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Electricity supply auctions: Understanding the consequences of the product definition

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ABSTRACT

We study the impact of product definition in electricity auctions. Recognizing the key role of the auction rules—pay as bid, uniform—the definition of the product itself emerges also as a critical step. Poorly designed products may impact both the market performance and the physical operation of the system. We investigate the impacts that the product definition can have on the market outcomes. A product definition implemented in some electricity markets is used to unveil critical aspects that must be considered when electricity products are defined. Our results provide guidelines for improving the product definition in electricity auctions.

1. Introduction

There is an ongoing worldwide trend towards the deployment of market structures in the electricity industry. The idea of implementing electricity markets started a few decades ago and it was sustained by several dimensions. The reasons to start this trend are multi-fold—technological, academical and historical—and can be summarized as follows. In the technological side, economically efficient generating units of small- and mid-size capacity became a reality [12]. Consequently, in the generation side emerged the possibility of having multiple suppliers of different sizes and the idea of implementing markets in electricity, at least in the generation side, started to take shape. The idea was taken in academia in which the framework of spot pricing for trading electricity emerged as a reality in the seminal work published by Schweppe et al. [23]. Last but not least, there was the historical context of the late seventies and early eighties in which the deployment of market structures at many levels of society became a popular trend [3,25,26]. These three dimensions paved the road to the deployment of market structures in electricity in Chile and UK in the early eighties [16] with the hope that the harnessing of the competitive forces would stimulate innovation, facilitating the achievement of a more efficient system which eventually would result in affordable prices. Although the restructuring process has brought some benefits, in particular in terms of increasing the efficiency and management of utilities [21], many authors have questioned and criticized the real accomplishment of the original market hopes and objectives [22,25,26]. Moreover, some authors still believe that the salient characteristics of electricity make vertical integration essential for an efficient planning and operation of electrical systems [15]. An historical overview about the development of electricity markets along with discussion of future challenges is provided in Chao et al. [5].

A key design element of electricity markets is treating electricity as a commodity. Accordingly, MW hs should not be treated differently to other commodities such as copper or oil. In addition, the MW h *commodity* can be provided without apparent distinction by any generating technology. As a result of this electricity-as-a-commodity viewpoint, several market structures from other commodity markets such as financial derivatives or forward contracts started to be adopted in electricity. Forward contracts are common instruments in commodity markets to hedge risk [14]. From the viewpoint of investments, a forward contract creates a long-term signal useful for investors whom do not want to rely on the volatility of the spot markets. In addition, a forward contract market could also improve market efficiency. Using standard economic theory, Allaz and Vila [1] show how the implementation of a forward market can make a duopoly market competitive.

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However, for the particular case of electricity, and once some of its complexities are considered, there is no clear agreement about the market benefits of forward contracts [2,17].

From a physical perspective, however, the use of forward contracts may facilitate the achievement of other objectives such as resource adequacy or appropriate technology mix. The auction processes held in Chile and Brazil are examples of the use of forward contracts for facilitating resource adequacy [16]. In addition, in the case of Brazil, the auction processes have facilitated the integration of new types of technologies. In terms of designing a market for electricity contracts, what and how to buy/sell are two natural questions that arise. Therefore, the essential issues are: (a) the product definition, the way in which the load is going to be categorized and what the basic unitary product is; and (b) the auction format, the way in which the sellers and the buyers are brought together and the method to clear the underlying product.

Several of the research efforts in electricity auctions have been focus primarily on the nature of the competitive bidding processes and on what auction formats and rules should be adopted, e.g., uniform or pay-as-bid formats [11], bypassing the discussion on the product definition. Those discussions are important especially given the experience in other instances such as US spectrum auctions, in which the results illustrate how the auction format and rules can impact the market outcomes [6].

