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Conflicts of Interests between Different Market Players in Smart Grid Environment

School of Electrical Engineering

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Työssä on tutkittu millaisia eturistiriitoja syntyy mahdollisesti eri toimijoiden välille älyverkkojen yleistyessä. Sähkön tuotannon kasvava joustamattomuus ja kysynnän jousto aiheuttaa eri toimijoiden rooleihin muutoksia. Näiden muutosten myötä voi syntyä tilanteita joissa toimijoilla on eri intressejä.
Luvussa 6 on kartoitettu eri pelaajien väliset eturistiriidat. Lähteenä on käytetty eri toimijoiden näkemyksiä haastatteluin ja kirjallisuutta. Luvussa 7 on tarkasteltu jakeluverkkoyhtiön ja sähkönmyyjän välistä mahdollista eturistiriitaa kuormien ohjauksen suhteen.
Potentiaalisia eturistiriitoja on tunnistettavissa, mutta ne eivät ole ylitsepääsemättömiä. Yleisesti ottaen haastatteluissa oli näkemys että jakeluverkkoyhtiön roolissa on eniten näkemyseroja, mikä vaatii selvennystä.

Avainsanat: Älyverkot, eturistiriidat, sähkömarkkinat, kysynnänjousto, hajautettu energiantuotanto

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ABSTRACT OF THE
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Preface

This thesis was provided to me by Fortum through SGEM- research programme. I'd like to thank them for identifying this intriguing task.

Graditudes to Oleg Gulich and Matti Lehtonen for their brilliance.

It truly has been a pleasure.

Keilaniemi, 14.12.2012

Olli Aaltomaa

Contents

Symbols and abbreviations

Symbols

σ	Deviation
σ^2	Variance
$\bar{x}$	Mean value

Abbreviations

AMM	Automatic Meter Management
AMR	Automatic Meter Reading
BRP	Balance Responsible party
CAPEX	Capital expenditures
CVPP	Commercial Virtual Power Plant
DER	Distributed Energy Resources
DG	Distributed Generation
DR	Demand Response
DSO	Distribution System Operator
EMV	Energiamarkkinavirasto
ESCO	Energy Service Company
HEMS	Home Energy Management System
ICT	Information and communication technologies
OPEX	Operational expenditures
PX	Power Exchange
RAB	Regulated Asset Base
RES	Renewable Energy Sources
TSO	Transmission System Operator
TVPP	Technical Virtual Power Plant
VPP	Virtual Power Plant

1 Introduction

The energy business is in a state of change. The energy market is one of the last industries that transforms from analogue to digital. Environmental, political, and technological pressure defy the underlying traditions for a radical change: the energy infrastructure has to be transformed into an active network, with intelligent components and advanced communication gateways. This change will give rise to the development of new business concepts and the coming into existence of new services.

There is no such thing as neutral development, where the competitions and roles are cemented on the way we see them now. Changing of the business environment forces the stakeholders to fit into the new system. Changes are on the horizon and it is beneficial to identify possible disturbances and act pro-actively.

The main objective of this thesis is to identify the potential conflicts of interests that actors experience causing by the change in environment. The focus was on Nordic countries.

Thesis is based on literature study and on interviews. The interviews were conducted in the autumn of 2012, and the interviewees represented the views of different stakeholders in energy domain. The perspectives of interviews include: a generator, a retailer, DSO, TSO, a regulator, an aggregator, a representative of large net-buyers of electricity and representatives of finnish energy industries. 22 different persons were interviewed and the list of interviewees can be found in Appendix **??**. Since the literature does not have sufficient amount of information about potential conflicts, interviews create the core of this thesis.

Chapter 2 focuses on the concept of the Smart Grid, its benefits and the development phase where the business is going right now. In Chapter 3 the focus is on basics of electricity markets and the differences compared to other commodity markets are examined. Chapter 4 maps the future of the energy markets and the general trends behind the development.

In Chapter 5, the challenges and possibilities are discussed. The views come from merging the literature study to the views acquired from interviews.

Chapter 6 focuses on potential conflicts of interests among players. In every sub-chapter the conflict is introduced in short, with further discussion and finally possible solutions are proposed to erase the conflict.

Case study shows the effects of an aggregator behaviour to the grid, which is depicted in Chapter 7. The relationship between an aggregator and the DSO is examined in more detail, whether load controlling can cause conflicting interests between two players.

Main findings of the thesis is recapped in Chapter 8.

2 Smart Grids

The concept of Smart Grid has been the focus point of research in energy world for almost a decade. The idea is to introduce information and communications technology to the electrical grid, and use the information gathered to enable more intelligent grid design and use.

As the Smart Grid enables vast amount of new possible features, it has several definitions ranging from technical perspective to more benefits-oriented approach. EURELECTRIC, the Union of Electricity Industry has defined Smart Grids as follows:

- EURELECTRIC: "A Smart Grid is an electricity network that can intelligently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to efficiently ensure sustainable, economic and secure electricity supply." [7]

A Smart Grid is an enabler on transition to digital world with advanced technologies to monitor and manage the transportation of energy in future, where there are new requirements on how the system works. In higher level it helps the energy system to upgrade its transition to more sustainable world, striving to integrate renewable energy, improve the energy efficiency and cutting the greenhouse emissions. In figure 1 the transition to more sustainable energy production is illustrated.

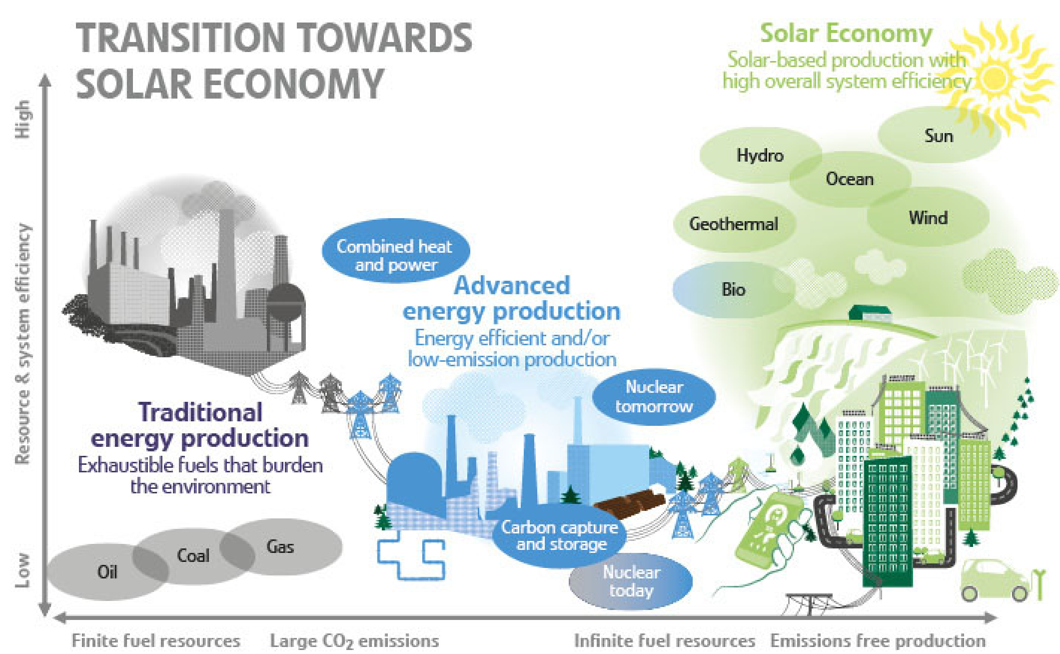

Figure 1: Transition from traditional energy structure to solar economy. [67]

2.1 Drivers

With the changes on how society is using the energy and how it is produced, the existing infrastructure undergoes several radical reforms as well. The energy system is turning into a complex power matrix as the share of renewable, intermittent energy sources increases in the energy mix. The challenge is to secure economic, reliable and sustainable energy system. Even though energy efficiency is one of the focus points that are pursued, it seems that there will be increase in energy demand. The intermittence of renewable energy is not the only challenge connected to it, but also the trend that most of the renewable energy generation will be distributed, which is a main contrast on how we see the energy infrastructure today.

Changes create a pressure to develop and make the infrastructure more agile, proactive, real-time, more intelligent. This is needed to ensure the security of supply, quality of supply and most of all safety in certain level of standard. [51]

2.2 Advantages

Adding more ICT and intelligence to the system is not cheap. Simply put, more expensive hardware that has to be added, completely new ICT architectures has to be created and more data is produced. Nevertheless, if the transition is done carefully, a Smart Grid has the potential to deliver vast amounts of savings. The measurement of the system improves, thus monitoring and finding more efficient solutions is easier. Processes can be re-designed more optimally, and utilization rate of different components can be improved. With more detailed data from customers wants and needs help to create better products and services which in turn help EU to achieve its targets of energy efficiency, integrate more renewable energy and cut down the emissions. Another relevant point on why is it necessary to start concentrating on Smart Grid is that the existing infrastructure is getting old. There is a need to vast investments so most optimal and cost-efficient solution is not so straight-forward than before. Technology develops and the old solutions get new competitors from innovative solutions that have lately emerged. [49] In figure 2 a variety of benefits from Smart Grids to different players are introduced.

A list gives a picture of the various benefits Smart Grids carry with them and with certain assumptions the points are applicable. Nevertheless it is very optimistic and best-case-scenario on what the Smart Grid is. Still, even with optimistic bias of the figure, it carries one fundamental lesson: bringing ICT to this sector makes all these listed improvements possible for the first time.

2.3 Transition to a Smarter Grid

Smart Grids are filled with promises to solve the problems energy domain experiences: better efficiency can be achieved, network will become more secure and demand becomes more flexible. It has been the hot topic in energy sector and academic research for a decade now. Even with a large interest towards it from the energy domain, a lot of work has to be done before it will be developed to the stage

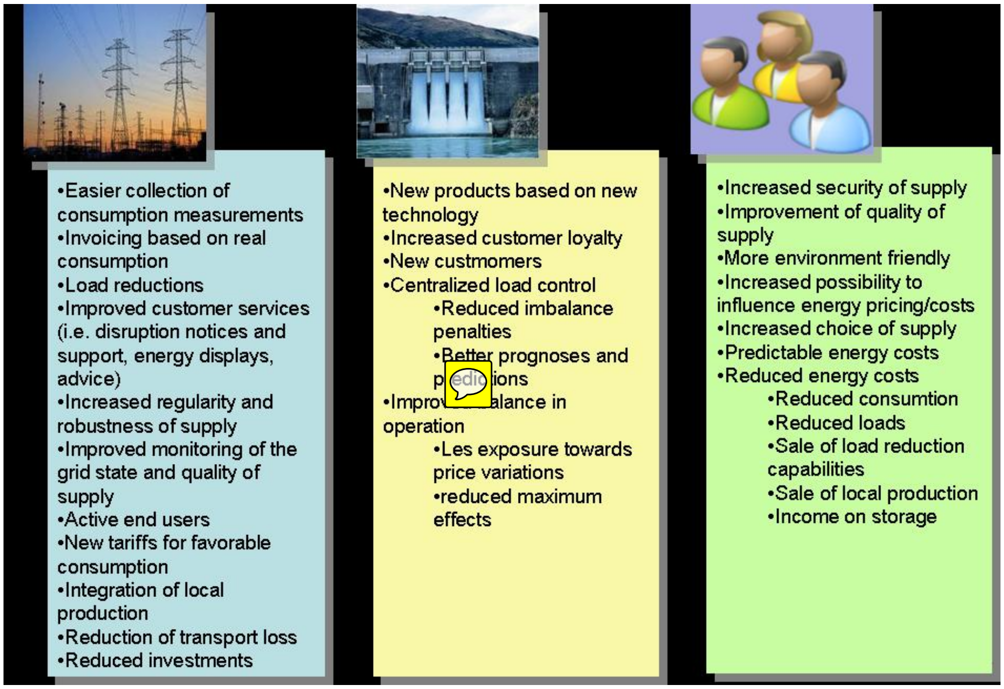

Figure 2: A list of benefits for Smart Grids. [10]

where it can be implemented to the infrastructure in a large scale. With new technologies and business cases barriers and challenges still remain to be solved, testing and pilot projects has to be performed. More information about the challenges that Smart Grid experiences can be read from [49].

As the concept of a Smart Grid is holistic by its nature, the approach for the R& D needs to take notice on several players in order to achieve optimal solutions. Projects need to adapt a new kind of thinking of R& D, where it is seen more as a network, focusing on collaboration in the whole system level. A Smart Grid has pushed project management to take into consideration more aspects since product and technology complexity increases. The demand to cooperate is essential because of the high technological investments and the need for specialization to even smaller fractions, and finally bringing all this together to create something new and functional. [52]

Not only the complexity is increased because of the collaboration with different electricity market actors, but also because of the synergy to ICT sector. Data is gathered and distributed, which means that solutions from ICT is needed to enable the transition. System becomes more complex than ever before.

The initial R& D stage has been carried out and at the moment the development phase has been focusing on pilots showing feasibilities of different alternatives and variations of products and services connected to Smart Grid domain. Ones that show potential will be taken to the next stage, to a larger scale demonstrations of concepts. In Figure 3 the projection of the Smart Grid development is shown.

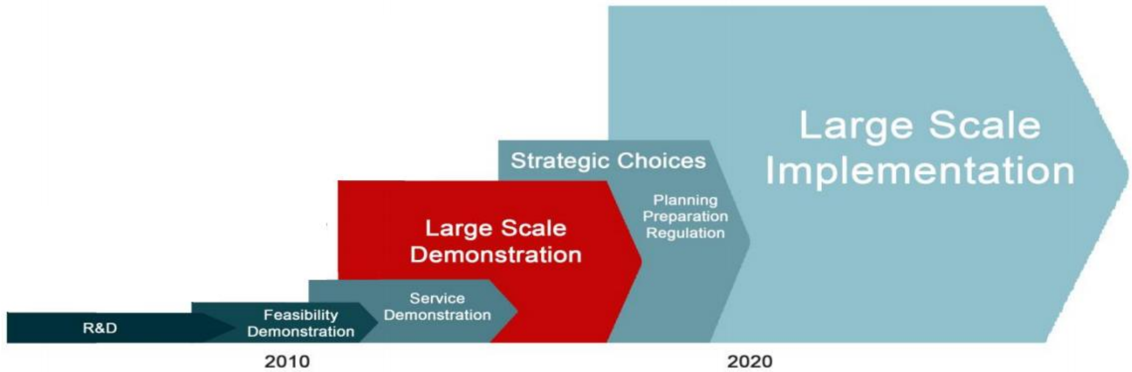

Figure 3: Projected development for Smart Grids. [50]

2.4 New concepts introduced by Smart Grids

Smart Grids enable concepts to the energy field which have not existed before. A short description of new concepts are discussed in this section.

