Auditing, Accounting and Business

Mario Blázquez de Paz

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Chapter 2

Energy and Digitalization

In this chapter we study the main characteristics of **electricity markets**. We study the main characteristics of those markets that make them special in different dimensions. We study the reasons because companies can exercise **market power** in those markets. We analyze the design of **electricity markets in Europe**, and also the design of those markets in smaller markets, i.e., the **distribution sector**. We focus our attention on the role of digitalization in electricity markets, paying special attention to the business model implemented by the **Norwegian company NODES** that uses digitalization to increase flexibility in distribution electricity markets.

2.1 Instructions

In this chapter we study the role of digitalization in the energy sector. In the first part, we study the main features of electricity markets. In the second part, we study the design of local electricity markets. In the third part, Guro Grøtterud who works in NODES will present the business model and the market design implemented in NODES to foster flexibility in the electricity market.

1. Read the material for this chapter. If you have time, read the first two papers in section 2 (Overview).

2. Read the paper in section 4 (Distribution electricity markets. NODES company business model). The paper can be downloaded from the website.

3. During the last part of the lecture on Monday 20th November, you will work in groups to analyze that paper and prepare a short presentation for the rest of the class. That will help you to prepare some questions for the talk of Guro Grøtterud.

4. On Wednesday 22nd November Guro Grøtterud will give a talk about the digital value chain and the business model implemented in NODES to trade flexibility in the distribution electricity market.

2.2 Introduction

We start the chapter with some questions that will help us to frame the main topics that we will cover in the chapter. Which is the **main characteristic of electricity markets**? Which is the main characteristic of electricity markets that facilitate the **exercise of market power**? Which could be the mayor impact of **digitalization** in electricity markets?
Question 1. Which is the **main characteristic of electricity markets**?

- Demand is difficult to **forecast**.

- **Storage** is prohibitively costly.

- Demand and supply have to **match** all the time.

Question 2. Which is the main characteristic of electricity markets that facilitate the **exercise of market power**?

- The **transmission line** can be congested.
- Low **demand elasticity**.
- Electricity cannot be **stored**.

Question 3. Which could be the mayor impact of **digitalization** in electricity markets?

- The introduction of sensors at **home**.
- The introduction of sensors in the **grid**.
- Real time electricity pricing **apps**.

Question 4. If an electricity distribution company offers you to place sensors in your house to control the main electronic devices on your behalf by offering you an economic compensation. Would you **accept that offer**?

- Yes, substantially.
- Yes, slightly.
- No

2.3 Overwiew

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. In this section we study four papers that analyse that process in detail. Those papers have been written for prominent researchers that has been involve in the liberalization process of electricity markets in Europe and United States.

Based on those papers, we could identify the main problems in the restructuring process, and how we could use those lessons to analyse the current challenges in electricity markets.

The authors analyse the restructuring process using different approaches, however there are many ideas that appear recursively in the papers. Try to identify those key aspects and try to think how those main aspects affect other utilities rather than electricity.

2.3.1 Borenstein, S., 2002, "The Trouble with Electricity Markets: Understanding California's Restructuring Disaster," Journal of Economic Perspectives, 16, 1, 191-211.

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.

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.

Question 3: Which is the role of **long-term contracting** in electricity markets? How **long-term contracting** could contribute to mitigate market power?

- When a firm has sold some output in advance, it has **less incentive to restrict its output** in the spot market in an attempt to push up prices in that market, since it does not receive the higher spot price on the output it has already sold through a forward contract.
- The incentive of a generating company to exercise market power will depend on its **net purchasing position** in the market at a given point in time.
  - If a firm were a large **net seller**, it would likely have an incentive to restrict output to raise price.
  - If it had sold much of its output under forward contracts,then it would have much less incentive to restrict its output to increase the spot price.

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.

2.3.2 Joskow, P., 2008, "Lessons Learned from Electricity Market Liberalization," The Energy Journal, Special Issue on the Future of Electricity, 9-42.

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

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.
- The integration of spot wholesale markets for energy with the efficient allocation of scarce transmission capacity.
- 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.