In the literature we find little discussion about the characterization of the product in electricity markets. In the context of a public information game theory, Elmaghrabi and Oren [9] and Elmaghraby [10] make an analysis about the impact of the demand packaging in the outcome efficiency, showing how vertical-type packaging does not have efficient equilibria. Similarly, Barroso et al. [4] and Moreno et al. [16] present some notions about the importance of the product definition. This apparent lack of interest in the product definition might be also an aftermath of treating electricity as a standard commodity. However, this view fails to capture many of the complexities associated with electricity production such as ramping rates. For example, due to technical limitations, a coal power plant has a maximum load ramping that unable it to provide energy faster than an hydro power plant. In a similar way, nuclear units are usually used as base-load resource, due to their lack of ramping capabilities. Consequently, it is not only the energy that matters but also the instantaneous power and its trajectory. In addition, there are unique characteristics of electricity such as lack of massive storage capability, just-in-time manufacturing use and the several technical constraints of electricity generation that needs somehow to be considered in the specification about what is being traded in these markets. Recognizing in the definition of products the multiple capabilities and services that different technologies can provide seems critical for having a constructive relationship between the physical systems and the market structures.

There are real market designs that help to illustrate the impact of a poorly defined product. A clear example is the auction process performed in Illinois during 2006 [18]. The level of prices attained in the process was so high that the auction was canceled after one year of its realization and a new scheme for the procurement of power was defined [13,19]. The final auction prices for a subset of the auction products and the spot market prices in Illinois during 2007 are illustrated in Fig. 1. Note that the final auction prices of some products are above the market prices for about 90% of the time. In previous works the failure of the Illinois process has been attributed to the product definition based on the so-called *tranches* [18,7,8], definition that has been also used in auction process held in Maryland, Ohio, Pennsylvania and New Jersey. In addition to the Illinois experience, the aftermath of auctions using this type of products has been less than promising. For many years, electricity rates in New Jersey increased considerably after the implementation

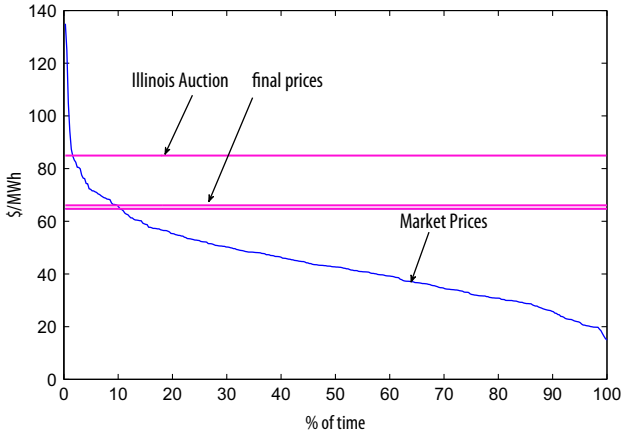

Fig. 1. Prices range of the illinois auction.

of auctions with these type of products. In Ohio the results of one auction realization were rejected by regulators. In Maryland, the implementation of the auction in 2007 resulted in a 72% increase of the electricity rates de Castro et al. [8].

In this paper, we discuss the impacts of product definition in electricity auctions. Although the implications of a poorly defined product are noticed in both the market behavior and the physical operation of the electricity system, our focus is mainly on the market performance. Through some cases and examples, we identify critical market aspects that should be considered in the product design. Our results reinforce the importance of defining properly the product in electricity markets and provides guidelines for future research. The structure of this paper is as follows. Section 2 is devoted to provide economic reasons along with illustrative examples to show the impact that the product definition can have in the market outcomes. Analytical results about competitive prices for tranche-based products are presented in Section 3. Final remarks on product definition challenges are discussed in Section 4. Concluding remarks and future research directions are presented in Section 5.

2. Analyzing a product definition

When a market for contracts is implemented, a natural question arises: How do the terms of the contract impact the market outcomes? Such question has been overlooked in the electricity markets literature, mainly because in standard commodity markets the product definition is somehow natural—for Example 1 barrel of oil or 1 lb of copper. However, electricity is radically different to any other commodity due to the technology involved, its link to a physical network that is highly complex, and its importance for the well-functioning of society. Based on previous electricity auction processes, we claim that the product definition is a key element of any market for electricity contracts.

In this section, using a particular type of contract, we provide key elements that should be taken into account in the design of electricity contracts. Such elements are mainly related to economic and market performance. Although not discussed in this work, the definition of the contracts also impacts the achievement of other objectives beyond market and economic ones. In particular, the terms of the contracts will also play an important role in achieving objectives such as system reliability and environmental fulfillment. A non-interfering linkage between the market and the physical operation of the system can be only achieved by having products that capture the physical constraints and needs for achieving those objectives. Attributes such as location of the generating resources, volatility that different resources injects into the system, environmental