2.4.1 Distributed Generation

One major change in the energy system is the transition from centralised production to more geographically scattered units. Historically the power grid has consisted of large centralised power plants, taking benefit from economies of scale and building them close to resources. The resources have not necessarily been close to consumption, resulting in long transmission distances of electricity. Also the amount of electricity generation has been constant and the location is known. The grid planning in this model has been relatively simple: the power flow is known both in size and the direction.

Distributed generation consists of smaller electricity production units which are less site-specific. The size of the DG does not have exact range, but if it is defined to take into account small-scale production and micro-production, it can range from 2 MWs downwards. Generally DG production units are considered as renewable energy sources: solar, wind, hydro and bio power. [48]

If DG starts to gain popularity widely, it creates challenges from traditional energy business perspective. As it is intermittent by nature and dependent on local weather events, both amount and location of production is not known accurately. Controllability of the system requires more automated solutions to keep under control.

2.4.2 Energy Storages

The value of flexibility in energy market increases in the future, mainly because of the emergence of renewable energy. Renewable energy has often incentives to produce energy whenever possible, thus making the production structure more inflexible, causing the demand flexibility to become more valuable.

Therefore storing energy has been a great interest in different R& D projects lately. Traditionally there hasn't been energy storages in the energy system. It has not been profitable to acquire energy storage, since the price of electricity hasn't had enough volatility to have incentive for demand flexibility. Initial investments for building energy storages are significant, there are losses when storing the energy and the coefficient of efficiency when transforming the energy from one form to another reduces the benefits.

The situation is changing in the future. First, the battery technology has developed very fast because of projects in hybrid and electric vehicles, which has pressed the prices of storages down. Second, changes in energy generation incurs costs to the strengthening of the electric network and less controllability implies to the increasing volatility of the electricity prices. The energy storages can help to balance the situation, both network-wise as well as market-wise. [**?**]

Energy storages have a role also in securing better functioning in transmission and distribution system level. Storages help the balancing of demand and intermittent generation, which has the benefit for both TSO and DSO. TSO can reduce the peak generation capacity investments. If energy storages are connected in distribution networks, it has an effect in grid topology as well as planning of the grid. In some cases, DSO might be able to defer the investments for strengthening the grid. [**?**]

The emergence of electric vehicles add another variable in the future's outlook. When the cost of the vehicles exceed certain point the change can be quite rapid, and with large scale roll-out have a large impact on the energy setting, which has to be solved in short time-frame.

2.4.3 Virtual Power Plant

Virtual Power Plant is a concept where the energy production portfolio is created from the small-scale energy production units, resulting the generator actor from consumer-side. Usually the small-scale production's output is too small to be able to participate in wholesale electricity markets, so it is needed to collect a crucial mass before it is possible. Markets see the VPP as an normal production unit, but in reality power plants location is not undetermined, created virtually.

Koeppel proposed the following definition of a VPP :

> "VPP stands for a concept of combining different types of renewable and non-renewable generators and storage devices to be able to appear on the market as one power plant with a defined hourly output." [46]

Two different types of VPP are identified: commercial and technical. The difference comes from the target market:

- Commercial Virtual Power Plant (CVPP) operates in wholesale markets. Revenues come from produced energy and the geographical location of production does not have any meaning whatsoever.

- Technical Virtual Power Plant (TVPP) offers ancillary services to system operators in order to maintain the stability of the grid. The production units should be in the same geographical area. [10]

VPPs ease the controllability challenges of the future if the DR, DG and ES can be combined under one umbrella and control with reason, i.e. production and consumption rates get the signal from either system-side or market-side.

Also by gaining the market access and the benefits regarding it, it works as an incentive for end-users to acquire more micro-generation. The public acceptance of the new products is important, since VPP require certain critical mass before it can fully benefit from markets. This requires the controllability hand-over from end-users own hands to some centralised actor, since at present DG is often controlled by the owners themselves.

2.4.4 Smart Meters

The EU has mandated that 80% of households in the EU must have a smart meter by 2020. [65] This is an ambitious target and it has been questioned whether wanted effects can be achieved most efficiently through regulation.

Nevertheless, Automated Metering Management (AMM) provides crucial parts of the Smart Grid philosophy. An old adage says "You can't manage what you don't measure." This is exceptionally true when it comes to influencing the energy consumption. Without the knowledge about electricity consumption, a customer does not see the effects of its actions regarding energy efficiency. In Finland the roll-out of the smart meters have been on their way already, and the meter measures the hourly energy consumption and is able to take into account the end-users own energy production. Collecting this information means that customer can start using Demand Response, energy efficiency actions, energy storages and it lowers the bar for micro-generation.

Technically AMM enables the possibilities. None of these expectations will be realized without the active participation of the customer. The task of getting a customer to genuinely change its energy usage is easier said than done. It will require a comprehensive communication efforts in order to get a customer involved in this process. Communicating these ideas to the end-user and point out that it is worthwhile to participate will be the hardest task.

Innovative products are the key to increasing end-user participation. The starting point of attracting people's attention is that they are very passive about seeking information. It has to be done as easy as possible for them to acquire information on how to change the behaviour.

Good example is from Helsingin Energia, which has a web-service called Sävel+, where one can follow the energy consumption in different time-scales, resolution ranging from a year to an hour. In Figure 4 an example from the User Interface is shown.

The application does not provide the data in real-time, but in a few days delay. The application also gives reference values to other houses with similar conditions, and provides the comparison of end-user's own consumption. It is first of its kind in

Figure 4: Author's energy consumption 21.10.2012 in Sävel+ application.

Finland, so there is room for improvements from ICT-perspective. Nevertheless, it is a first step to the right direction and sets the starting point about the possibilities in service sector.

2.4.5 Demand Response

The price of electricity varies constantly in the wholesale markets, depending on the amount of supply and demand at each moment but the retail customers usually see flat priced electricity. The price signal does not come through from the markets, so the customers do not have any incentive to change their electricity usage to more reasonable, optimal way.

Before, this disconnection from market signals didn't matter as much as now and the flexibility for electricity systems came almost solely from the power production side. Now with more rigidity in power production that renewables introduce and the technology development in load control systems has brought up the Demand Response as a potential solution in balancing the demand and the supply. [16]

2.4.6 Distributed Energy Resources

Term Distributed Energy Resources (DER)is a term that is used usually when there is a need to emphasize the overall effects of the production and consumption in lieu of only production. Generally DER consists all of the above: distributed generation, energy storages, virtual power plant, demand response.

From the overall benefits of these new concepts, Shandurkova et al. [10] listed as in Table 1.

Stakeholder	Benefit
Owner of DER (prosumer)	Capturing the value of flexibility Increased value of assets through the markets Reduced financial risk through aggregation Improved ability to negotiate commercial conditions
Network operators TSO and DSO	Increased observation over DER for operation through aggregation Advantage gained from flexibility of DER for network management Improved optimization of the grid investments Improved coordination between DSO and TSO
Supplier and aggregator	Creation of new offers for prosumers Mitigating commercial risk
Policy makers	Cost effective large scale integration of renewable energies while maintaining system security Opening the energy markets for small scale participants Increasing the global efficiency of the electrical power system by capturing flexibility of DER Facilitation of renewable targets and reduction of CO_2 emissions Improvement of consumer's choice
Society	DER will contribute to a more economically attractive electricity cost, thus contributing to a more competitive market Improved power services, or reduced economic cost of current services Disruptions and cost of added transmission and distribution infrastructure are delayed

Table 1: Benefits from DER to different stakeholders [10]

List is an extensive look on the potential benefits. It has to be noted that there is not one way to implement the DER. DER is a complex concept with vast amount of variables that are dependent from economical, regulated, political, technical development factors. The positive benefits do have boundaries and requirements before the full potential can be achieved. More detailed briefing can be found in [10] and [?].

3 Electricity Markets

Electricity markets and its best conceivable structure has recently been under discussion. In the past the electricity was considered clearly to be a monopolistic business, since the production has economies of scale and is very capital-intensive. The delivery of electricity to the end-user is completely dependent on vast, expensive transmission and distribution grid. These factors made the business to be controlled by few large actors.

As the world has developed and the collaboration among countries has increased, the electricity markets are pushed from national markets to larger entities. The political environment has also been intriguing driver for establishing transparent electricity markets. On one side, interest in re-arranging the public services has boosted to form transparent market environment which would do innovative, market-based solutions and find the balance through these mechanisms. Second, the integration of all common internal markets have been a target for European Union. The development of European electricity markets is influenced greatly by the new energy policy of European Union. [21]

With liberalization of electricity markets, the product, electricity becomes a commodity in the same way than for instance oil, grain or coffee. As in all the other commodity markets, the outcome is the wholesale market and a retail market with three usual players: producers, retailers and end-users. With electricity, a more sophisticated trading pattern takes hold and new players emerge as well: the traders and the brokers. [26]

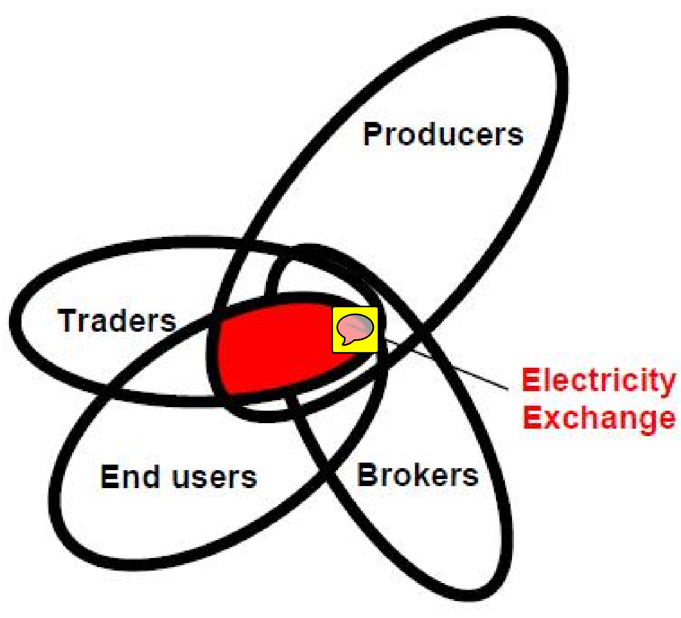

Figure 5: Players forming the electricity exchange. [26]

A trader is the entity which owns the electricity while the trading process is running. How the electricity ends up to the end-user can have several routes, for instance trader can buy the electricity from the producer and sell it to the retailer, or buy from retailer and sell it to another.

Brokers act as an intermediary player, negotiating purchases in return of a fee or commission. A broker does not own the asset itself. A retailer can ask the broker to find a producer who will sell given amount of electricity at given time.

3.1 Peculiarities of Electricity Markets

The electricity has very interesting characteristics in its very nature. The most interesting oddity which distinguishes it from other commodity markets is that it cannot be stored in large scale, at least not very cost-efficiently.

To some extent electricity can be stored for later use by using pumped-storage hydroelectricity systems and furthermore the flow of water can be adjusted to some extent to have more production at times of high consumption, but even with these two exceptions, electricity is hardly comparable to other commodities like minerals or oil for which the storage capacity is many orders of magnitude greater when compared to the average volume of consumption. [28]

New kind of energy storages have been much of interest in energy business recently but so far, the energy storages are in very early stage of R & D with lot of uncertainty on when it will become feasible in large scale, or ever.

Since electricity cannot be stored, the demand and supply has to be in balance every moment at given time. Consequently, demand and supply vary continuously. Even small changes in load or generation can cause significant changes in prices. This creates several underlying principles and explains many aspects we see in the electricity field.

The next four sub-chapters will examine these principles.

3.1.1 Seasonality

Due to the real-time balancing and the cyclical demand the electricity prices are very cyclical as well. This seasonal component is very dominant in electricity markets and different patterns of it can be found in the timespan of a day, a week and a year. [29]

Day-level and week-level differences arise from the pattern of how society works.

Yearly-level seasonality arise due to changing climate conditions, where the temperature changes and amount of daylight set the pace to the demand. Depending on what is the production structure markets, also supply-side experiences climatic changes. For instance the Nordic market is very seasonally fluctuating in supply side since the production has a vast amount of hydropower, which is heavily dependent on amount of rain and snow melting.

3.1.2 Volatility

The volatility of market prices in energy markets are very high, it is completely in different scale (100 – 500%) compared to currencies (10 – 20%), interest rates (10 –

20%) or compared even to the volatility of stock rates of return (20 – 50% volatility). This means that markets carry high risk to operate. [4]

This can be traced back to the lack of storages and transmission capacity. Without inventory short-term's precise balancing is hard to achieve.

With more renewable energy, volatility is expected to rise even further because of the difficulties in controlling the production level.

3.1.3 Mean reversion

In comparison to most financial markets, another fundamental difference in electricity markets is that it is mean-reverting. The term mean reversion is a concept to describe a stochastic process which has a tendency to remain near, or tend to return over time to a long run average value. [?]

The explanation for the mean reverting nature of the electricity spot prices get into the marginal costs of production and demand fluctuation. When the electricity demand increases, the generation facilities with higher marginal costs of energy production emerge on the supply side, which pushes prices up. As the demand decreases to normal levels the profitability of these this more expensive production modules disappears and they will be turned off, resulting the prices to drop. This kind of operating structure supports the thesis that there exists mean reversion in electricity spot prices. Empirical studies show also that hourly electricity prices are mean-revert around an specific hour mean level.[30]

3.1.4 Peak Prices

In addition to previous oddities, the electricity markets experience infrequent, unpredictable peak prices. Price peaks can be a result from many different factors. Weather can create a high demand, the system can experience outages in supply side or scarce capacity can result in very high prices in certain areas. [31]

If the price is not restricted, negative prices can occur as well. RES' generation is made beneficial with subsidies, like the feed-in-tariff which guarantees certain compensation level to its owner. This means that it is always beneficial to produce electricity. Due to the operative costs of nuclear power plants, it is not preferable to ramp down the generation for the short time periods. With this stiffness of energy production, a situation might occur that the generation exceeds the demand and causes the price of electricity to go to the negative side. In countries with significant amount of RES, this has been experienced.