Question 3: Could you identify bad practises that induce a **lack of investment in transmission capacity**? Could an only market mechanism induce the correct investment decision in transmission capacity

- Fragmented transmission **ownership**.
- Separation of **system operations** from **transmission maintenance** and **investment**.
- Poorly designed incentive regulation mechanisms (Joskow, 2005).
- Relying primarily on **market-based "merchant transmission" investment**, that is where new transmission investments must be fully supported by congestion rents (the difference in locational prices times the capacity of a new link) is likely to lead to inefficient investment in transmission capacity (Joskow and Tirole, 2005).

2.3.3 Newbery, D., 2005, "Electricity Liberalization in Britain: The Quest for a Satisfactory Wholesale Market Design,", The Energy Journal, 26, 43-70.

Question 1: Can you enumerate some of the ideas proposed by Newbery to **increase competition in electricity markets**?

Newbery proposed a market design similar to the one proposed in the previous papers. His paper is relevant because he also analyses the role of **market structure** to guarantee that the electricity markets work properly.

2.3.4 Wilson, R., 2002, "Architecture of Power Markets," Econometrica, 70, 4, 1299-1340.

Integrated vs unbundled market

Question 1: Wilson define three main points to define the **role of the System Operator (SO)**, and to determine which **market design** is the best (integrated systems vs. unbundled systems). Could you identify them?

- **Allocate** multiple scarce resources and to account for other constraints that are not priced explicitly,

- Enabling market participants to **contest the prices** derived from this optimization by offering better terms, and
- Taking advantage of participants' superior **information** about local factors affecting scheduling and operations of their own plants.

Question 2: Can you identify the main **weaknesses of integrated systems**?

- In some cases prices are related vaguely to optimized shadow prices on scarce resources. The difference between the injection prices at two locations can be interpreted as the implied scarcity value of transmission between these locations, but it is only by solving a large set of equations that one might infer the implicit shadow prices on the transmission constraints enforced by the engineers. **In contrast**, unbundled systems are more explicit, and more important, every price can be contested by competing offers.
- Pricing is especially vulnerable to **incentive effects**. Forward contracts can be difficult to be modelled and those could cause incomplete markets.
- Pricing is distorted whenever **optimization is imperfect**. Lack of information on suppliers' costs could make prices uninformative.

Question 3: Model comparison. Under which circumstances **integrated systems perform better than unbundled systems**?

- When optimization to meet system constraints is more important than participants' flexibility, and
- Shadow prices on system constraints are more accurate measures of opportunity costs than clearing prices in markets.

Market Microstructure

Question 1: When the transmission line is congested, the dispatch in the market could follow two approaches. Could you explain the approach proposed in the **NordPool** and the approach proposed in **California**? Which are the main differences between both approaches? In the California market design, the suppliers play a game called the **dec game**; could you explain the logic behind that game and its economic implications?

- In the **NordPool** the SO raises the price charged in the importing zone for withdrawing power, and to reduce the price paid in the exporting zone for injecting power, until the net flow matches the available capacity; the difference between these two zonal energy prices is then the usage fee charged for flows from the exporting zone to the importing zone - and equal credit is given for counterflows. In effect, NordPool uses the inframarginal bids in the supply and demand functions submitted in each zone as offers to increment or decrement energy output.
- Zonal pricing in an unbundled system like California's enables strategies like the following — called the dec game. A supplier who anticipates intrazonal congestion affecting his injection node can sell a quantity $3Q$ in the day-ahead energy market at its clearing price P when he knows that in real time the SO will be forced to invoke the dec he offers for the quantity $2Q$ at the spot price p^*, which is typically lower than P when decs are invoked, or at his bid price p, which is even lower (even negative) when his dec is invoked out of merit order.

The net result is that the supplier collects a profit $[P - p^*]2Q$ or even $[P - p]2Q$ on the extra quantity $2Q$ that he knew initially he would not produce.

The adverse consequences could be long-term if anticipated profits from the dec game induce an entrant to build a new plant in the most congested area, the opposite of what is required for efficiency.

2.4 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.

2.4.1 Integration of electricity markets in Europe. The role of the system operator.

This section is based on the next document: European Commission, 2015, "Options for Future European Electricity System Operation." (Only the first 11th pages.)

The European power sector is undergoing important changes. Especially the increasing penetration of renewable energy sources (RES), as part of the transition to a de-carbonised power system, results in a need to continuously assess and decide upon (the adoption of) alternative technologies, policies and practices. We study the main points presented in European Commission (2015) to improve the design of electricity markets.

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).

