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The cost of electricity interruptions in Portugal: Valuing lost load by applying the production-function approach

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ABSTRACT

Despite the fact that the current level of energy supply security in Europe is quite satisfactory, new challenges present a potential risk of jeopardising the current state of affairs. Among others, key challenges are related to the strengthening of the market framework (in the context of deregulation and unbundling as imposed by EU directives) and the increasing penetration of renewable energy sources in the generation mix (with inherently greater variability). Under these circumstances, assessing the value of lost load (VoLL) is useful to support energy decision-making, including benefit-cost analysis and the design of suitable regulatory frameworks. This paper develops VoLL estimation using a macroeconomic technique, namely the production-function approach. The VoLL determines the foregone value added due to electricity outage. The production-function method is applied to the Portuguese case and an average VoLL of 5.12 €/kWh is found. The paper also presents the VoLL results obtained for various economic sectors as well as households. Moreover, the temporal variation of the VoLL along typical weekdays and weekend, in winter and in summer, and for the most relevant sectors (manufacturing, retail services, and households) is demonstrated and discussed.

1. Introduction

It is commonly accepted that electricity supply-quality regulation has three components:

(i) continuity of supply, related to network and service reliability and availability;
(ii) power quality, related to the characteristics of supply voltage; and
(iii) commercial quality, related to timeliness in dealing with customer requests.

One of the main goals of electricity supply regulation concept is to balance customers' willingness to pay network tariffs and their expectations for minimum levels of supply quality. Recently, this topic became more relevant in Portugal. Rate-of-return economic regulation, in which total utility costs were fully recovered by the tariff has evolved to a price-cap regime, in which the utilities' allowed revenues are capped in a level that does not necessarily reflect actual costs. This change was implemented with the objective of improving the utilities' economic efficiency. However, it also presents a risk that firms will postpone investments and, consequently, decrease the quality of service provided to customers (Ajodhia and Hakvoort, 2005; Ajodhia et al., 2006; Fumagalli et al., 2007a). As such, more effective regulation of supply quality is needed.

The continuity of supply features is measured in terms of incidents in the electrical grid that result in interruptions to customers. Accordingly to the regulatory code, continuity of supply deals only with interruptions that last for more than three minutes, the so-called long interruptions. Some commonly indexes are used to assess the continuity of supply both at the Transmission System Operator (TSO) and Distribution System Operator (DSO) levels. Two of these indexes are:

- System Average Interruption Frequency Index (SAIFI). This index measures the average frequency of power-supply interruptions in the system, expressed as the number of interruptions per customer, per year.

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- System Average Interruption Duration Index (SAIDI). This index measures the average cumulative duration of power-supply interruptions in the system, expressed in minutes per customer, per year.

Fig. 1 and Fig. 2 report the past ten years of SAIFI and SAIDI data for Portugal's high-voltage TSO grid and low-voltage (LV) DSO grids, respectively.

One can see in Fig. 1 that TSO performance is mostly satisfactory, although it is occasionally spoiled by some Force Majeure (FM) events or by security reasons. In fact, the Portuguese TSO experienced zero long interruptions in year 2012.

The performance of the DSO (Fig. 2) is also satisfactory, and shows remarkable progress since 2003. An absolute small number of incidents is not to be expected, due to the particular characteristics of the MV and LV grids, namely their radial structure, as well as extension and larger number of electrical devices. Moreover, interruptions in the distribution network are sometimes caused by faults in the transmission network. These data include all long power-supply interruptions felt by the customers, namely the FM events, which represent on average 25% of the electricity outages. In general, FM events are associated with bad weather conditions.

Supply-quality regulation can be exercised by means of a set of direct and indirect instruments. Examples of direct regulation tools used in Portugal are: (i) defined minimum standards for the supply continuity, alongside with monetary compensations to the customers in case of noncompliance; and (ii) financial incentive schemes to encourage system operators to improve the quality of power supply. Indirect tools applied in Portugal include: (i) national voltage quality monitoring programmes; (ii) the regular reporting and dissemination of electrical network performance data; and (iii) national and international benchmarking (Ajodhia and Hakvoort, 2005; Giannakis et al., 2005; Fumagalli et al., 2007b; CEER, 2012). Monetary compensations to the customers and financial incentive to the system operators are undoubtedly two of the most important tools used in electricity supply-quality regulation because they have a direct and measurable impact on the net revenues of the regulated companies.

