Ch2. Energy and Digitalization

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What do we study in this chapter?

- We study the main **characteristics of electricity markets** and how that affect the design and the business models in those markets.
- Large scale electricity markets: We analyze the design of **European electricity markets**.
- Small scale electricity markets: We analyze the design of **distribution electricity markets**.
- We study the **NODES business model** that uses digitalization to foster flexibility in the distribution electricity market.

Overview

The objective of this section is to provide a general **overview** of the restructuring process of electricity markets that has taken place in the last years. Electricity markets have been liberalized in the last two decades.

Based on those papers, we could identify the **main challenges in the design of electricity markets**.

Overview. Borenstein, 2002

Question 1: Which are the **characteristics of electricity markets** that facilitate the exercise of market power?

- Demand is difficult to **forecast**.
- Demand is **insensitive** to price fluctuations.
- Supply faces **binding constraints** at peak times.
- **Storage** is prohibitively costly.
- Demand and supply have to **match** all the time.

Overview. Borenstein, 2002

Question 2: Which are the **market designs** proposed by Borenstein to mitigate market power in electricity markets?

- **Long-term contracts** between wholesale buyers and sellers.
- **Real-time retail pricing** of electricity, which indicates to the final consumer on an hourly basis when electricity is more or less costly to consume.

Overview. Borenstein, 2002

Question 4: How **real time pricing** could contribute to mitigate market power?

- Real time pricing would prevent **extreme price spikes**.
- It would also reduce the financial incentive of sellers to **exercise market power**, since one firm's reduction of output would have a smaller effect on price than it does when demand is completely price-inelastic.
- The effect of real-time pricing also has very important implications for the **negotiation of long-term contracts**. If sellers, at the time of negotiation, believe that real-time pricing is likely, then they will reduce their forecasts of the average spot prices they would be able to earn if they did not sell through a long-term contract. As a result, the sellers will be willing to accept a lower long-term contract price than they otherwise would.

Please, answer questions 1 and 2 in the webpage of the course (link).

Overview. Joskow, 2008

Question 1: Which are the **characteristics of electricity markets** that facilitate the exercise of market power?

- Generator market power arises as a consequence of **transmission constraints** that limit the geographic expanse of competition.
- **Generation ownership concentration** within constrained import areas.
- The **non-storability** of electricity.
- The very **low elasticity of demand** for electricity

Overview. Joskow, 2008

Question 2: Which are the basic features that guarantees a proper **market design** in electricity markets?

- Transparent organized **spot** markets for energy and **ancillary** services (day-ahead and real time balancing).
- **Locational pricing** of energy reflecting the marginal cost of congestion and losses at each location.
- Auctioning of **transmission rights** to hedge congestion, serve as a basis for incentives for good performance by system operators and transmission owners, and partially to support new transmission investment.
- An **active demand side** that can respond to spot market price signals.
- **Forward contracts** to mitigate market power.

Please, answer questions 3 and 4 in the webpage of the course (link).

European electricity markets

The purpose of this section is to present some of the key aspects in the **integration process** of electricity markets in Europe. It also introduces two

relevant elements in the design of electricity auctions: the **design of transmission tariffs** and the **delineation of bidding zones**.

European electricity markets. Introduction

The main **goals** that should lead any proposed changes to **system operations** and **planning**:

1. Security of supply (secure for everybody)
2. Market facilitation (affordable and competitive pricing)
3. Integration of RES (environmentally sustainable).

European electricity markets. Introduction

To facilitate the **governance** of the system operator in the integration of electricity markets in Europe, the European commission proposed the next parties which will assume different roles:

- The **European Commission** to formulate general energy policy and directives
- **European regulatory body** (current ACER) with the power to independently check the formulation and execution of methodologies, processes and procedures in line with the general policy
- **Regional Operation Centres** (ROC) to execute prescribed tasks according to the formulated methodologies, processes and procedures; responsible for execution
- European entity (current **ENTSO-E**) for development and implementation of methods and tools for LT planning and SO.

European electricity markets. Transmission tariffs

In the presence of transmission constraints the equilibrium prices differ across markets generating **congestion rents**.

In a **perfect competition scenario**, the congestion rents are enough to finance the investments in transmission capacity.

However, in the presence of **uncertainty** or **lumpy investments** it is necessary to introduce tariffs to finance the investments in transmission capacity.

European electricity markets. Transmission tariffs

In the majority of the European countries, the tariff structure is based on a **point of connection tariff** system (ENTSO-E, 2016; Nord Pool, 2010). The point of connection tariff consists of two parts, a **power charge** and an **energy charge**.