3.2 Nordic Electricity Markets

The Nordic electricity markets consists of Finland, Sweden, Norway, Denmark, Estonia and Lithuania. These previously national markets opened up for competition in generation and retailing, and integrated into a single Nordic electricity market between years 1991 and 2000 making them one of the first free electricity markets in Europe. Estonia and Lithuania joined to the Nord Pool Spot in 2010. [26]

The energy is traded in financial market NASDAQ OMX Commodities Europe and in physical energy exchange Nord Pool Spot AS. NASDAQ OMX Commodities Europe offers the market place for derivatives contracts with different time scales, from days up to six years. Financial instruments are used to manage risk and guaranteeing electricity's price in the future. Nord Pool Spot AS provides the platform for physical power trade. It operates on day-ahead markets, Elspot, as well as intraday market, Elbas. In Figure 6 the countries and the bidding area division of the Nord Pool Spot Power Exchange are introduced.

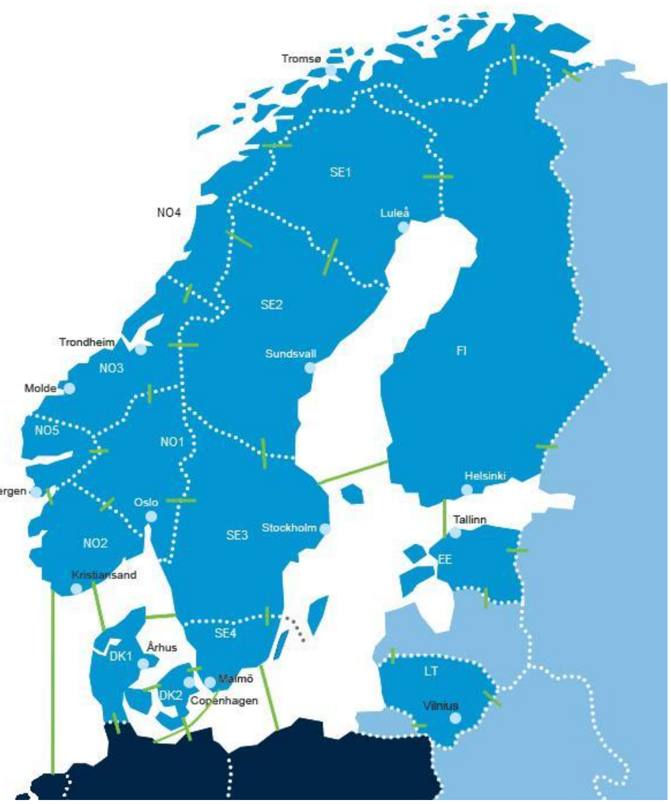

Figure 6: Nordic electricity markets and the bidding areas. [?]

As mentioned, the Nordic electricity markets are one of the first free electricity markets. Liberalization of the electricity markets means that vertically integrated electric companies unbundle the transmission part, which is seen clearly as monopolistic business, and production as well as retailing to separate entities. Transmission and distribution are strictly regulated entities in order to avoid misuse of monopoly position. Generation and Retailing activities enter the open markets, which brings them under competition. Competition makes the processes more effective and the customer gets the benefits of enhanced situation. Unbundling is illustrated in Figure 7.

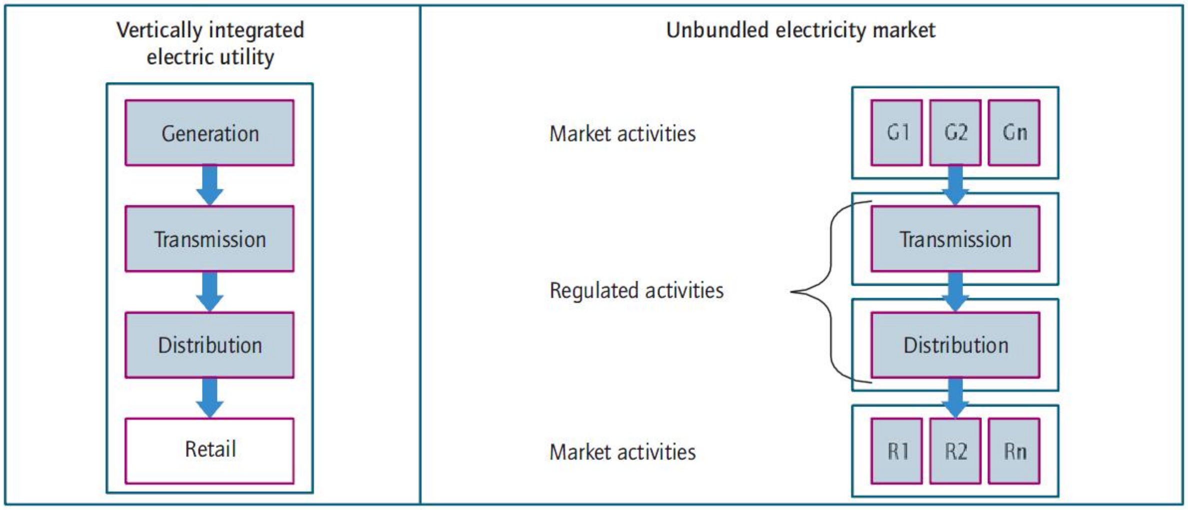

Figure 7: From integrated electric utility to unbundled electricity market. [16]

3.2.1 Elspot market

Elspot is a day-ahead closed auction where hourly power contracts are traded for physical power delivery for every hour during the next day. The members place their orders, hour by hour, to Nord Pool Spot's web-based trading system, SESAM. The orders can be sent up to 12 days ahead and the gate closure for the orders for the next day is at 12:00 CET. [26]

Elspot is an "energy-only" market, meaning that the exchange concerns only energy (MWh) without taking into account capacity (MW).

When all the participants have submitted the orders, the prices for every hour can be determined. By combining different offers and bids, the supply and demand curve is formed, and the intersection point between market and supply curves is the system price of the current hour. Figure 8 illustrates the forming of a system price.

When calculating the system price, possible transmission capacity constraints are neglected. In reality there is often restrictions in capacity between the areas, and the Elspot market is divided to several price areas which are formed by taking the actual transmission capacity into account. [26]

3.2.2 Elbas market

Elbas is a continuous intra-day market including the Nordic region, Germany and Estonia. Elbas functions as a balancing market for Elspot: it has an important role for risk reduction as well as provides the potential for making profit. The balancing trades can be done until one hour prior to the delivery. Elbas markets offers the alternative solution to minimise participants' imbalances after the gate closure of a day-ahead markets. Together with Elspot they create an efficient Power Exchange structure.

Trading takes place every day and the markets stay open until one hour before

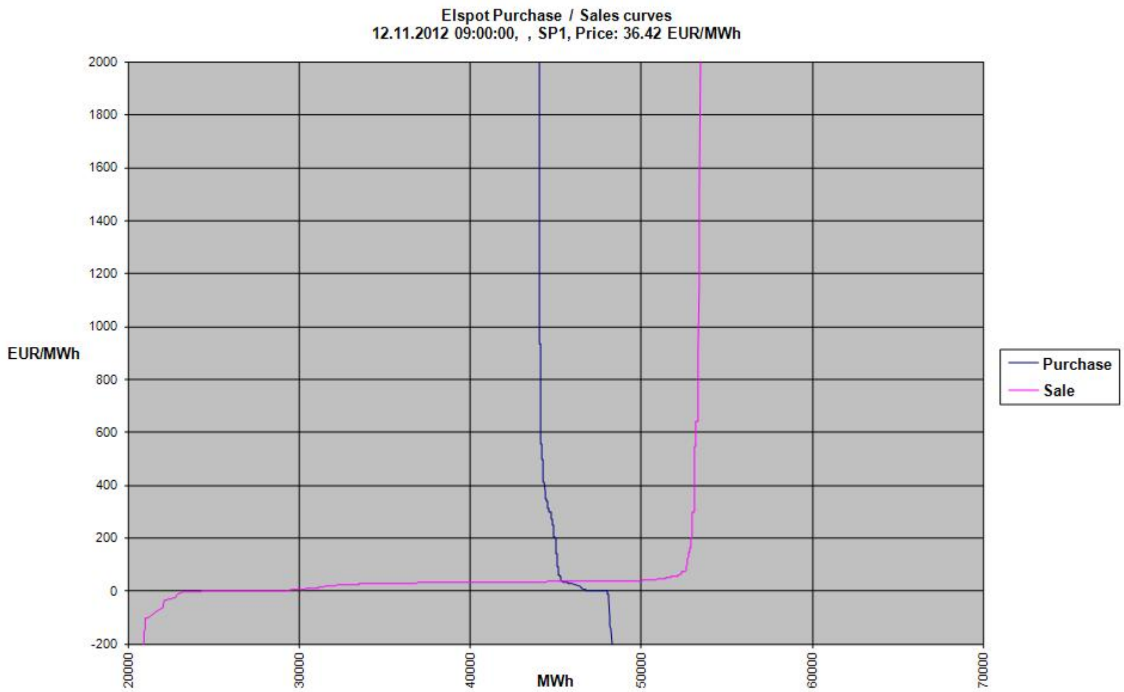

Figure 8: Formation of a Spot-price [26]

delivery. Price structure is based on first- come, first- served principle, lowest sell price and highest buy price comes first, with no attention to when the order is placed. [26]

3.2.3 Competition situation

Even though the Nordic Markets have a lot of participants, according to Finnish Competition Authority the market still has oligopolistic features. From production-side, entering the markets is difficult since heavy investments are needed in order to achieve enough production to meet the minimum requirements for market participation. Also the regulation obstacles for building new power plants are strict, making it challenging to build new generation. [5]

Although some remarks about competition, a general opinion is that electricity markets in Nordics work well. Nordic electricity markets are fragmented among large amount of players, introducing the competition to the energy domain. In Figure 9 the dispersion of different parts of Nordic electricity business is illustrated. With fragmentation, it is more difficult for a single actor to affect the price of electricity by its actions.

This has not been the case previously. Before, every national markets were dominated by one large player, for instance Vattenfall had over 50 % market share before uniting the national markets to one entity. Now, with integrated markets, the combined market share of 4 largest producers is close to 50 % (See Figure 9). From competition standpoint, Nordics are close to a single market. [32]

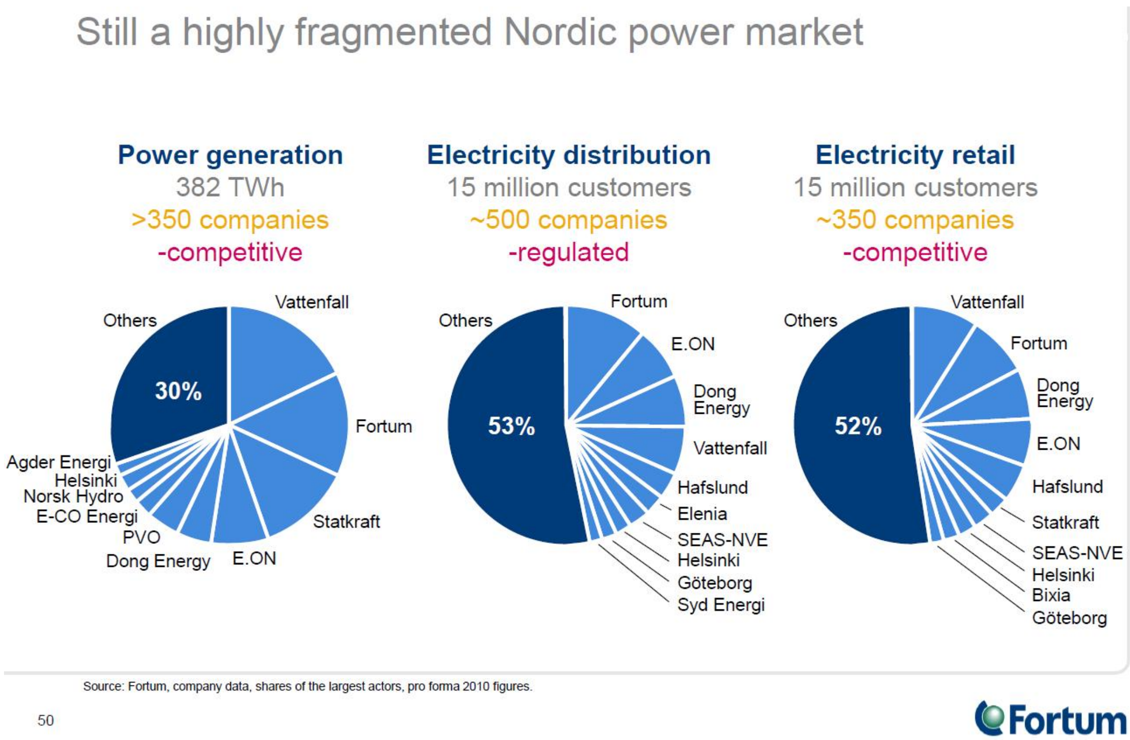

Figure 9: Fragmentation of Nordic electricity markets. [67]

Over 70 % of electricity consumed in Nordics is exchanged in Nord Pool, which ensures the high liquidity of the markets. [26] Also the high volatility that has been experienced in electricity prices is a sign that signal from changes in demand and supply go through to the markets. From a social point of view, it is important to ensure that the market prices reflect the production's marginal costs. When the system is dominated by hydropower, exploiting the market power is not easy to detect, since generator has the possibility to either use or to store water in a reservoir. This decision is made on factors such as forecasting of water levels and length of winter season for instance. For outside observer it is hard to say whether the decision is reflecting the use market power or expectations about future's climatic situations. [32]

The transparency requires that open competition is really happening, and the amount of Over the Counter (OTC), bilateral agreements should be set under the competition as well. Still, there are signs that market participants are still in unequal position because of asymmetric information between large and small players. With size comes benefits, the actors with large production or consumption resources have more detailed and real-time data on the market compared to ones with more limited resources. [31]

The gains from open competition model are seen as beneficial in the long run. But in order to realize these gains, market has to monitor the situation whether the open competition actually is happening. The barriers for entry both in generation and retailing whereas bringing even more innovative actors has to be as low as possible. [34]

3.2.4 Special characteristics of Nordic Electricity Markets

Nordic electricity markets has been a pioneer on unbundling the generation and retail from the natural monopolistic infrastructure side. Before, the monopoly rights and self-sufficiency requirements led to building excess capacity. The aim of the electricity market reform was to even the price differences in different regions, add transparency to the markets and to remove the over capacity thus improving the overall efficiency of the markets. [68]

Unbundling has had wanted effects: it has increased the competition on both wholesale and the retail markets, causing the diminishing of the profit margins. Also the production overcapacity has been reduced, increasing the power industry productivity.