The **system planning and operations** that should be taken into account in the new regulation scenario are the next ones:

1. Long-term network planning (years),
2. System operation before real-time (months, day-ahead, intra-day),
3. Real-time system operation ($<$ 15 minutes)

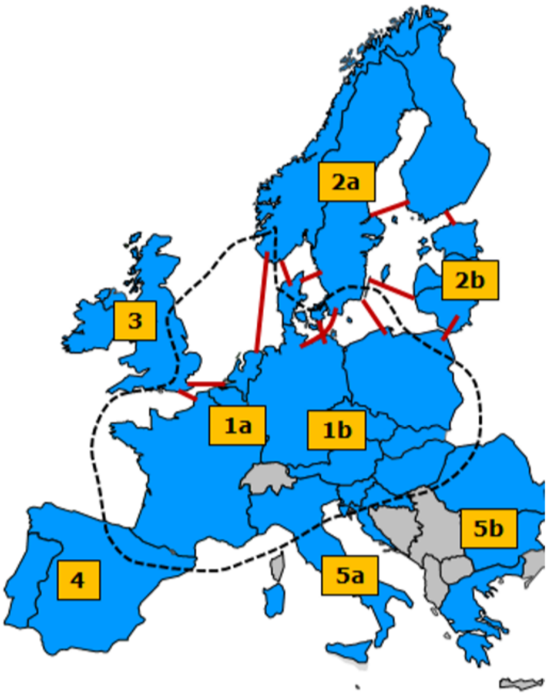
According with the European Commission, the long-term planning and system operator before real time operations should be centralized. The **benefits from centralization** are mainly related to:

- Network planning,
- and system operations functions such as capacity calculation, congestion management, adequacy assessment and balancing.

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

Figure 2.1: Geographical partition for TSO coordination



- **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. In consultation with ACER (who sets up guidelines by request of the EC) this body develops the framework (e.g. grid codes) for execution of the tasks by ROCs and ensures overall alignment between them, and with national TSOs.

The European entity for the development and implementation of methods and tools (current ENTSO-E) is responsible for development of the way of working of the foreseen ROCs in line with guidelines and/ or regulation. This is then monitored and enforced by the regulatory body (current ACER).

The European Commission propose the next geographical partition for TSO coordination (figure 2.1):

- CWE+CEE,
- Nordic + Baltics,
- UK + Ireland,
- Iberia and
- Italy + SEE.

2.4.2 Transmission tariffs

This section is based on the next documents:

ENTSO-E, 2016, "ENTSO-E ITC Overview of Transmission Tariffs in Europe: Synthesis 2014." (Only the first 21st pages).

Nord Pool, 2007, "TSO Congestion Rent. How to Calculate the Congestion Rents."

Nord Pool, 2010, "Point Tariff System."

In the presence of transmission constraints the equilibrium prices differ across markets generating **congestion rents**.[1] 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.

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 **users of the grid** are charged for injection or outtake of electricity at a connection point in the transmission grid. 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 cost the subscriber has to pay is the product of the annual capacity subscription and the power charge in the 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.

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.[2]

2.4.3 Bidding zones

This section is based on the next document: Ofgem, 2014, "Bidding Zones Literature Review."

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

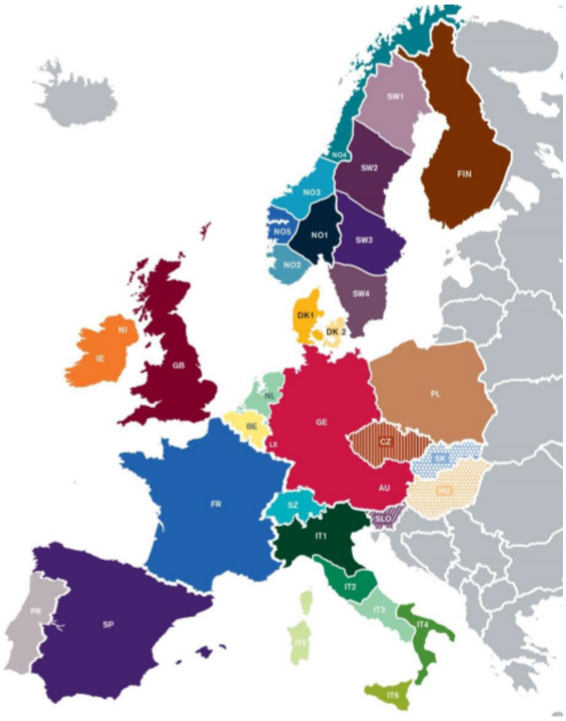
Bidding zones in Europe are currently defined according to differing **criteria** (figure 2.2).