The **power charge** covers costs for expansion, operation and maintenance of the transmission grid. It is based on annual capacity subscription for injection and outtake of electricity at each connection point.

The **energy charge** is based on the transmission losses in the transmission grid caused by injection and outtake of electricity in different connection points. It is dependent on how the generation or load are distributed in the grid.

European electricity markets. Transmission tariffs

The power charge and the energy charge have a **geographical** (latitude, north/south) and a **time component** (day/night, winter/spring, peak/off-peak) that provide a long-term locational signal on where it is optimal to add generation and load capacity from a grid perspective.

European electricity markets. Bidding zones

A bidding zone is the largest geographical area within which market participants are able to **exchange energy without capacity allocation**.

Bidding zones in Europe are currently defined according to differing **criteria**.

- The majority are defined by national borders (eg, France or the Netherlands);
- however, some are larger than national borders (eg, Austria, Germany and Luxembourg or the Single Electricity Market for the island of Ireland)
- and some are smaller zones within individual countries (eg, Italy, Norway or Sweden).

European electricity markets. Bidding zones

How bidding zones can be delineated? Delineating bidding zones according to the location of network constraints may be undertaken in a number of ways.

- Nodal pricing: The equilibrium price across markets differs when the transmission line is congested.
- Zonal pricing: The equilibrium price across markets is the same even when the transmission line is congested.

European electricity markets. Bidding zones

Why does bidding zone configuration matter?

- An optimal delineation of bidding zones should promote robust price signals for **efficient short-term utilisation**
- and **long-term development** of the power system,
- whilst at the same time **limiting system costs**, including balancing costs and re-dispatch actions undertaken by TSOs.

Distribution electricity markets. NODES

In this section we study the role that companies like NODES has on the design of **distribution electricity markets**.

We start analyzing some **use cases** in that company, then, we study the **market design** implemented by NODES.

NODES. Use case: NorFlex

This transaction is the first of its kind, pioneered within the NorFlex pilot project, where **flexibility offered** from industrial, commercial buildings or households can be bought by both local grid companies and Statnett as a result of the coordination between the two marketplaces.

The first trade resulted in activation of flexibility from greenhouses.

An important part of the project is to demonstrate how **aggregation, trading and activation of flexibility can be done in an automated process**.

This important to Statnett, who are not set up to manage small bid volumes.

Statnett uses electronic processes (e-bestill) when the bids are activated, and NODES are forwarding these activation signals.

NODES. Market design

We start the lecture watching a video about the NODES market design: (link).

Which are the main characteristics of the market design proposed by NODES?

NODES. Market design

We study the market design implemented by NODES by analyzing the Use Case NorFlex and focusing in the role that NODES could have promoting flexibility in the EV sector in Norway.

Smart EV charging:

- New innovative technology enables Electric Vehicles (EV) charging to become smarter.
- Remote monitoring and activation of charging enable new business models to develop.
- This creates value to the customers that are willing to make upwards or downwards adjustments in their consumption.

NODES. Market design

Aggregating domestic flexibility from E-mobility.

Tibber is an energy company mainly focused on **residential customers.**

Tibber interacts with its customers via its **app**.

When a person downloads the app and becomes a customer, they can **pair electric appliances** to the Tibber app.

Smart Charging guarantees the customer a **discount** for their EV charging cost in exchange for letting Tibber control the device, always complying with the constraints previously defined in the app by the customer.

NODES. Market design

Tibber reflections.

Forecasting load on a portfolio level for baselines has been a very difficult challenge to solve, considering the size of each fleet and the randomness of customer behaviour.

When it comes to trading, **algorithmic automated trading** was developed for the project, which would need to be further developed as market liquidity increases.

In Norflex, meter data is reported to AssetHub. AssetHub is a platform developed by the DSO. Tibber believes that this **is not a scalable solution**, considering that there are hundreds of DSOs in Europe.

An ideal solution would be to have **one platform at a country level**.

NODES. Market design

Conclusions

1. This paper has described how smart charging of EVs in Norway can stimulate the use of **EV flexibilit**y to offer new services for solving congestion management in distributed grids via a new marketplace, NODES.
2. While some **market barriers** have already been solved, others still require attention. There is still a need for more **testing** of baseline methodologies for congestion management and testing of independent aggregation.
3. Smart and flexible solutions are required in order to facilitate a cost-effective development of the power system. **Electric transport** is one of the options that have the potential to start playing a key role in developing a smart network.

Please answer questions 5 and 6.