Still, it has to be noted that even though positive developments in energy industry, the public opinion has been less enthusiastic about the electricity market reform. Main reason for this has been the increased retail electricity taxes which cause households to pay more for the electricity than before. Also the complexity of the billing is seen as too complicated to understand. These are more external factors and political decisions rather than a sign of badly functioning electricity markets, but it is hard to communicate to large audience. [32]

Nordic electricity markets have certain characteristics in its structure. The structure has designed to be fitted in conditions Nordics have, but several aspects can be adopted generally to other markets as well.

Four points is recognised why the Nordic electricity market has succeeded:

1. A simple but sound market design, to a large extent made possible by the large share of hydropower.

2. Successful dilution of market power, attained by the integration of the four national markets into a single Nordic market.

3. Strong political support for a market-based electricity supply system.

4. Voluntary, informal commitment to public service by the power industry. [32]

Points 1 and 4 are characteristics of Nordic society, but the other two points are general and worth striving for in other markets as well.

Figure 10 shows that in Nordics there are vast amount of hydropower, which is not usual in other parts of Europe.

Main difference to the situation in Europe is that hydropower-dominant electricity systems tend to be energy-constrained rather than capacity-constrained. The level of water reservoirs, which work as a ”electricity storage”, is the essential feature in the system rather than amount of production capacity. With cold winters the electricity consumption varies more in the Nordic countries compared to the situation in Europe. This has required to build a strong network in the first place. The

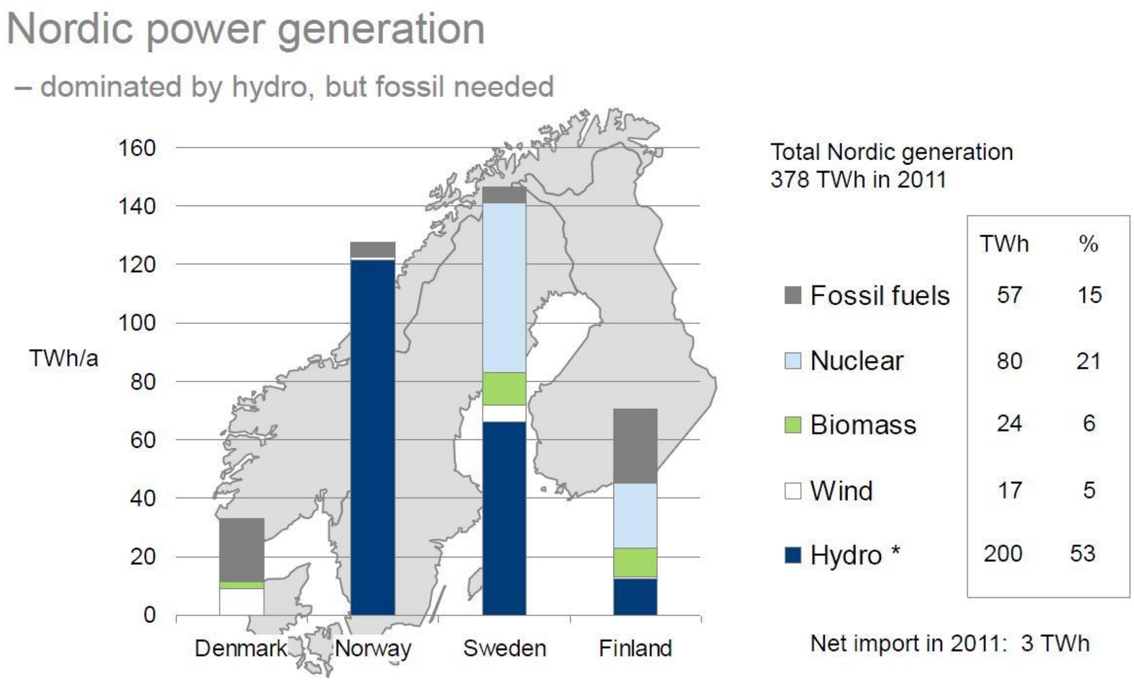

Figure 10: Nordic Power Generation. [67]

whole approach for the situation is different, since only lately with DER, there has been increasing pressure for grid strengthening in Europe. Hydropower has many useful characteristics in it. In comparison to fossil fueled power plants, the start-up costs of power plants are insignificant, which in turn gives the right signals for the efficient allocation of resources.

Point four is also area-specific for Nordic countries. The atmosphere around the electricity environment is still careful among the actors, with fear that if there will be scandals concerning using market power, it will create more regulations and the direction back to the regulated, old system. [32]

The general points from the Nordic experiment that can be implemented to larger scale are quite self-explanatory: Dilution of market power as well as continuing political support with courage to stand behind the long-term strategical decisions.

For Nordic market, the unbundling has brought the situation what was pursued. It has decreased the amount of unused capacity to the markets. Overcapacity doesn't exist anymore, there has been a few minor power shortages but so far the markets have been able to take care of it. [33]

3.3 Roles of Different Players

3.3.1 Generator

A regulated or non-regulated entity (depending upon the industry structure) that operates and maintains existing generating plants. The generation company may own the generation plants or interact with the short-term market on behalf of plant owners. In the context of restructuring the market for electricity, the generation company is sometimes used to describe a specialized ”marketer” for the generating plants formerly owned by a vertically-integrated utility. (eia

3.3.2 Transmission System Operator

An actor who is responsible for the maintenance and operation of the High Voltage Electricity Transmission System. This carries power from central power stations to the Distribution System, where responsibility transfers to the DSO. [45]

Transmission System Operator is the backbone of the whole electricity system. It is responsible of maintaining the physical electricity delivery.

NordREG identifies the core tasks of TSOs accordingly:

1. Ensure the operational security of the power system
2. Maintain the momentary balance between demand and supply
3. Ensure and maintain adequacy of the transmission system in the long term
4. Enhance efficient functioning of the electricity market

Apart from these common core tasks, TSOs may have some other duties that are not included in these tasks about system responsibility, depending on different legislations in different countries. [17]

NordREG have defined that TSOs act in three different roles in the Nordic electricity framework. They are as follows:

- Transmission operator
- System operator
- Balance settlement responsible

Transmission operator is responsible for tasks 1. and 2. Task 3. is fulfilled when TSO works as a system operator. The task 4. concerns all of the roles introduced. [17]

Other important tasks are to secure the functional, transparent and open electricity markets.

3.3.3 Distribution System Operator

DSO manages and operates a distribution network for energy (electricity, gas, heat) or water. DSO has operators, control rooms and various ICT systems for distribution management and automation. In the competitive electricity market the distribution of electricity is usually a natural monopoly controlled by the regulating authorities. [45]

role for operating regional distribution grids of electricity supply, who plans, builds and maintains distribution infrastructure responsible for regional grid access and integration of renewables, regional grid stability, load balancing and connections to grid users (generators and consumers) at distribution grid level

3.3.4 Retailer

An actor in the competitive electricity market that connects retail market customers with the wholesale market. [45]

3.3.5 Customer

So far, the customer has bought electricity from retailer with a contract. Customer is usually the end-user of a commodity electricity. They are the users of the energy supplied and do not pass it on to further customers. [45]

3.3.6 Balance Responsible Party

Each party operating in the electricity market must take continuous care of its power balance, i.e. the party must maintain a continuous power balance between its electricity production/procurement and consumption/sales. In practice, an electricity market party cannot do this by itself, which is why it must have an open supplier which balances the power balance of the party. A party whose open supplier is Fingrid is referred to as a balance responsible party.

The open delivery between Fingrid and a balance responsible party is agreed upon through a balance service agreement, whose terms are public and equal to all. Upon signing the balance service agreement, the balance responsible party obtains the open electricity delivery and also the services related to imbalance settlement between the balance responsible party and Fingrid as well as an opportunity to participate in the balancing power market.

The balance responsible party must also adhere to the valid application instruction for balance service.

4 Future Trends of Energy Markets

4.1 European electricity market integration

The European Union concentrates on creating the integrated, internal energy markets. The designed market structure would include flexibility and higher transparency compared to the situation nowadays. It is needed to ensure a favourable and secure energy supplies for industry and households, as well as to tackle the climate and energy challenges. European Union's Energy Strategy aims to fully integrate the different energy markets into one by the end of 2014. By combining the fragmented markets into one entity promotes better competition, better products and results in more secure supply.[69]

Initial integration is in target at 2014, but longer time scale scenarios are examined as well. Designing the functional market for Europe, the following aspects are seen as important features to be taken into account:

- Over-all system costs
- Volatility in the electricity prices
- Generation mix
- Geographic location of generation and demand
- Effects on network expansion
- Demand response
- Trade-off between market risk and regulatory risk [60]

The increase of renewable production creates the change in the generation mix. More volatility is introduced and it is to consider whether it is possible to rely on renewables due to its intermittent nature. Intermittency creates the situation where it is needed to build an excess capacity to secure the required level of security of supply. Large volatility in generation levels puts the transmission network under stress.

As there is excess capacity of renewables with low marginal costs, it presses down the price of electricity, causing the traditional power plants investments' payback times to grow, thus making them less attractive.

As seen, two crucial challenges have been identified concerning the capacity of distribution network and the generation structure. Moreover, intermittency result to more volatile electricity prices. This is a fact that is hard to explain to the public opinion and media since electricity is seen as a commodity which is assumed to have little variation on its price.

Public opinion and media attention towards electricity has significant impact when deciding the target model. If there is a consensus that volatility of the electricity prices is not acceptable, political decision can steer the market model to less optimal, but less volatile situation. How the electricity markets evolve depend greatly from policy-makers. [60]

4.1.1 Market models

Different market models can be created by taking different aspects into account, e.g. price formation, regulatory decisions, level of competition. Usually two different market models are introduced by taking the focus on the network capacity. The question on how well the system is capable to respond to demand of the market is crucial. EU's strategy at the moment is to build a market platform which enhances the competition over different nations' borders, which means vast investments to the transmission networks. Another option is that markets adapt to the transmission capacity. In figure 11 the main differences of two scenarios are depicted.

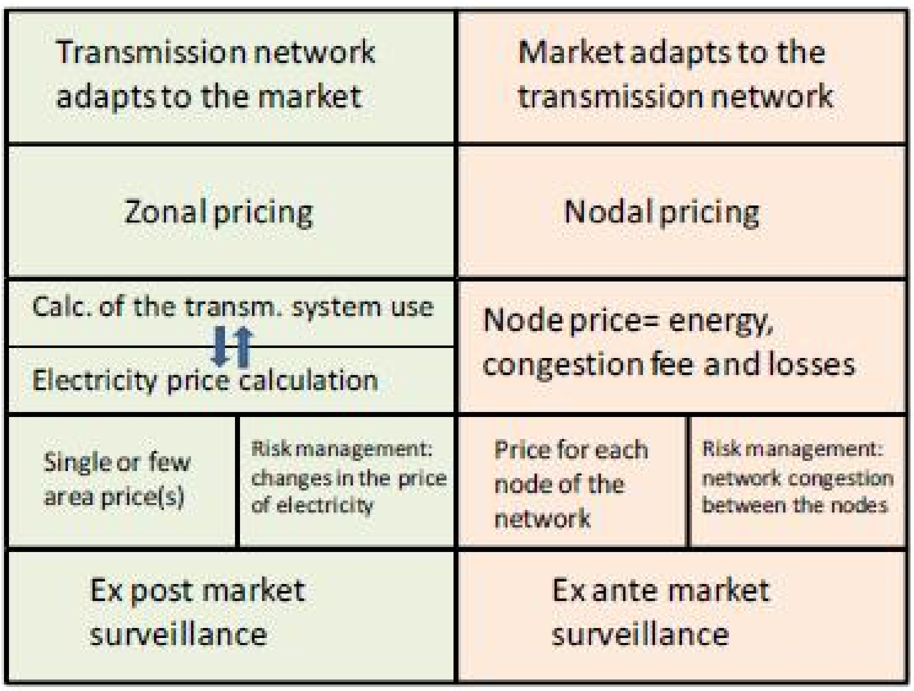

Figure 11: Proposed models for markets. [21]

The transmission capacity is the determining factor between the models. If there is enough network investment plans, the markets can be integrated in such a way that there is no restrictions among areas. Without strengthening the network, it becomes a bottleneck which the market has to adapt to. Both scenarios are described in more detail in the next sections.

4.1.2 Open markets (Scenario 1)

Vision of Scenario 1 potential relies mainly to two things: the sufficiency of transmission capacity and the active engaging of the demand side. These two factors open the free competition in the electricity markets. Without bottlenecks in a transmission network a large price areas can be formed, equalizing the price of electricity in large areas. The need for regulation is carried out reactively, as the areas are so vast, the risk for exploiting the market power diminishes through increased number of competitors in wholesale markets.

With active demand side management the price setting power from the generators is limited, causing more optimal allocation of generation resources. This leads to a correct marginal costs from production to reflect in market price.

In Scenario 1, the price calculating method is different from the Scenario 2. TSOs are responsible to provide information about available transmission capacity, and the Power Exchange creates the price from the sale and purchase orders. [21]

4.1.3 Capacity markets (Scenario 2)

Another scenario forms when there is constraints in the transmission system. This splits the markets to small fragments, separate networks with generation and consumption of electricity. This causes the price of electricity to vary locally, meaning that the regulation differs from the Scenario 1. Locational marginal pricing poses a threat to a use of a market power. This means that the need for market regulation is much more strict to avoid the misuse of positions. In nodal pricing model the generator's bids are monitored and the prices of electricity are usually restricted to certain limits. Restricting price can be a questionable act, since the high electricity prices give the signal for the need for more production capacity. With restriction this signal doesn't come through to the markets, and alternatives are sought from other solutions. For instance, there can be a separate capacity markets, which guarantees more investments to the new capacity, and the generators get compensation for its existence, whether it is used or not.

