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Organization and functioning of liberalized electricity markets: An overview of the Dutch market

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ABSTRACT

In this paper, we examine the organization and the functioning of the Dutch electricity market. First we describe the organization of the Dutch electricity supply chain and the role of the main market participants including the transmission system operator, distribution system operators, program responsible parties and metering companies. We then describe the organization of financial trading and clearing mechanism of electricity through the organized futures exchange (The European Energy Derivatives Exchange), and the spot market (Amsterdam Power Exchange) which includes the day-ahead market and intra-day markets. We also detail the functioning of the imbalance market and reserve capacity management in the Netherlands.

Through a set of numerical analysis, we provide an exploratory analysis of the APX day-ahead spot prices and the real-time imbalance prices using electricity price data from 2002 to 2013. We observe the price spikes both in the day-ahead and imbalance markets usually occur around 6–10 AM and 5–7 PM. We also observe that in the imbalance market system overages happen significantly more often than shortages pointing out that the market tends to buy more than what is demanded. This could be explained by the risk attitude of the market participants in the imbalance market.

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1. Introduction

Liberalization of the Dutch electricity market has started with the introduction of the 1998 Electricity Act. This act provided individual customers and suppliers with more freedom when procuring and selling electricity, while also establishing a market framework that is focused on reliability, sustainability and efficiency. The 1998 Electricity Act established a new state-owned entity, Tennet, to serve as the transmission system operator (TSO) of the high voltage grid (220 kV and 380 kV). Later, the Dutch government also unbundled the medium- and low-voltage transmission grids (<110 kV) and generators in 2008 [7]. This resulted in a new group of entities, called distribution system operators (DSOs), which own and manage the medium- and low-voltage transmission grids.

Following the introduction of the Electricity Act of 1998, the Dutch electricity market has developed into a complex business environment in which market parties can freely trade electricity. The Dutch TSO, Tennet, is the main hub for all transactions and also the owner of the Amsterdam Power Exchange (APX), which trades and clears electricity contracts in the Day-Ahead Market. Tennet and APX are also the parties that enable cross-border transactions, either through auctioning of transmission capacity or through the Day-Ahead Market. The cross-border integration of electricity markets is currently in progress in Europe [29,2,14].

Transmission constraints in the Netherlands also play a key role in electricity markets, especially when considering cross-border transactions. In general, transmission constraints between different regions or countries may have a significant impact on price dynamics (Haldrup and Nielsen [15]), and amplify the volatility of prices. Transmission constraints can cause different prices in different regions and some of these regions can suffer from volatile prices. As demand increases and capacity utilization increases as well, more expensive plants have to be activated. This can cause the price curve to be very steep [26,1].

In electricity markets, spot and futures contracts only function as a preliminary schedule since the demand and supply of electricity cannot be predicted perfectly; and hence another market is needed for ancillary services. The reserve capacity (imbalance) market is the marketplace where these services are traded. These services are provided by power plants and factories that are able to react to deviations in real-time from the preliminary schedule [36]. In particular, the capacity reserve market values the flexibility of electricity generation and consumption, while the spot markets only value the energy content of the transactions (Möller et al. [27]).

In this paper, we provide an overview of the functioning and organization of the Dutch electricity markets. First we elaborate on the liberalization of the markets followed by a discussion on electricity generation and distribution. The discussion focuses on the main market participants, such as the transmission system operator, distribution system operators, program responsible parties and retailers. Following that, we describe the organization of the financial trading and clearing mechanisms for electricity through the organized futures exchange, European Energy Derivatives Exchange (ENDEX), and the spot market, the Amsterdam Power Exchange, which includes the day-ahead and intra-day markets. Finally, we detail the functioning of the imbalance market and real-time reserve capacity management.

We also provide an exploratory analysis of the prices in these markets. We observe that price spikes both in the day-ahead and imbalance markets usually occur around 6–10 AM and 5–7 PM. Nevertheless, the imbalance prices are significantly more volatile than the day-ahead prices. In particular, although day-ahead market prices do not present any downward spikes below three standard deviations of the mean; the imbalance market does have such spikes. In addition, a close examination of the imbalance market reveals that the risk premium in the imbalance market for buying electricity (relative to day-ahead market) is 4.94 EUR/MWh while the premium for selling to the system is 4.79 EUR/MWh. Unlike usual commodity and stock markets, the imbalance market displays different risk-premiums for buying and selling electricity. This is because 18% of the time the Dutch system operator executes both an upward dispatch and a downward dispatch during the same program time unit (PTU) which leads to diverging buying and selling prices for that time period.

1.1. Liberalization of the Dutch electricity market

In the European Union, liberalization and restructuring of electricity sector dominates the energy policies since the middle of the 1990s. The overarching aim of these policies is to design an efficient, competitive and sustainable energy market across the European Union. Three electricity related directives (European Commission: 1996/92; 2003/54 and 2009/72) are introduced for the liberalization of the electricity markets in Europe [23]. The first energy directive consisted of common rules for the reorganization of the national markets, whereas the second directive introduces the conditions for cross-border trading of electricity. It also orders to separate core activities of the network companies, such as the generation, trade and sale of energy. The third directive established the Agency for the Cooperation of Energy Regulators to help managing the cross-border trading of electricity.

One of the fundamental concepts of these directives is so called unbundling, the separation of the market functions traditionally provided by a single utility into functionally independent parts. The policy makers decide on the degree of unbundling. Four different types of unbundling can be distinguished: functional unbundling, management unbundling, legal unbundling and ownership unbundling [17,3,10]. The Dutch practice follows the ownership unbundling option, which is the splitting of commercial activities from network operations (this option is also favored by Soares and Sarmento [28] for electricity networks). In this model, generation companies cannot acquire shares in network operators and similarly, network operators cannot hold shares of generation companies. In parallel to the unbundling process, new regulations also introduced competition to the wholesale market through supplier selection. Starting with the large industrial consumers in 1998, the demand side of the market is fully liberalized by 2004 [6].

The Dutch TSO, Tennet, is the main hub for all transactions and is the participant through which the government enforces and steers the market. The distribution of electricity is handled by nine state-owned distribution system operators (DSOs). The main purpose of this setup is to isolate the natural monopolies from the rest of the electricity supply chain (including production and retailing) where the firms can freely compete. DSOs are regulated by the government, and they are compensated based on their