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The costs of electricity interruptions in Spain. Are we sending the right signals?☆

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HIGHLIGHTS

- We calculate the costs of electricity interruptions in Spain.
- We find that in 2008 the cost for the Spanish economy of one kWh of electricity not supplied was around €6.
- The results imply that Spain is underinvesting in short-term energy security.

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ABSTRACT

One of the objectives of energy security is the uninterrupted physical availability of energy. However, there is limited information about how much is the cost of energy supply interruptions. This information is essential to optimize investment and operating decisions to prevent energy shortages, or, alternatively, to determine the strength of the signals to be sent to the agents so that they may invest accordingly. In this paper, we estimate the economic impact of an electricity interruption in different sectors and regions of Spain. Although there are several caveats in our analysis, we find that in 2008 the cost for the Spanish economy of one kWh of electricity not supplied was above €4 even in a conservative scenario, which is higher than the signals currently being sent as incentives to avoid these interruptions. This might result in an underinvestment in short-term energy security, particularly when we add the usual risk aversion of most consumers.

1. Introduction

Security of supply is considered as an important objective of energy policy in many countries around the world. Together with efficiency and sustainability, the European Union includes security of energy supply as one of the three pillars of its energy policy (European Commission (EC), 2008).

In particular, the focus on the security of supply of electricity has increased since the liberalization of the electricity sector in many countries. Theoretically, a liberalized market increases competition and, thus, leads to a more efficient outcome. However, in absence of a proper regulation, electricity suppliers may not have the incentives to ensure a socially optimal security of supply (Rodilla and Batlle, 2010). Batlle et al. (2007) divided the security of electricity supply in three components:

- A short term level, which refers to the ability of existing generation capacity to meet actual load and support unexpected disturbances such as electrical short circuits.
- A medium term level, defined as the ability of the already installed capacity to supply electricity efficiently, and therefore, depends on generation and resource management decisions.
- A long term level, which refers to the existence of enough available capacity, both installed and/or expected, to meet demand.

Arguably, the medium term level is one of the most relevant and common. In the last years many countries have experienced electricity shortfalls due to this reason (some examples are California in 2000 and 2001, Norway in 2002, France and Germany in 2003, South Africa in 2008 and 2009, or most recently, Japan in 2011).

The consequences of these outages are particularly important for most societies, very dependent on the availability of electricity,

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and may generate large economic and social costs. However, and despite this importance, there is limited information about the consequences and the economic impact of the security of electricity supply. This information is critical to respond optimally to these problems: How much should we invest to prevent outages? How should we operate our power systems to minimize them? In case there is an outage, should we interrupt supply to all sectors or regions equally?

These questions are becoming more relevant with the increased penetration of renewable energy sources. Although renewable energy reduces the dependence on imported fossil fuels and increases the diversity of electricity sources, therefore increasing energy security in the long term, the variability and partial unpredictability of electricity production from renewables makes necessary to reconsider the operation and control of the electricity system (IEA, 2007; Perez-Arriaga and Batlle, 2012). Again, estimating the economic cost of outages is required to determine the amount of backup capacity to be installed, or the optimal fuel stocks.

Therefore, we consider more important than ever the adequate quantification of the economic consequences of electricity interruptions, since that will allow us to achieve an optimal level of security of electricity supply. This optimal level can be achieved either by setting directly the amount of reserves, the network investments, the operating procedures, or the quality of service (such as SAIDI or SAIFI) requirements; or, by sending the right signals or incentives to the agents in the liberalized power system. In both cases, we need to know beforehand the benefits derived from having fewer interruptions.

The aim of this paper is to quantify the economic impact of the loss of electricity supply, focusing particularly on its physical availability. Following Bohi and Toman (1996), we will estimate the loss of welfare resulting from a change in the physical availability of electricity.

Several studies have already addressed this particular issue.[2] Most of the studies are based on customer surveys (e.g. Targosz and Manson, 2007; LaCommare and Eto, 2006; EPRI, 2001). Although customer surveys can be a good methodology to estimate power interruption costs, they present some problems. The primary problem is the time and high cost associated to the collection and analysis of the data. Besides, the results may be biased given that the provision of security of supply is typically a public good, and therefore prone to suffer from a free-riding effect. Therefore, typically customers will have an incentive to give higher values to interruption costs.