Another problem which comes with price restrictions is the losing incentive for demand flexibility. If the price does not go through correctly, there is no need for curtailing the electricity when there is a scarcity in generation. [21]

There is a danger that markets are not liquid and transparent and in addition the integration of different markets suffer when these kind of instruments are taken in use, even though there would be more transmission capacity planned in the future. European Commission has taken a stand against this. Some of the Member States have introduced a plan to initiate these plans for securing the sufficient generation capacity through alternative instruments than "energy-only"-markets, i.e. initiating capacity markets. European Commission sees that if the capacity mechanisms are not designed well, are introduced prematurely and without satisfactory level of co-operation at EU-level, there is an ample risk of distorting the optimal market situation, bringing counter-productivity to the markets. [69]

Effects of capacity markets have been debated mainly qualitatively, but also simplified scenarios with quantitative analysis have been introduced. Two different alternative cases has been taken into account: EU-wide capacity markets and capacity markets only in Germany. [71]

EU-wide capacity market vs capacity market only in Germany In Figure 12 the comparison between the base case (no capacity markets) and EU-wide capacity markets is presented. As it is seen, the nature of capacity installed has to be such that it provides the secure generation when it is needed. Additional capacity that would be installed would be conventional energy production, which is against the targets of the EU's 20-20-20-plans.

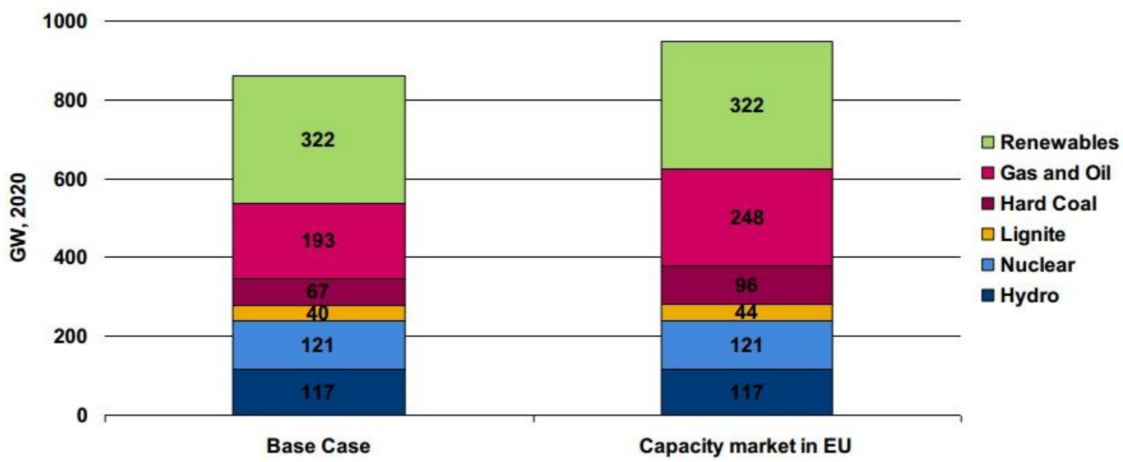

Figure 12: Effect of capacity markets in EU-level. ([71]

Energy demand is expected to experience only modest increase in European level by the year 2020. Additional power capacity for the sake of keeping the prices even is not what would be optimal from the society perspective, nor is the will of EU's strategy.

In Figure 13 the comparison of capacity market in EU and only in Germany is shown. A case study suggests, that introducing the capacity markets to whole Europe, looking at the pattern of exports and imports it would not be completely changed, but it would result in some changes in power flows, for instance the Netherlands would change from net importer to net exporter. If the capacity markets are adopted only in Germany, it starts to have an effect to the patterns. There would be a significant growth in exports.

A case study analysis shows us that the capacity markets will impact cross-border flows, and even more so if it is not implemented in a coordinated, EU-level.

In summary, threats and opportunities about the possible effects of capacity markets are introduced in table 2:

4.2 New Stakeholders in the Energy Markets

4.2.1 Prosumers

As one of the most prominent changes in the electricity business is the uprising of renewable energy sources and distributed generation's role in a sustainable solution to the energy field. Political support has ignited the small scale production to be more profitable.

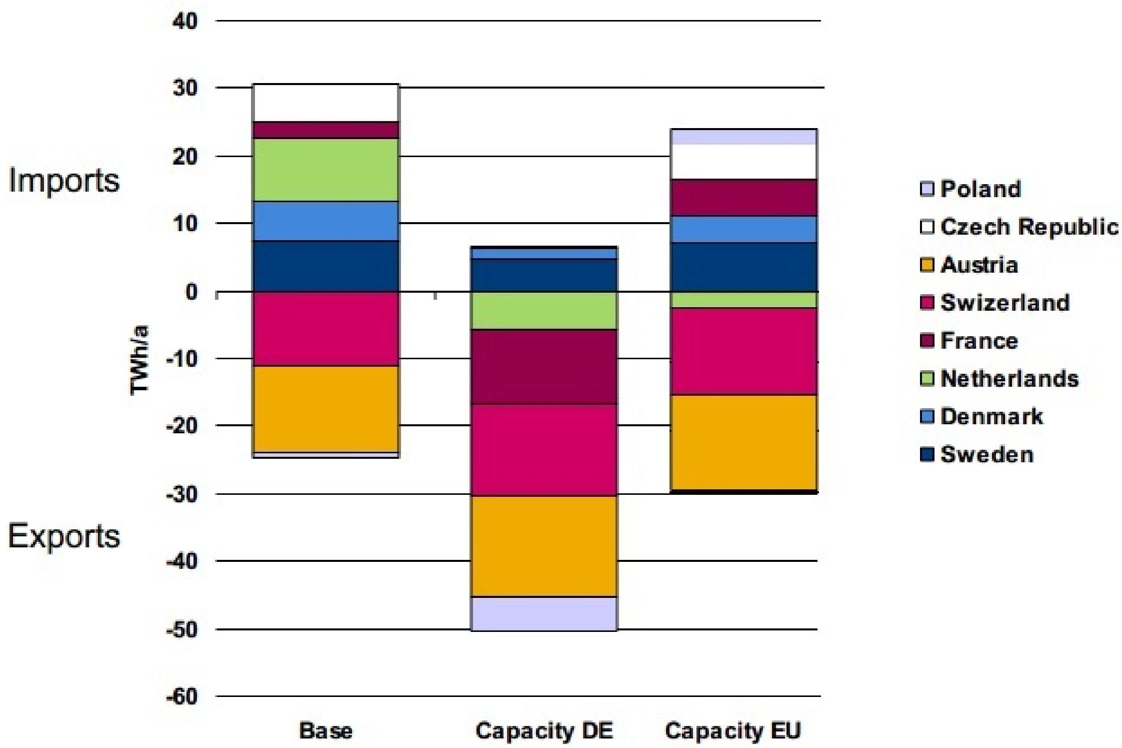

Figure 13: Impact of capacity markets in cross-border flows. [71]

This has big impacts on the role of the consumer as we know it. With this technological development even a small consumer can start to produce its own energy for own use and also to produce beyond own needs.

With own production the consumer's role turns into two-folded: a consumer is both on demand and supply side. This new emerging term a "prosumer" can be defined as an economically motivated entity that:

- Consumes, produces, and stores electricity and energy in general.
- Optimizes the economic and to some extent the technological, environmental decisions regarding its energy utilization.
- Becomes actively involved in the value creating effort of an electricity or energy service of some kind. [10]

Today the role of the energy-producing consumer is relatively new and very limited in scale and importance. Nevertheless, large-scale deployment of prosumers can happen quite rapidly so it is of great importance to examine the effects proactively. Questions arise that what role this newcomer plays in the energy value network, where large companies play a dominant role? [18]

	Threat	Opportunity
Regulation	Investments do not depend on the markets	Safer-income helps to fund investments
Market integration	Different systems in different countries, distorting competition and reducing efficiency	Incentives are already national
Demand flexibility	Larger proportion of fixed costs and more consistent prices does not provide incentives for demand flexibility	Fixed payment beforehand can enable demand flexibility
Competitiveness	Chances for inefficient markets, expensive for customers	Can allow new players in the field
Loss of the exchange liquidity	Larger proportion of fixed income reduces the incentive to hedge	Smoother rates reduces the need for hedging

Table 2: Yearly differences in average spot prices and amount of potential saving. [70]

Prosumer is quite small considering the energy and power. A single prosumer cannot participate to Energy Markets very efficiently since the asset from single microgeneration plant is very marginal. Alone it doesn't have very much benefit but if there would be an actor that can collect this excess power from a mass of prosumers, it starts to matter. This is where the so called aggregator concept is seen useful, which is discussed in the next chapter.

4.2.2 Aggregator

The concept of an aggregator tries to activate the demand-side which helps to solve the fundamental problems that are connected to the nature of the electricity: storaging and flexibility.

An aggregator collects the It contains Virtual Power Plants which can operate on the markets by selling the surplus production from the DER. The intriguing difference to present situation is that energy and revenue doesn't flow anymore only from customers to other participants, but the flows can change direction, according to how Markets operate.

Looking at the latest successful offerings that have re-defined the business world, the main idea has been to create a platform that links together two distinct groups of users, for instance Google joins together Web surfers and advertisers. These two-sided networks are called platforms. Two -sided networks differ from traditional market places in a fundamental way. In the traditional value chain, value moves from left to right. In the two-sided networks, cost and revenue can move to both directions, because the platform has a distinctive groups on both sides. The platform gets costs on serving both groups but it is also able to collect revenue from both sides. [13]

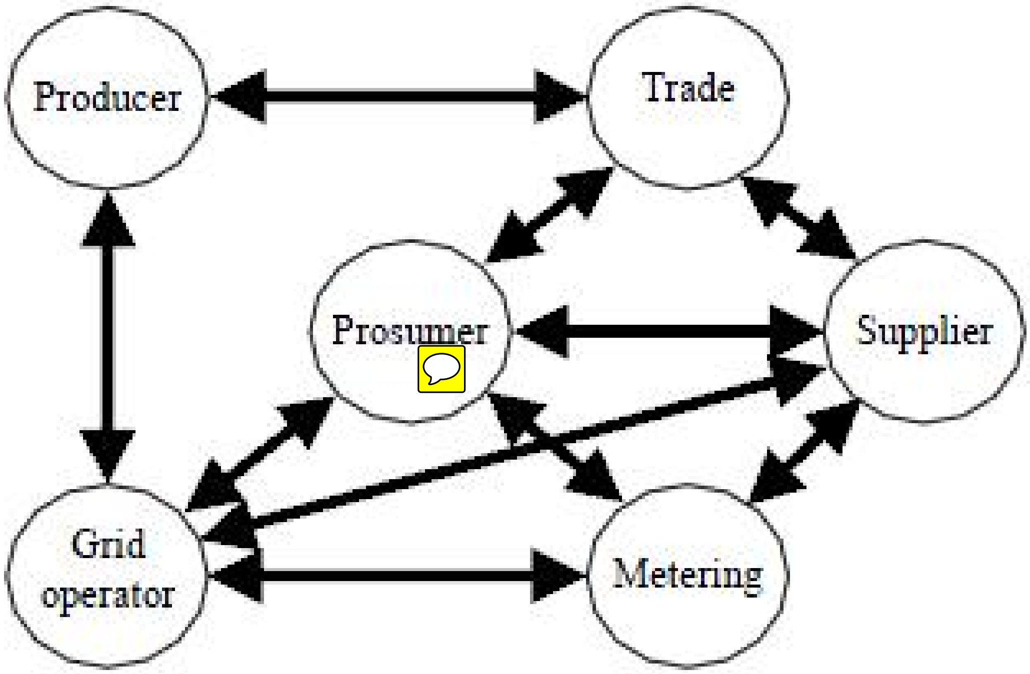

Figure 14: Prosumer in a complex value network. [18]

The concept of an Aggregation has characterics similar to two-sided networks. Aggregator collects the controllable loads and microgeneration together as a VPP and can act in electricity markets as a producer and consumer. So far, this has been in such a small scale that real-life examples from the subject remain unseen. In the future electricity markets face the question that are there bids for both supply and demand or is demand taken as a constant determined on the basis of a load forecasting program? Letting customers or aggregators enter bids for their demand gives them the opportunity to indicate the value of their load more transparent. There is little experience of the subject with demand-side bids and therefore it is not clear how this affect the actual behaviour of the consumers. [15]

The aggregator's job is to enable the demand response and bring it to the wholesale market. It has proven difficult to identify any best or good practice in this area, on reason is that no criteria have been agreed for this assessment s. 24 market model BAU

One of the worries is that the regulatory organizations, industry and government want to define smart grids too soon when trying to foresee what happens. This can be a restraint to the smart grids development. Market based development is more innovative, better solutions and products are done in contrast to development via regulation. On the other hand, Many of the developments are very very costly so companies want to be sure about the regulations, it shouldn?t change too often because then it will be obsolete soon. Oksanen s. 74

DSO's cannot perform demand response aggregation because they cannot participate in electricity markets. Also, if they performed load control only to improve network operation (for example voltage control), they would interfere with market-based load control. Besides, load control during system contingencies can also be carried out by a deregulated aggregator participant based on DSO's request. Therefore the role of DSO as aggregator will not be discussed further. Ikäheimo DER s. 13

And there is a debate whether this happens through DSO's smart meters or further in future with home automation systems and the meter has only its basic function: calculating energy and the time of consumption. Typically, two-sided networks have a 'subsidy side', that is, a group of users who, when attracted in volume, are highly valued by the 'money side', the other user group. Because the number of subsidy-side users is crucial to developing strong network effects, the platform provider sets prices for that side below the level it would charge if it viewed the subsidy side as an independent market. Conversely, the money side pays more than it would if it were viewed as an independent market. The goal is to generate ?cross-side? network effects: If the platform provider can attract enough subsidy-side users, money-side users will pay handsomely to reach them. Cross-side network effects also work in the reverse direction. The presence of money-side users makes the platform more attractive to subsidy-side users, so they will sign up in greater numbers. The challenge for the platform provider with pricing power on both sides is to determine the degree to which one group should be encouraged to swell through subsidization and how much of a premium the other side will pay for the privilege of gaining access to it. [13]

What this means as well is that finding the critical mass and right surroundings in order to make this happen.

This breakthrough, new thinking from the normal view with electricity as a commodity can bring a lot of new revenue streams through this intelligence.

4.2.3 Energy Service Company (ESCO)

Energy Service Company (ESCO) is an interesting and important concept when looking to the future. ESCO is specifically energy-oriented commercial business that can help promoting the energy efficiency and offer its expertise in energy solutions such as energy savings projects, energy conversation and energy infrastructure outsourcing.