- 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)

[1] The congestion rents are derived from the possibility to buy electricity in the cheap market and to sell it in the expensive market. Nord Pool (2007) explains the algorithm to work out the congestion rents. It also explains that in the Nord Pool, the TSO uses those rents to finance the investments in transmission lines (Finland and Sweden), or to reduce the price charged to consumers (Norway and Denmark).

[2] For a complete review of the tariff system in Europe and comparisons among countries see ENTSO-E (2016).

Figure 2.2: Bidding zones in Europe



- and some are smaller zones within individual countries (eg, Italy, Norway or Sweden).

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.

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.

The delineation of bidding zones has important impacts on **market efficiency, liquidity**, issues with **market power, investment signals** for new generation, **distributional** impacts and the cross border **flows**. We analyse one by one those impacts.

1. **Impact on efficient use of the network**. The configuration of bidding zones has important implications for system operation, providing short run signals to users of the network that impact on the utilisation of available capacity and ultimately the overall efficiency of the system. These short run signals also have a long-term impact, influencing the long-term investment decisions of market players.

- Delineating bidding zones according to network constraints would allow these constraints to be managed by capacity allocation rather than re-dispatch (ie, ex- post modifications of generation schedules undertaken by the SO), **lowering constraint management costs for the SO**.
- In export-constrained regions, the average wholesale price of electricity is likely to fall. Conversely, the average wholesale price of electricity is likely to rise in those areas at the other side of the constraint, where demand is higher. There is therefore a **distributional impact** to be considered through any reconfiguration of bidding zones.

2. **Impact on market liquidity and hedging**. The conventionally perceived impact on market liquidity arising from the configuration of bidding zones is that of **falling levels of liquidity as the number of zones increases**. This is a direct result of the smaller size of the markets, with fewer market players and as such a lower level of churn.

   Lower liquidity consequences:

   - Lower liquidity could mean a less clear indication of the **future value of power** from the market, which adds a layer of risk which could lead to inefficient investment, or efficient investment not taking place.
   - A fall in liquidity could also mean an increase in the **cost of risk**, due to lack of trading partners; this could well have a knock on effect on investment.

3. **Impact on investment**. The configuration of bidding zones is crucial to provide long-run signals that may affect investment decisions. The more the bidding zones configuration reflects the physical network constraints, the greater the efficiency of the price signals for cross-zonal network development and the price signals for generation and load investments.

   There are many **practical considerations** that should take into account to guarantee the correct investment decisions:

   - **Lumpiness and economies of scale** of transmission investments.
   - **Uncertainties** about future generation investments and demand growth.
   - Difficulty of decentralising charges for **reliability** and quality of service.
   - Transmission charges.

4. **Impact on market power**. The precise impact of the number of bidding zones on market power is unclear in the literature.

   - Fewer, larger bidding zones imply a large number of market players in any market and as such **greater competition** and liquidity.
   - Larger bidding zones **may create potential market power** in re-dispatch markets, if it is assumed that larger bidding zones implies greater need for managing congestion through re-dispatch.

5. **Impact on cross-border flows**.

   - If bidding zones are not delineated according to network constraints, there is an inherent **risk to the efficiency of power flows across borders**.
   - Prices in zones that are delineated according to network congestions are more reflective of local conditions whereas larger zones that suffer from internal network congestion do not tend to accurately reflect local conditions in their uniform wholesale prices, potentially resulting in sub-optimal interconnector flows.

- **Optimal interconnector usage** between countries would be more likely if both sides of the interconnector use zonal pricing, as long as the zones are configured according to network constraints.

2.5 Distribution electricity markets. NODES company business model

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.

2.5.1 Use Cases.

Below, we study to use cases implemented by NODES to understand the market design and the business model of the company.

Use Case 1: IntraFlex: Auto-rebalancing energy suppliers

11. November 2019 (link).

Building on the success of its current procurement of flexibility services, Western Power Distribution has launched IntraFlex, a new innovation project with NODES and Smart Grid Consultancy.