In this study we use the production function approach, following previous works such as Nooij et al. (2007) and Leahy and Tol (2011). This method relates the electricity use and the value generated with it to estimate the costs of electricity interruptions. In contrast to other methods, the production function approach does not require analyzing each sector separately, and provides an objective assessment of total costs. Furthermore, it relies on available data, which facilitates the analysis.

Compared to previous literature, this paper offers a more detailed temporal, sectorial and geographical estimation of the costs of an interruption in electricity supply, and also refines the way in which assessments should be done for the different economic sectors. In particular, we estimate interruption costs excluding those sectors in which electricity is not essential, and therefore, a more precise value is provided. We study the Spanish electricity system since we consider it is a very good example of a system with a large penetration of renewables and therefore in pressing need for a good estimation of the costs of electricity interruptions.

[2] Table 6, in the appendix, summarizes several interruption cost studies.

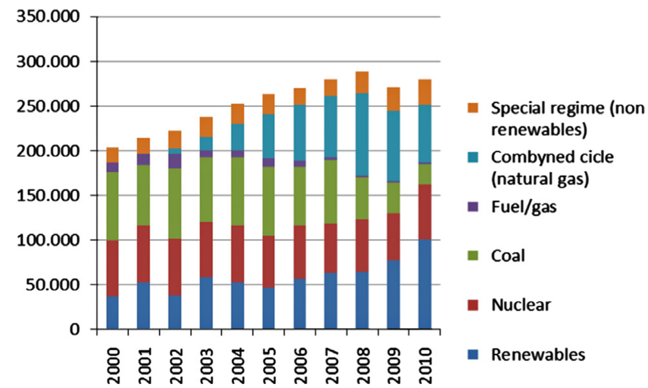

Fig. 1. Spanish electricity mix (GWh). Source: Red Electrica Española.

The Spanish electricity system has changed considerably in the last decade. While renewable energy sources and natural gas combined cycles have increased their weight in the electricity mix, coal and nuclear plants have reduced their share in the electricity production. Fig. 1 shows the electricity mix in Spain from 2000 to 2010.

Although the penetration of renewable energy technologies has contributed both to diversify electricity production sources and to reduce dependence on energy imports, there are still some challenges for the Spanish electricity system. First, in absence of technologies that allow energy storage and/or demand response services, renewables, at high levels of penetration, require backup capacity. Some technologies such as wind, hydro and solar, depend on natural cycles, and therefore increase the variability of energy production. Second, although the share of nuclear has decreased, its total production is still high. Nuclear plants are characterized by a low flexibility and therefore cannot be used to back up renewables. Third, the electricity interconnection capacity between Spain and France accounts for only 3% of the maximum current demand on the Iberian Peninsula. This value is below the 10% interconnection capacity which the European Union established as a minimum level in the Barcelona Summit in 2002. The last potential challenge for the security of electricity supply in Spain is the growing electricity consumption. The commitment of European countries to reduce CO_2 emissions can lead to an electrification of the economy, especially in the transport sector. This would imply a higher electricity demand which should be met with new capacity. A changing electricity system requires a careful analysis and management. The high penetration of renewable energy and natural gas in the Spanish electricity system has some advantages, but also entails some new risks regarding security of supply which need to be assessed and managed.

The results obtained in this paper can be compared and also used to refine those obtained with other methods. We show the costs of electricity interruptions in different sectors, regions and years. As mentioned before, this information could be valuable for policy-makers or managers of the electricity system. From the supply side, the estimation of electricity interruption cost is useful to optimize fuel stocks, capacity reserves and investment decisions. From the demand side, it can help to assess demand-side management measures, such as demand-response programs, which try to optimize the operation of the power system.

The paper is organized as follows. Section 2 presents the different methods employed in the literature, and the methodology proposed. In Section 3 we apply the production function approach to the Spanish economy and compare our results with previous results in the literature. In Section 4 we discuss our results from a regulatory point of view. Finally, in Section 5 we offer some conclusions.