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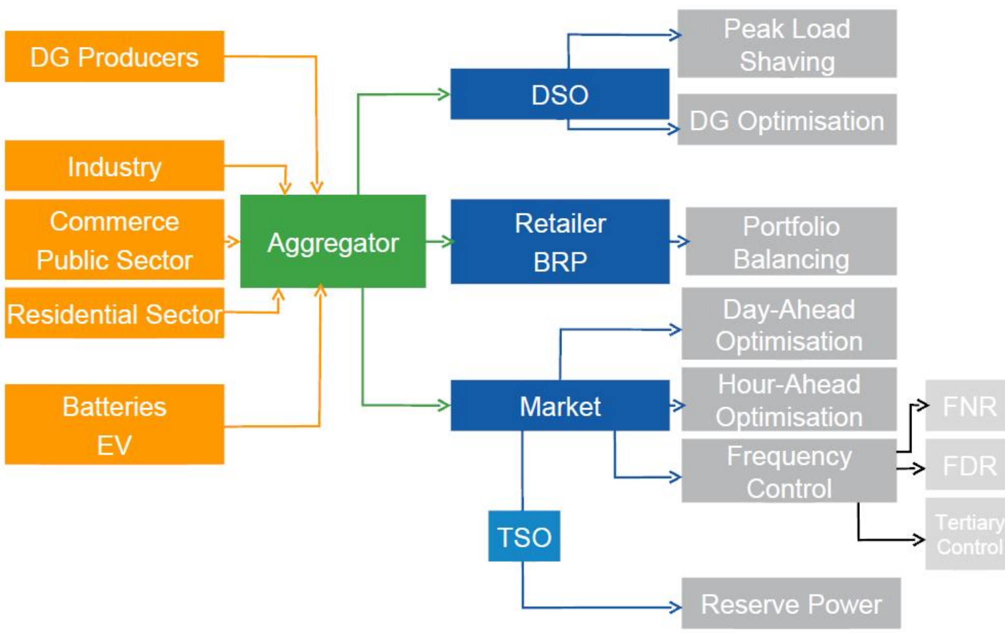

Figure 15: Synthesis of the Aggregator's Business Services, Clients and Providers [16]

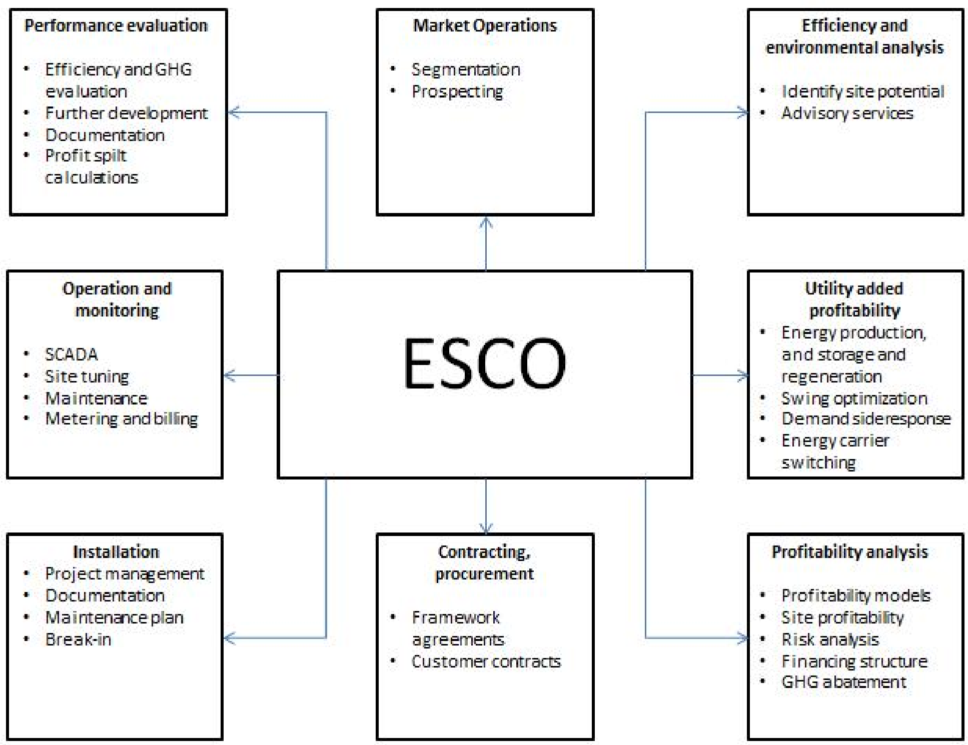

Figure 16: Possible service portfolio of ESCO [10]

5 Challenges and Possibilities

As any market has revolutionary transitions, roles and responsibilities of different players can experience redesigning. New players can emerge and new roles have to be established. With proactive collaboration among participants, the markets can find the optimal solution under new set of rules. When establishing the roles, conflicts can occur among participants and some responsibilities are not so easy to categorize under certain actor. The change can be managed smoothly and without major frictions, but it is also possible that some new concepts are not easy to be defined belonging to a certain actor. Finding a solution that is satisfactory for all the players can be hard to achieve.

Even vast changes do not necessarily change the roles too much and the threats for any actor can be minimal. Future's uncertainty creates doubts among players, but it can be that changes to environment brings unforeseen benefits for all of the players.

In this section the challenges and possibilities for different actors are discussed, as well as comments about changes of the market platform and the improvements suggested. The discussion for this Chapter come from the interviews backed up with literature studies.

5.1 Power Exchange

The traditional market platform faces challenges in a new environment. It has been designed from the needs of traditional energy business aspect, where location and the amount of energy produced were easier to predict. Emergence of RES has been one of the main drivers for the European market integration, a long process where the first steps have been taken. To create an integrated Power Exchange which takes into account the new requirements as well as requires collaboration among PXs is hard to establish.

5.1.1 Challenges

Potential loss of liquidity on the PXs Larger proportion of fixed income reduces the incentive to hedge [70]

Difference in business objectives of PXs Deciding the common goals for the PX is difficult, and one main reason is that PXs have different interests and views on business objectives. Lundin [63] categorizes these as follows:

- PX as a state institution and steering regulated by law – Run more like a part of the government?s administration
- PX owned by TSO:s – Balance between business and public service interests
- Business entities owned by market participants or other general exchange providers – Focus on business and what's in the interest of the participants

With different behaviour and the focus among PXs, it is hard to find the solution that would be suitable for everyones' needs.

Competition among PXs From the previous point, as it is not possible to find the satisfying solution for everyone, different PXs are under the competition situation where the strongest wins. Competition hinders the collaboration for striving for integration of the PXs.

Disagreement about common PX's structure PX's have a variety of different kind of structures for day-ahead markets, intra-day markets as well as a variety of balancing mechanisms. The functionalities are not easy to integrate, as different mechanisms have different benefits and restrictions. PXs have biased view on what would be the optimal solution for the whole Europe.

Creating a trading mechanism for whole Europe According to Lundin [63], the core challenge for PXs is the creation of the integrated trading mechanism to whole of Europe. The calculation of the spot price and reference price, which covers all the areas and simultaneously takes into account the capacity on all cross border allocation in one batch. The challenge is not a technical: one price calculator for the Europe is technically easy. Problem is the lack of interest to strive consolidation of the business forward at fast pace.

Integrating the product portfolios First obstacle when discussing the coupling of the markets comes from designing the new product portfolio. It is hard to put together different time periods that exist in different PXs now. Time resolutions for intra-day vary from 1 hour to 15 minutes, depending on PX.

Capacity markets If Europe's political environment starts to lean towards capacity markets, it is a threat to PXs. In capacity markets the price is regulated, so the role of PX can be questionable. PX does not have a role in a regulated markets.

5.1.2 Possibilities

Benefits from european scale markets it can happen through organic growth or acquisitions and mergers.

Additions to product portfolio TSO has accurate production and consumption plans More attention on activating bids on Balancing market by TSO 15 min period is very short for physical regulations Can lead to unnecessary regulations No time for actors to correct imbalances Will need much more attention by market actors (full time job follow Balancing market)

Time Windows In Nordic markets, the time frame of the market gate closure and delivery hour is relatively long. In a day-ahead Elspot markets, where the largest amount of electricity is traded, the gate closure happens everyday at 12:00 CET for the next day's hours and intraday Elbas markets work as a balancing tool until hour prior to delivery.

Historically, in this timespan the forecasting was possible to do in an acceptable accuracy level. The energy production structure was more robust with traditional power plants as the production has been easier to manage in longer time frame. With DER and DR, uncertainty for forecasting in both the loads and the generation causes new challenges. A pressure for shortening the time-frames from what we are seeing now is evident: weakened forecasting make intra-day markets more relevant. In Germany with high amount of DER, in 2011 the intra-day electricity markets' gate closure has been shortened from 60 minutes to 30 minutes before delivery hour. [59]

Due to the changes in structure of how electricity is produced and consumed, one solution could be the re-designing the markets, either by moving physical markets closer to the delivery hour or by creating intra-day markets as the main exchange platform.

Changing the time frames can create unpleasant situations to existing players. At the delivery moment, the TSO has all the responsibility in keeping the grid balanced. Going back from there, TSO is delegating the risk and responsibility forward to the other parties. It is a question that who has the benefit of keeping the time frame so extended as now and what implications it has if shortening it. It affects to both the market side as well as system side. It is another question whether this shortening happens naturally or is there a need of doing it through regulation.

For certain kind of generators it makes sense to keep the time-frame longer. Power plants with limited generation adjustment but good predictability of production, the shorter time-frames do not bring any benefits. Longer time-frame gives more time to react to the market situation.

As the technology evolves, players create more pressure to Nord Pool Spot for providing incrementally faster data handling and calculation. This efficiency enhances the whole markets functionality and enables more optimal adjustment of the production: number of ramps will go down as well as cost savings through better optimization of the production structure. [80]

When considering the big picture, the markets should be still developed in such a way that flexibility both in demand and generation are still mainly in the wholesale markets. When forecasting accuracy weakens, it makes the job for Balancing Responsible Party even harder and at the same time opens possibilities for an intra-day aggregator. Also flexible generation benefit from this forecast accuracy weakening. The closer we get to the delivery hour, the less there is either generation nor load to be fast enough to react. This means that value of flexibility will become even higher in future. [72]

5.2 Aggregator

Drivers for aggregator business vary from environment. In the USA it has been because of the bad infrastructure. Germany started the "energy turnaround", the term which includes the increasing renewable energy replacing conventional energy sources and also phasing out nuclear power.[77]. In the Nordic market structure occasional price peaks cause the driver for flexibility. [91]

Positioning of an aggregator in electricity markets depends from the assumptions that verifies its existence. Two aspects are important to identify: which providers have enough potential to form the service, and who are the customers interested from flexibility service.

Challenges and possibilities which an aggregator experiences in future are discussed.

5.2.1 Establishing a place in Markets

Demand flexibility needs an aggregator. The energy production has economies of scale, but demand response has different idiosyncrasies. It has to be built from small units in order to get the critical mass needed to make an impact. The electricity markets get a new actor, which hasn't been there before.

A new actor in the closed environment can cause confusion among players. How to implement a new actor and its role in optimal way is under the debate. Existing roles of different players have established over time and certain actors are regulated with law (DSO, TSO) so an aggregator position in this environment is not clear yet. [91]

Becoming a market actor or not An aggregator does not necessarily have to participate in electricity markets. It can provide a service to the customer which optimizes the energy usage to be as cheap as possible. By modificating the customers' load curves, an aggregator causes deviation to the consumption profiles. Retailer has to forecast the profile beforehand, and deviation means additional risks to the retailer. If an aggregator has this kind of business model, conflicts occur without communication between players. Functional communication is essential to make the business viable for aggregator.

Other solution is where an aggregator provides the electricity to the customer, i.e. becomes a retailer. When becoming the market actor, communication need with a retailer disappears but now an aggregator is responsible for the balance sheet, which brings new risks and challenges. This business model has its restrictions, since retailer business is not the core competence nor focus for aggregator. Therefore, it sounds logical that collaboration can bring more benefits to both players.

Strategic decision about customer segment In different markets there are different potential clients to be found. A size of an client can vary from large single industry player to small, single household with electrical heating, with very different preferences and expectations from the service. Market research is an essential task to do, to find the providers that can be flexible enough. Market research is a long and complicated task to do properly. To find processes that can be re-arranged more optimally will require deep understanding from customer's needs.

Strategic decision about choosing operating markets Another strategic decision needed is the decision on which markets an aggregator is operating. Demand Response can be offered to several different markets, depending on the nature of the flexibility possibilities in each load. Participation possibilities for different markets range from Spot-markets to fast disturbance reserves.

Selection depends mainly from the time-slot in which the load can be turned off without causing major disturbances to other processes, for instance the cooling systems in cold storages have boundaries concerning the maximum temperature allowed to keep food products fresh.

Another aspect when deciding the market is the reaction speed of the load controlled. Markets that are related to power shortages can happen fast. For Balancing markets the load reduction is required to be activated in 15 minutes.

Of course, an aggregator can choose several different markets to operate, but it requires effort and lots of automation to constantly update the highest value from different possible markets.

5.2.2 Challenges

Several challenges were discovered from the real-world implementations of aggregator. Based on interviews, the main problems are as follows.

Attracting clients Attitudes of the clients whose loads could be controlled has proven to be mixed. Main reason is difficulty to estimate exact savings it would bring to a client. Savings volatility makes the pricing of the service difficult. Usually the loads are a part of the processes that are delayed because of the DR. If one cannot estimate the savings, comparison of a trade-off of this action cannot be done.

Clients also have popular misconception that the benefits are such small that it isn't worth executing. Argument for this can be based on arbitrage: if savings through better adjustment of electricity usage is risk-free a rational actor should do it. [91]

For small-scale clients the challenges is that it is hard to reason the benefits because of the lack of knowledge about electricity markets. Initial investment for HEMS can be too high and payback times can prolong to several years which reduces the attractiveness of the product. Also the development of the systems are rapid so one gets advantage to wait for a longer time. [85]

Communication with policy-makers As the DR is such a new concept, getting regulation adapted to DR has been a challenge. From traditional perspective, where the problems with grid stability has been solved through big projects like building more transmission lines causes certain mind-set to politicians. This new, capital efficient technology is not easy to explain. Since it's not easy to comprehend, policy-makers don't understand to create incentives for it, which in turn means that ancillary services do not seem so attractive to actors under regulation. [77]

5.2.3 Possibilities

Markets have a need for DR Alongside with sufficient transmission capacity, price elastic demand is seen as of crucial importance when creating the functioning markets. [21] There is clearly a demand for this kind of actor who collects the flexibility from smaller fractions to larger units that can participate in markets.