Guaranteed standards for continuity of supply are included in the Portuguese electricity supply code. These standards take the form of maximum limits on the number and duration of interruptions experienced by each customer per year and may be viewed as a commitment of the company maintain a certain level of supply for their customers. Whenever individual limits are exceeded, customers are informed and monetary compensation is automatically paid. The total amount of compensation annually paid to customers is disallowed from cost recovery under network tariffs; in other words, the cost is borne by company shareholders. In this way, the network operator is motivated to ensure performance.

To complement to guaranteed standards and monetary compensations for nonfulfillment, incentive schemes comprised of revenue increases (rewards) and decreases (penalties) are also provided in the Portuguese electricity supply code. As a matter of fact, Portugal is considered one of the pioneers in Europe in implementing this type of incentive scheme (Fumagalli et al., 2007b; Growitsch et al., 2010). As an example, the Portuguese Energy Regulatory Authority (ERSE) put in practise, since 2003, an incentive to improve the continuity of supply in the Medium Voltage (MV) distribution network. The basis of the incentive scheme is shown in Fig. 3.

The scheme is grounded on historical values of the energy not distributed (END_{REF}) indicator, a dead band ($END_{REF} \pm \Delta V$) is used to avoid the incentive activation when small performance improvement or deterioration is experienced. On the other hand, in order to avoid overstating the impact of the incentive on the company economic results, the maximum amounts for reward ($RQS_{máx}$) and penalty (RQS_{min}) are defined. When the performance improvement or deterioration is placed between the dead-band boundaries and the reward and penalty limits, the amount of the incentive is calculated based on the value of the energy not distributed (VEND).

The incentive scheme to improve the continuity of supply in the MV distribution network has been an important tool to induce a noticeable enhancement of the continuity of supply in Portugal. Fig. 4 shows the duration of unplanned interruptions experienced by Portuguese and European MV customers for the period 2002–2013.

A considerable mismatch can be seen between the Portuguese continuity of supply indexes and those for Europe in the past years, but more recent results show a noticeable convergence. We believe that this positive trend is a consequence of the application of the incentive scheme. Considering that: (i) the incentive scheme proved its effectiveness over the past years; (ii) the Portuguese continuity of supply indexes are in line with the European ones (Faias and Esteves, 2013), and (iii) the Regulatory Authority does not intend to provide regulatory signals that would result in over-investments in the networks by the DSO (and ultimately tariff increases), the incentive scheme parameters have remained unchanged over the past years. However, as the current incentive scheme is based on an average continuity of supply index, it follows that there are some customers whose continuity of supply is much better or worse than the average. In an attempt to reduce this divergence, a second component of the incentive scheme is being currently introduced with the aim of specifically improving the

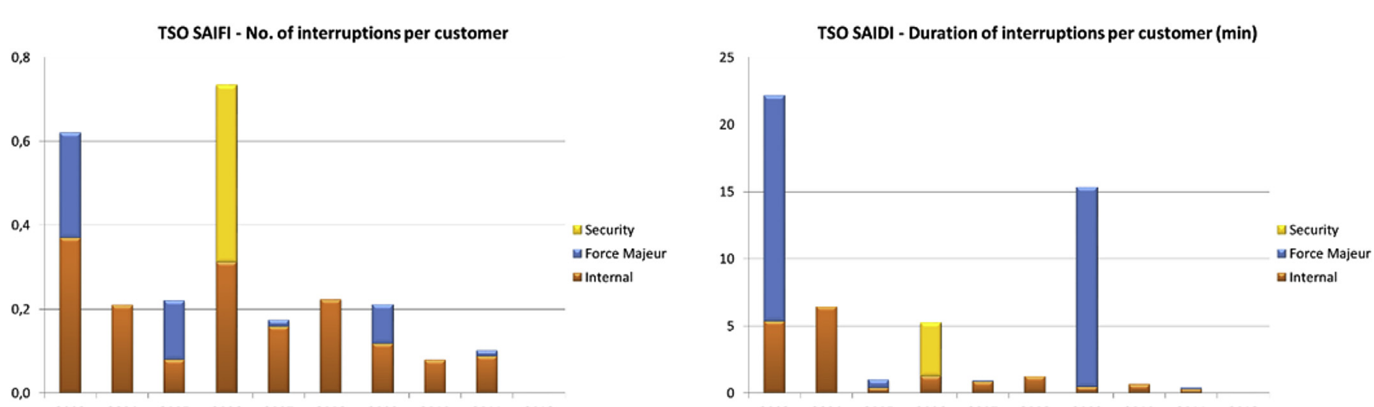

Fig. 1. Ten year evolution of the annual SAIFI (left) and SAIDI (right), TSO grid, Portugal. Source: ERSE – Portuguese Energy Regulatory Authority.

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