The Network Innovation Allowance funded project will look to deploy the NODES platform in the UK and create new, closer to real time, flexibility market for the Distribution Network Operator. This will allow for providers to offer flexibility in the day-ahead and intra-day time-frames with a number of features developed to ensure that any actions do not create imbalance in the wider electricity market.

Operating closer to real time should allow new participants to access the markets whilst key features such as a day ahead information services as well as an auto-rebalancing function to the intra-day market will look to lower supplier exposure to imbalance costs and decrease the costs of providing flexibility in the long run.

The project will utilise a market platform designed and operated by NODES. This has been piloted in other European trial and will be extended by NODES as part of the project to add imbalance mitigation features.

The trial will be supported by Smart Grid Consultancy who will provide project management skills, technical expertise and on the ground recruitment know how.

The trial start with stakeholder engagement aimed at validating the market design and ensuring its value to the UK electricity system "This trial will help us to better understand the impact that calling flexibility will have on energy suppliers when we establish a flexibility market that operates close to real-time. Utilising the NODES platform will allow for new flexibility providers to offer their services confidently in the market" says Ben Godfrey, Network Strategy Manager, WPD

Use Case 2: NorFlex project demonstrate integration to Statnett's mFRR market.

11. January 2022 (link).

On Thursday 6th January 2022 3MW of flexibility from the NODES marketplace was transacted in Statnett's mFRR market.

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.

«Statnett has in a previous pilot project (eFleks) tested flexibility, where the aggregators have participated directly in the TSOs balancing markets. What is new in the NorFlex project, is that we are testing how a local flexibility market can be offered to both local grid companies and Statnett's balancing markets, simultaneously. This has never been tested before and can contribute to increased liquidity in markets and the customers' ability to make money» Says Pasi Norrbacka, Project manager for NorFlex at Statnett.

He continues by saying that the pilot project gives valuable learnings around «independent aggregation» which is currently not part of today's regulation.

«The grid companies have traded local flexibility on NODES during 2021. In its last phase, the project will test the aggregation of flexibility integrated into Statnett's mFRR market. NODES is an independent marketplace where flexibility from 1KW upwards can be bought and sold between the local grid operator and aggregators. Flexibility not bought by the local grid companies is aggregated and offered into the Statnett mFRR market, in minimum block sizes of 1MW» says Daniel Stolbotn, NorFlex project manager at NODES.

A more sustainable and efficient power grid

The innovation project NorFlex consists of partners Agder Energi (project owner), Glitre Energi, NODES and Statnett. The project aims to develop and test technology and business models that is enabling a more efficient and sustainable power grid.

«To avoid bottlenecks in the grid, households and commercial companies can be paid to reduce their consumption, for example by switching off EV charging, boilers and other consumptions in a short period. The local grid companies Agder Energi Nett and Glitre Energi has tested this with flexibility from greenhouses, schools and nurseries by using different types of technology» says Inger Ose, NorFlex project manager at Agder Energi.

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.

«In the future there is a growing need for flexibility to balance the grid when the larger part of the production is sourced from renewable sources. It is therefore important to find good solutions for flexible power consumption and working market mechanisms. The NorFlex project will give us valuable knowledge on how distributed flexibility can be made available to local grid companies and the system operator. The project will contribute to reduce investment needs in the grid and a better managing of operational challenges for the grid companies » explains Norrbacka.

About NorFlex:

- NorFlex is an innovation project run by Agder Energi (project owner), Glitre Energi, NODES and Statnett. The project runs from 2019 to end of March 2022.

- The project is one of eight large scale demonstration projects funded by Norwegian Enova
- The project aims to develop and test technology and business models that is enabling a more efficient and sustainable power grid.
- The aggregators Ishavskraft, Noova, Entelios, Tibber, Istadkraft, Futurehome, Glitre Energi Strøm, Volue, True Energi and LOS participates in the NorFlex project with different types of flexibility and technology.
- In the project period households and companies can get renumerated to reduce their power consumption when the grid load is high. Byers of this flexibility can be local grid companies or Statnett.
- NODES is an independent market operator offering local marketplaces for trading flexibility.
- The project has been granted an exception to the regulation in order to offer aggregated flexibility to Statnett's mFRR market with bid size down to 1 MW in the test period.

2.5.2 Market design

Video that explains the market design (video).