Market is in need for this kind of service, but system side is interested as well. Demand flexibility can be exploited to problems from both sides: bringing savings from markets to customers as well as bringing relief to congestion problems that system will experience.

Shorter time resolution demands more automated systems Inevitable shortening of the shorter time granularity makes aggregator via direct, automated load control even more valuable. Price of flexibility increases, and since the time window is so short inexperienced customers do not have resources to follow the signal shifts fast enough. Through this scenario, it can be seen that in future the demand for dynamic tariff combined with direct load control gains interest. Absence of direct load control can lead to a situation which is unfair for the customer. [79]

Prosumers need an aggregator for market participation vpp etc etc

5.3 Retailer

Smart Grid enable a vast spectrum of what can the retailer do outside from the traditional scope: at present the core business is risk management in electricity markets.

5.3.1 Challenges

Competition increases Smart Grids enable more active customer participation with better understanding on how the energy is consumed. There are different ways to increase the energy efficiency which brings new participants in the markets, such as HEMS-companies and ESCOs.

Emergence of the new players mean that the competition from customers tightens. Trend is that retailers become more of a service providers, which help customers to save energy through collaboration. [79]

Retailers stretch out from their present core business, which is acquiring the electricity from wholesale market and selling it to customers.

Updating the strategy Since the nature of the business evolves, the retailer has to update the strategy accordingly. If the scenario is not well known, choosing the right strategy results in profits and by choosing more invalid strategy risks the whole business. Analysis of the future and innovativeness is in high value when deciding the winners out of market change.

By moving the business more to the service-side, retailers have to adapt with new kind of requirements. More customised services will become popular, resulting more demanding environment.

5.3.2 Possibilities

Easier to differentiate from competitors With more options in possible strategies comes also an advantage. It is easier to differentiate own business from other service providers, by creating services to the certain segment. By creating differentiation of products successfully, a retailer can achieve monopolistic nature in certain area, where perfect substitutes for the service are hard to find.

Collaboration with other sectors Retailers have vast experience from electricity markets' behaviour. Collaboration with a company which has different core business can create advantages to both players rather than expanding too much to new area [72]. For instance, collaboration with There corporation which manufactures HEMS, Fortum has been able to create completely new product, Fortum Fiksu, where There-corporation provides the hardware solution for controlling the loads and Fortum provides the electricity contract. Through synergy a customer gets a service which decreases the electricity bill by optimising the heating load usage. [**?**]

Furthermore, creating new products and doing market research requires investments. Collaboration helps to share the R & D costs by reducing the obstacles to experiment different alternatives. [78]

Product portfolio increases AMM provides very accurate data on customer's behaviour. With this more accurate data, the retailer is able to create more detailed picture of customers needs, which lead to a variety of different products and services. Larger product portfolio enables the business growth and provides larger customer base with more competitive products.

5.4 DSO

Changes in environment affects the DSO as well. Inflexibility in production side will make the stability of the grid more difficult to manage. The transition from passive, solving situations by grid investments approach towards more ICT-centric business has impacts for the regulated, neutral player as well.

5.4.1 Changes in the role

Because of the natural monopoly, DSO's business is regulated. Regulation causes certain restrictions and limits in its role. The revenues are fixed and participation to the electricity markets is limited.

DSO has been seen as a neutral market facilitator, enabling the platform for the functional electricity markets. Smart Grids have a lot of components that can be used in the open markets, like energy storages and DR, so the Smart Grids has to be seen more than just a technical infrastructure managed by the DSOs. Generally, the role of DSO after enabling Smart Grids remains as a neutral actor. DSO provides the platform for competitive players to offer new services. Creation of new services should be created by market and the regulatory framework is built accordingly. [58]

However, in areas where there are already significant amount of renewable energy production, ideas for updating the DSOs role to more active approach has emerged. DER causes DSOs to reinforce the grid connections to secure the grid stability. Grid has to be designed according to the peak load, which can happen only few times a year. If the peak hours do not happen very frequently, it would be beneficial to avoid these through flexibility services rather than investing more to the grid. It is discussed that if DSO has more options in managing the production or consumption, it could optimise the investments to the grid more efficiently.

It is suggested that DSO could acquire DER services from open markets. A new market platform would be created for aggregation services and price will form according to who needs it most, whether it is signal from markets or from the system level. Commercial players offer the services to TSOs and DSOs as pictured in table 3. This concept is market driven and based on voluntariness, with benefit of creating new business potentials to energy environment. [57]

Actor	Role
The TSO	Demander of flexibility services
The DSOs	Demander of flexibility services
The Commercial players (Retailers, aggregators etc.)	Supplier of flexibility services (Through aggregation of Consumer / DER resources)
The Consumers / DERs	Supplier of flexibility services

Table 3: Roles of different actors in flexibility service model. [57]

This viable market platform idea has certain aspects to be solved before implementing. Possible challenges can be enlightened with examples.

Players might have unequal power position If DSOs rely on the DR and does not invest to the grid, it can result to a situation where supplier of flexibility services can put unnaturally high value to the service, since DSO has no choice but to buy it anyway in order to secure the grid stability. On the other hand, it is stated by law that if security of supply is at stake, the DSO has a right to drop the loads in order to secure the stability. If DSO can affect to the flexibility himself, it reduces the need for this kind of market driven solutions.

Does not have desired effects to network planning DSOs are seen as a potential customers for this kind of service. A threat is that even though DSO has interest in flexibility services, the practices of long-term network planning may remain unchanged, and the distribution grid still is planned in ”fit-and-forget” approach, meaning that it takes into account the peak power. TÄHÄN SAARISEN HEITTO. This results that planning still is done with an assumption that there is no intelligence in the grid. Without exploiting the intelligence of Smart Grids the benefits are just marginal, if any. If planning tools do not develop, it continues to be business as usual.

In order to make DSO believe that flexibility service markets are relevant is to create a guarantee that DSO has the service available when needed. A privilege certificate to the service over others' signals can build trust to this concept.

Requires regulatory changes At present the regulation does not take into account the procedures done with DR.

Problem is that DSOs stronger involvement is not necessarily market-based solution. It can be done many ways. But just a right for curtailment of consumption or generation to avoid bottlenecks means that the markets do not function properly. With monopoly business, it is questionable whether it can be expedient behaviour to start participating in markets.

A farrago of signals may result unoptimised controls The system becomes easily very complex when there are several signals from different sources. Signals can have opposite effects and the overall optimisation and the real price-calculation can become difficult. As an example, if the price forms in free markets, the DSO has calculated that at certain price range it is cheaper to use the flexibility service rather than strengthening to the grid. TSO has made the same calculation and has its own price range. Electricity markets create 3rd price range for the parties offering the service. Problem arises if these three prices conflict, i.e. everyone has an exigent need for the service at the same time. Therefore the price may get so high that it is not profitable any more, but since the need for it is crucial the service has to be bought no matter the cost. Strengthening the grid would have been cheaper in the first place.

5.4.2 Challenges

Data Management One of the main challenges is the managing and distributing the data, which now has become as a very relevant part of the DSO's business through new regulation. In Finland the DSOs are responsible for acquiring, storing and delivering the data from Smart Meters to other market parties. It is a completely new function for the DSOs. [84] After the acquiring the data, it has to be verified. The system built has to be very reliable, since the mistakes and flaws become very costly: retailers' and DSOs' billing rely on the data acquired.

Tariff structuring The present tariff structure for the DSO does not reflect the costs. It should be changed from energy-based to power-based, for instance ”bandwidth”-tariff, where the customers pay for the maximum capacity they use.

This system has been criticized for not taking the energy-saving aspect into consideration, and also that if it would be introduced in short time, the differences for the customers might be too radical. [84] It has also to be noted that if the signals come from both the markets and the system level, the signals can be conflicting. There can be a problem that customer can have mixed signals and does not understand what to do. This confusion can lead to unwanted behaviour, even though the idea was initially to have better overall optimisation for society.

Further in the future when microgeneration has a significant part from the energy-mix, with more own production, there is a possibility that grid is used more in a way of a "battery", and net energy consumption can become quite small. This is a risk for DSOs to lose their revenue if the tariffs take account only energy consumption. One solution, how to get the tariffs closer to realistic is to change them, to power broadband tariffs, when investments made to strengthen the grid goes to those customers who actually demand it. [78] [**?**]

It is bigger problem than the one with aggregator controlling the loads. This is from Nordic history. The network has been strengthened so much already because of the cold winters and the heating. It isn't the biggest problem right now. [80]

DR causes problems

5.4.3 Possibilities

Better knowledge from the situation on the grid Data collecting also means a lot of opportunities for the DSOs. By knowing the consumption and how it is behaving in the grid gives the better understanding of the grid and DSOs are able to create their own processes and make the development of the business easier.

Better tools for Network Planning

Deferring investments with ancillary services

DSO as Market Facilitator huono kappale muokkaa

A lot have been debated on how to arrange the demand response today. With Smart Meters installed, now it is first time to make it possible to collect loads for controlling. Question remains that how should it be handled. Work Group for European Commission has suggested a model where DSOs and their AMR meters work as market facilitators. This means that a new service for this sector has born: DSOs have access to control the loads, for instance in Finland there is a vast amount of electrical heating that can be fairly easy take under control.

As we can see, by re-designing, unbundling the markets further even more functions come to the open markets. DSOs can sell this controlling service to the retailers in order to develop business further and also add value by making the system more wise.

With this controllability, conflicts may arise. What if everyone wants to control the loads in such a way that grid isnt going to hold it and some prioritising has to be done.

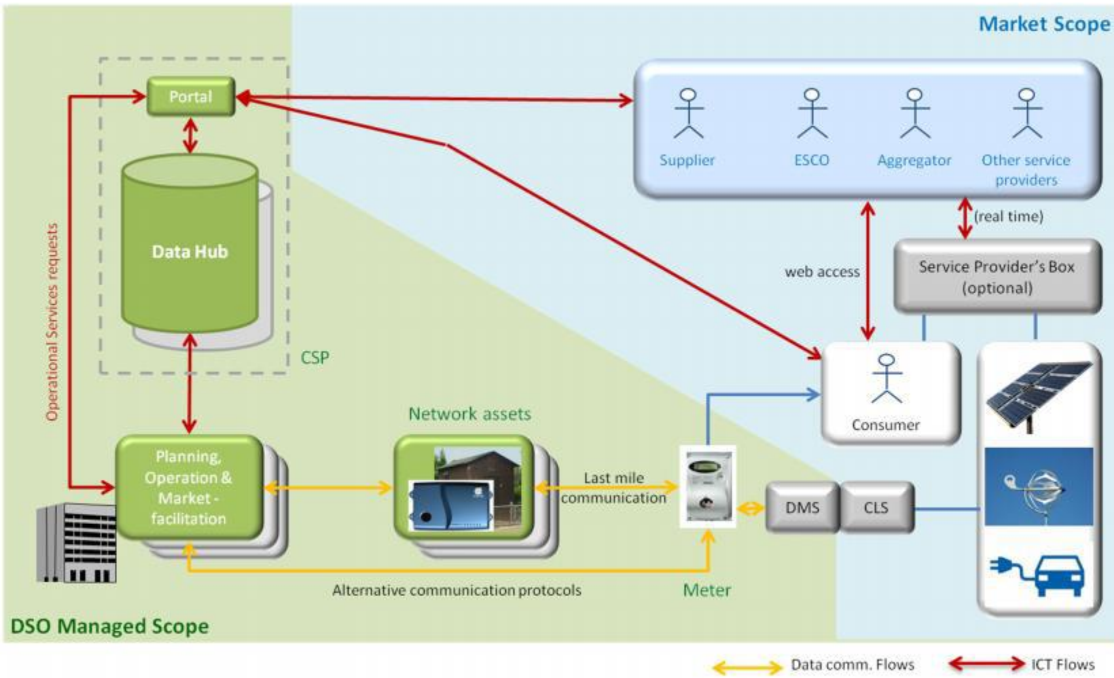

Figure 17: 'DSO as Market Facilitator' Market Model - High-level overview. Source: [11].

Challenges concerning this model occur.

So far, it seems that it is a very cost-efficient way of doing this. This model helps DSOs to have adequate view of their grid which means that security of supply can be kept in reasonable level.

5.5 TSO

5.5.1 Challenges

Lobbying for the Nordic Market Model in Europe On market perspective, the largest challenge for Fingrid is the ongoing European Market integration. Although the European Commission's target model for the market integration is similar to Nordic market model, it has caused a lot of resistance in Continent of Europe. There should be more drive to this target model direction. [76]

With responsibility to keep the balance of physical system, TSOs need to have a good prediction what are the implications of unflexible renewable energy for physical grid. With the integration to European Markets it is

Exploding Reserve costs

Forecasting becomes harder because of the tuotantorakneene muuttuu jäykemmäksi

5.5.2 Possibilities

Deferring investments with DR Jäppinen sees the benefits of the new functionalities coming from DR-side. "Building cables is a very expensive business. If there is a possibility to defer these further via DR it would bring huge benefits to the TSO. TSO doesn't need to design the cables according to peak power, which is needed only few hours per year if DR could reduce the peak in congestion situations. This means considerable amounts of money." [85]

5.5.3 Establishing a new Role

One segment that is important for TSOs in the future is to establish a working communication gateway in customer - DSO -TSO chain. There hasn't been any need for this in the past but now there should be more collaboration among these stakeholders to facilitate signals on what is happening in the grid. [76]

Data Hub Operator

5.6 Generator

5.6.1 Challenges

DER has an effect on markets

Subsidy policies It depends whether this fluctuation is a good or a bad thing. If you can have controllability over your production, the peaks are beneficial, whereas base power plants ie nuclear power plants care about the mean value over longer time period. That is, as long as there's not a situation where you don't have to ramp your power plant up and down.

Challenges start to occur when the system start to have significant amount of renewable production. When renewable capacity is high at the times so that it affects base load power plants behaviour, something must be done. There can be a scenario that there is overcapacity from renewable energy and base load power plants, eg a nuclear plant.

Either the renewable production should be constrained or the nuclear plant's production. With renewables the control is more easy nevertheless, when as nuclear plant's response time takes more. The peaks from wind or solar can escalate quickly, within an hour or even less.

