus misinterpret the benefits of reliability improvements and postpone infrastructure investments (Böske et al., 2007). In the special case of grid-bound supply systems, such as electricity,<sup>5</sup> customers have for physical reasons no option of choosing an operator with a more adequate level of supply security. In addition to these specific economic aspects of electricity supply security, the short- and medium-term resilience of infrastructures in spite of security-preserving investments not being made creates incentives to further postpone investments. Precise knowledge of the importance of uninterrupted electricity supply to society is thus paramount. This research aims at providing an economic assessment of the value of electricity supply security which can be used – among others – for energy political decisions, benefit cost analyses, or the design of regulatory frameworks.<sup>6</sup>

Since electricity supply security constitutes a non-market good, which can only be purchased in combination with the physical product (electricity), its value cannot be elicited by market transactions (Kariuki and Allan, 1996a). That is why usually the effects of a failure of electricity supply are utilized for the value elicitation of service reliability (Baarsma and Hop, 2009; De Nooij et al., 2007, or Woo and Pupp, 1992, for instance). In this study the costs of power cuts to non-household consumers, which include businesses, public sector entities and non-government organizations (NGOs), along with the Willingness-to-Pay (WTP) of household consumers to avoid power outages are analyzed as a proxy of the value of security. With the economic assessment tool presented in this paper it is possible for the first time to collect data on the power outage costs for different consumer groups and to simulate the effects of power outages from one to 48 h in Austria.

This paper proceeds as follows: Section 2 describes the different outage cost categories and introduces the methodology utilized to assess the losses due to power cuts. Section 3 contains the results from the elicitation of non-household consumers' outage costs and households' WTP to avoid power interruptions. The assessment tool and its application for a power outage case study (simulated 12-hour power cut in Austria) are presented. Section 4 summarizes and adds a conclusion concerning the need for further research.

## 2. Methodology

In this section we discuss different outage cost categories, our approach of modeling non-household consumers' economic losses in the event of a power cut, and the methodology to assess households' WTP to avoid them. As a starting point, three different loss categories which are relevant in the case of power outages are identified.

The first loss category, direct outage costs, includes the immediate consequences of a power cut. This includes – for instance – the repair costs for defective electrical infrastructure facilities. They are usually limited and can be quantified with high precision (Munasinghe and Sanghvi, 1988).

The second category comprises indirect outage costs which arise subsequent to power cuts. They form part of the total losses, which are causally linked to the absence of electricity supply in the aftermath of a breakdown. The cost of production outages, expenditure on idle staff and other opportunity costs to non-household consumers such as lost value added represent indirect costs. They make up a significant proportion of the total costs (Centolella et al., 2006, or Wacker and Billinton, 1989).

The third category involves the macroeconomic consequences of a perceived long-term change in the level of electricity supply. This includes the influence of the level of electricity supply security on the choice of business locations, the potential rise of production costs due to the increased need for backup-systems, or customer churn due to unreliability regarding delivery deadlines. This outage cost category depends on the attributes of the power outages and is not included in the assessment of the value of electricity supply security in this study.

Based on these cost categories, Woo and Pupp (1992) suggest three approaches to assess electricity supply security in monetary terms: proxy, market-based and contingent valuation methods (CVM). As market based methods, which for instance quantify the costs of back-up-generation and insurance purchases, only monitor individual cost factors, a different approach was chosen in this paper aiming at assessing the entire macroeconomic dimension of electricity supply security. In accordance with De Nooij et al. (2007) we applied a proxy method which maps the lost value added for non-household consumers (Section 2.1), while CVM was used to elicit households' WTP to avoid power cuts (Section 2.2).

### 2.1. Non-household consumers

In line with Chen et al. (1995), we assume that non-household consumers experience exclusively monetary losses in the event of power cuts. The assessment of individual and aggregated outage-related costs is possible by a lost value-added regression model and data on economic activities. Losses have to be assessed depending on the time of the year the power cut occurs (summer vs. winter), the time of the day (working hours or non-working hours), the duration of the outage and other explanatory variables. Details of the regression and the estimation approach are in the Appendix A. An in-depth discussion of different assessment methods of non-household consumers' outage costs can be found in Kariuki and Allan (1996b).

De Nooij et al. (2007) apply top-down methods for the elicitation of outage costs. Their approach served as base model for this study. It requires that all (key) activities of non-household consumers are analyzed with regard to their dependence on electricity and the impact of possible restrictions of power cuts on the value-adding process. Thus, the overall dependence on electricity of the non-household consumers in question can be inferred from the aggregated monetary losses due to the impossibility of certain activities in the case of a power outage. These economic losses are subsequently diminished by that portion of added value which can be recovered later (at certain costs, which have to be added). To the lost added value calculated in this way the costs of idle staff capacity during the power outage have to be added in another calculation step. The same applies to the value of inputs lost due to the power outage under consideration.

To quantify the value added as one major input for the outage-related loss function, the staff costs and input expenses of sector-typical non-household consumers were deducted from annual turnover. This approach allows for the use of data which are available in great detail in public statistic databases (Statistik Austria, 2011). In order to derive the daily value added from the available annual data, we made use of the

<sup>5</sup> A detailed discussion on competition aspects, electricity markets and natural monopolies is found in Hogan (1993).

<sup>6</sup> Additionally, beginning in 2011 all member states of the European Union (EU) are required to assess the economic consequences of an interruption of the electricity supply system (EU Commission, 2008).

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