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. We study the next paper:

Abusdal, G. M., Hagen H., Kazemi S., and Pedersen J., 2022, "NorFlex: Accommodating E-mobility in the distribution grid utilising a flexibility market to manage grid congestion." *CIRED workshop on E-mobility and power distribution systems Porto*, Paper 1316.

I present a summary of the paper, and some questions to discuss the main points in the paper.

Introduction

E-mobility in Norway.

Norway is the frontrunner in terms of EV adoption, boasting a sixty five percent market share of new-sales in 2022.

Private Charging Point Operators (CPOs) were invited to bid for both construction and operation of the charging infrastructure. Today Norway has a network of fast chargers on the major corridors. The public fast (50kW) and ultrafast (>150kW) charging points are accessible 24 /7 and open to all types of EVs. In addition to CPOs developing fast chargers, other companies are developing AC charging at home and building complexes.

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.

E-mobility impact on grid congestions.

The uptake of EVs is growing rapidly, resulting in an associated charging infrastructure being rolled out. As the number of EVs increases, so does the electricity grid load and the potential need for grid reinforcement.

Charging EVs might represent a problem for the grid. Either when uncoordinated charging is started based on consumer behaviours from multiple chargers or started because of a coordinated charging process optimised on energy price alone. Smart charging represents both a challenge and an opportunity for the Distribution System Operator (DSO) in this respect.

Market-based approach

Sellers place sales bids of flexibility on NODES based on portfolios with one or more assets. Portfolios can be offered in the order book located at the lowest level of the grid and will be visible through linked order books on NODES. Each bid needs to have an associated baseline which will be locked in the event of a matched trade. The seller then provides meter data to the project's Asset Hub at a minimum of 2 hours before and 2 hours after the activated period.

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.

To be able to offer the price reduction, Tibber actively uses arbitraging of the energy prices, either spot price or intraday asset back trading; or by using the assets in flexibility markets, which can be provided to the TSO or DSO.

Results

Modelling the congestion areas/order books.

Building up the value chain and business models has been done by defining an area of the distribution grid where flexibility from various sources, levels, and providers has been incentivised through an open tender process. Flexible Services Provideres (FSPs) were invited to define and develop a business model using the market design of the flexibility market platform where the DSO and the TSO were the participants for utilising local aggregated flexibility. The pilot area is defined by the regional distribution grid transformers modelled in a DSO tool (GridTools) for assessing, optimising, and trading flexible resources through an API to the NODES market platform.

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. Developing a custom solution for each market would limit the expansion of aggregators and impair the use of those assets. An ideal solution would be to have one platform at a country level.

Conclusions

1. This paper has described how smart charging of EVs in Norway can stimulate the use of EV flexibility 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.
4. During the NorFlex project, real trading has been successfully demonstrated with both the sellers and buyers posting bids in the market. NODES market has matched, validated, and settled these trades. From Jan 1 2021 to Jan 31 2022, a total of 318 MWh has been traded for activation (ShortFlex) as a result of 12 618 trades at a volume weighted average price of NOK 8 381,00 per MWh. The lowest traded volume was 0,001MWh, and the largest traded volume was 5 MWh (NODES Market Data, 2022).

Questions

Question 1: According with the paper, which is the **business model** that NODES aims to exploit in the E-mobility sector?

- Creates value to the customers that are willing to make upwards or downwards adjustments in their consumption.
- Foster the development of renewable energy.
- Reduce the consumption of energy

Question 2: Which is the **main problem** that NODES aims to solve in the E-mobility sector?

- Solve the congestion problems in the grid that connect different countries.
- Solve the congestion problems in the grid at local level.
- Solve supply fluctuation of electricity du to the introduction of renewable energy.

2.6 Case Study: Digitalization and flexibility in local electricity networks

We analyze the role of digitalization to increase flexibility in local electricity networks. We study the business model developed by NODES to foster that flexibility.

In this case study, we try to answer the following questions:

- Which is (or could be) the business model for this case?
- Which is the digital value chain for this case?

- Which are the main challenges to implement those solutions from a technical and social perspective?
- Which are (or could be) the target groups for this business models?
- How we can use digitalization to foster flexibility in the local network?
- Could you design a Business Canvas Model for this case?

A link that we will use in the case study:

NODES

2.7 Bibliography

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