[86]

Challenge is also with small-scale production and the vast amount of it. If it operates under normal, open markets, everytime there is good sun or wind situations the production increases drastically. This leads to electricity prices collapsing momentarily. If the generator sees only these prices, it doesn't have incentives to make a move to this business. [86]

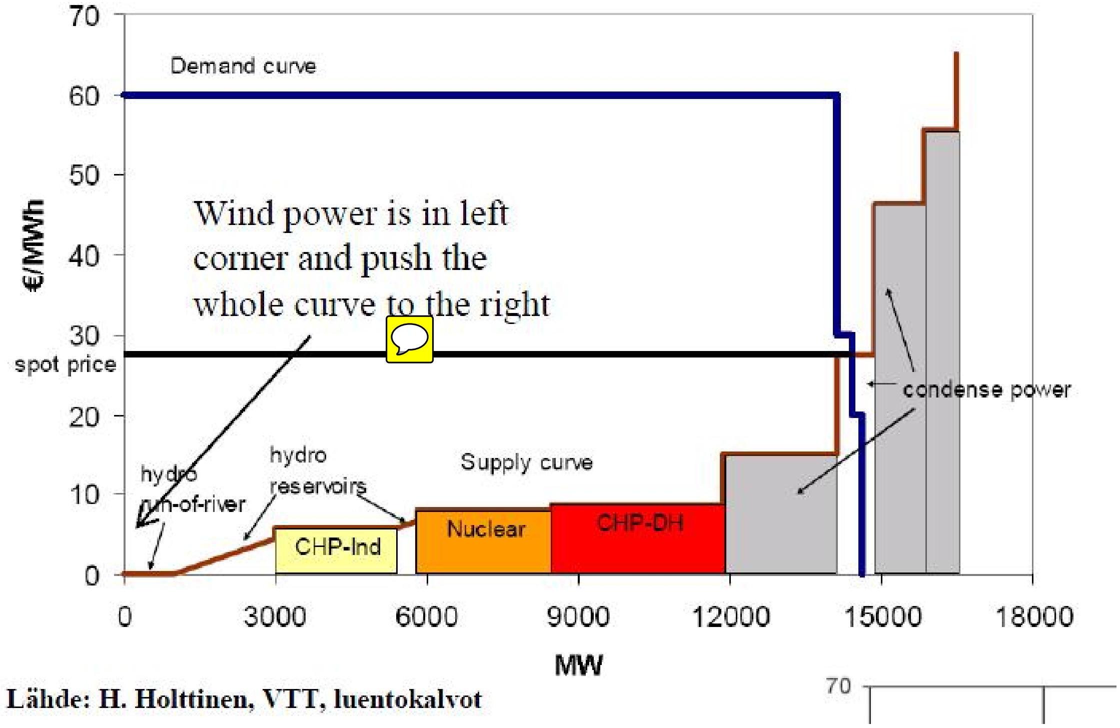

Figure 18: Renewable generation effects.

Of course in this context without bottlenecks and vast market areas, the problem isn't so straight-forward but still it adds extra concerns regarding the subject.

Capacity Markets Renewables should be more market-based. With huge feed-in tariffs it will just become messy. [89]

Capacity markets are discussed in Europe to smoothen the price curve. All these things gets us more away from the optimal solution. Capacity markets lead to situation which are regulated strongly, [86]

You have to be careful with actions regarding the capacity markets, it leads to inefficiencies since the idea is to have excess capacity that is not used - back to the old system. [76]

5.6.2 Possibilities

Value of flexibility increases Spikes are good for water and gas producers.

Taking advantage from tariffs and build wind power plants themseleves . Also more supply from DER can become risk if it is in big scale. These two functions press the prices down.

Also, there is a problem that in future flexibility will become even more valuable. What this means to traditional energy apart from water, is that the revenues will become smaller because of the inability to adapt in short timescale.

Forecasting will become more important, so maybe big companies have advantage in this. the better, more accurate the forecasting is, the better the results.

The role depends a lot on the system chosen from political policies. If the electricity markets work openly, and there will be large amount of microgeneration added to the mix it creates the situation where some investments are not needed from large utility company side. Then the generation level is close to optimal. When as if there will be capacity markets up and running, these investments for producting excess capacity means that there will be

With more flexibility in demand and more production out from their hands, it can mean that the Spot price will come down in a long run. Also the increased value of flexibility in short-term markets implies that the base-powered, traditional power plants with little possibilities to adjust the production, their profitability will go down.

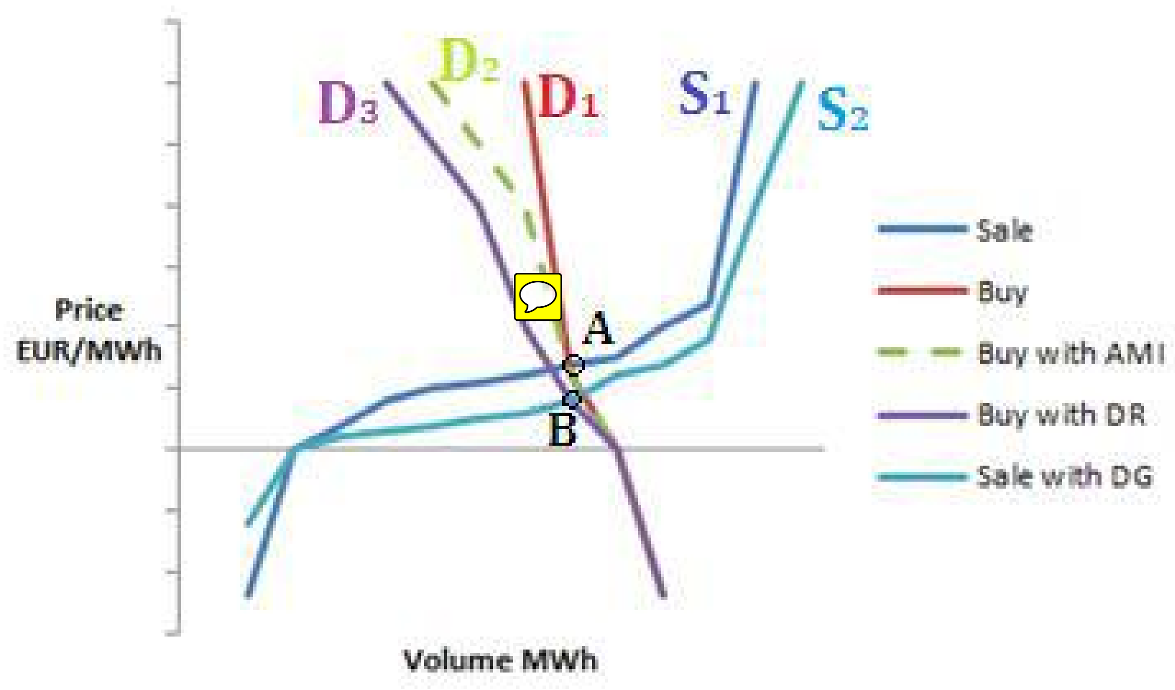

Figure 19: Effects of different techniques on price formation. [?]

What is good news in Nordics that huge amount of controllable hydro can be used to balance the situation more effectively.

With large-scale penetration of microgeneration coinciding with the trend that energy consumption may start to stabilize or even to start decreasing if all the plans for energy efficiency realize, the volume of electricity that is bought from the markets gets smaller.

The large-scale renewable generation with feed-in tariffs add the challenges to the energy-only market model as well from the reasons mentioned earlier.

5.7 Customer

Customers are the reason why all these things are done in the first place.

5.7.1 Challenges

Anxiety towards fairness From the market research, it was also noted that people might experience some "Big Brother watches you"-feelings. Many feel that in modern society there is a lot of surveillance even in places that are not necessary needed. It increases anxiety and adds more neurotic aspects to everyday life. [12]

5.7.2 Possibilities

With more accurate data collecting, the customers will get a lot better services from the retailers, etc. quality of services gets better, as well as more focused, custom-made services. Socially we go to the upper level, can be win-win situation.

Price levels With dynamic tariffs people encounter a conflict. A lot of them see the trade-off between convenience and benefit to change their living habits (save 2 cents when washing clothes at the right time). [12]

customer interface, (harmonization of the nordic retail markets)

Electricity contracts Electricity contracts should give the incentive to customer to save in expenses. If the contract is with a fixed price, it doesn't make any sense for customer to make any adjustments for their behaviour. [89]

Guidelines concerning load control The question about who gets the benefit and on what conditions with load control remains open. Demand flexibility has a lot of benefits to several actors and every solution means that it causes problems to other actors. One point of view is that the benefits from the DR go to the customer. When reducing the load at certain time, it means that something is not done, a part of the process experiences delay for instance. This action has an alternative cost. In order to get this flexibility to the markets, the benefit has to go to the player who is willing to change its behaviour. [91]

5.8 Summary

When finding new roles for the actors in the field, a more overall optimisation perspective is needed than today. The market mechanisms should be designed in such a way that system would be optimal for society and serve the means behind European Union's Energy Policy Preserving the Environment. This means that signals from markets but also in system level should be taken into consideration. This would mean that resources aren't used for nothing.

If the progress is steered too much in the direction of perfect competition it might cause unused resources. In the end the physical world is the one which sets the boundaries for everything and investments are done in vain just in order to build this market environment. On the other hand steering too much away from perfect competition causes unused resources. Long-term strategy should come from upper level and it should be transparent, clear and do not experience short-term corrective actions.

Data Hub has characteristics that could fit into the regulated side to get consensus and agreement from all parties to do it. This means that it is under the possession of a neutral actor. Fingrid as a data hub owner can be seen as a one solution. [84]

DSO and TSO stay still neutral parties, with some functionalities can be transferred to the open markets.

Retailer experiences more competition from aggregators and ESCOs.

Generator experiences lower Spot prices which means lower incomes for at least base load plants.

NP Spot has a pressure to enhance several functions of its market platform to more efficient.

6 Potential Conflicts of Interests

In this section the potential conflicts among players are reviewed. The nature of the conflict usually depends on what is the regulation scenario in question, examples could be for instance whether supplier centric model is adapted, or what happens if capacity markets occur. The scenario in which the conflict may appear are mentioned in each subsection. Many of them appear for reasons that were discussed in the previous chapter, from challenges that stakeholders experience. Also an aggregator and a retailer overlap in certain conflicts. This is because of the similarities: if an aggregator operates in wholesale and in retail markets it has no difference whatsoever compared to the role of the retailer.

Results have been acquired through interviews with industry experts, and evolved ideas further for possible additional solutions to overcome the potential conflict situation.

Potential conflicts are structured as follows. First, the short definition about the conflict. It is followed with more detailed description of the problem. Last, possible evasive action around it is proposed.

6.1 Customer – DSO

6.1.1 DSOs quality of service may be compromised

The increase of DER lead to increased volatility in voltage levels and in worst case can result in blackouts if the DSO cannot manage the local grid constraints accordingly. Standard EN-50160 mandates the DSO to be responsible of securing electricity availability to customer when needed. Due to the costs of grid expansions, quality of service DSO offers may be compromised.

Discussion Standard EN-50160 defines the voltage parameters of electrical energy in public distribution systems. It sets the quantitative values that service quality must deliver, by making the evaluation of the power quality possible.

The requirements become more expensive to fulfil with intermittent DER. Network reinforcements to integrate the new DG units are necessary, causing more costs to the DSO.

If the generation location starts to move to the areas where there hasn't been generation before, the cable capacity might be undersized. DSO has to re-evaluate its grid, since the situation can be that local congestions occur when the local production is over the local consumption.

Also the variations in voltage increases, causing harm to customer's devices.

Proposed Solutions As an regulated entity, the DSO has to provide certain quality level of service. Strengthening the grid is the traditional way around the problem but it is the result of strategic planning of the grid and applicable as an long-term solution.

With development in technology, DSO can widen the view to handle the challenge with new solutions: by using the SG components in order to use the grid more intelligently. For instance, DSO can invest to energy storages which have the capability to shave the peak and move it to a more reasonable time. Depending on business models, removing the bottlenecks with energy storages or through DR can be acquired from an actor from deregulated markets.

Solving the situation with a help of DER causes more potential conflicts. This is discussed in more detail in Chapter 5.4.1.

This conflict is only valid when there is significant amount of DER integrated and the grid experiences congestions. In Nordics it is not very current issue: the grid has been built to cope with vast differences in terms of capacity since the power levels fluctuate because of the electrical heating that is used in winter.

6.1.2 Guaranteeing privacy of consumers

AMM gathers detailed data from customers' behaviour. Ownership over the data, who can access it, benefit from it is not clear for the customer. Having control over data sets a lot of responsibilities for the DSO. Customers' privacy has to be ensured in every step it encounters in a value chain.

Discussion In Finland, the DSOs are obligated to measure and distribute AMR data to retailer for billing and to BRP for imbalance settlement purposes. From 2014, DSO is also required to deliver data to customer at the same time as it is delivered to BRP and retailer. The DSO alone is responsible for the accuracy of the data.

The ownership of the data is not defined explicitly. Thus, it is compared to personal data, meaning that DSOs are not allowed to submit the data to any other purpose than for billing and imbalance settlement without customers' permission. [94]

With AMM, the customer's electricity usage is monitored more in detail. This can be seen as a problem since it gives a rather detailed picture on persons' or families' living habits. As the world evolves to more digital, customers start to get interested on what is done with the data that is collected from them. In research it has been noted that many customers are scared about the loss of privacy. [12]

In future energy domain, companies that create services to customers are getting more interconnected and dependent. Call for ensuring the data privacy throughout the whole value chain exists. Through standardized architecture of the Smart Grid's communication interface can lead to successful result. [54]

Proposed Solution Customer acceptance is seen as a key success factor for enabling the Smart Grid. Therefore, privacy can be seen as a more important aspect than a cyber security. Transparent and clear communication towards customer is needed to avoid this conflict. The restrictions and anonymity level of the data gathered has to be explained to the customer very thoroughly. For customers searching information regarding this issue has to be made easy.

6.1.3 Cyber attacks expose the system to vulnerabilities

Smart Grid environment requires ICT systems, applications, Internet and different data exchange services. Adding ICT exposes the systems to cyber attacks.

Discussion As the crucial parts of the energy system is controllable through communication networks, vulnerabilities can be manipulated to even dangerous proportions. For instance it can be possible to shut down power from large areas, causing severe damage to every stakeholder.

Experts [54] commented that cyber security hasn't been taken enough into consideration in Smart Grid pilots. Reason for this is that cyber security hasn't been a major part of the design phase. Primary concepts of the smart grid, e.g. business models and functionalities need to be addressed and goals clarified prior more detailed concentration towards cyber security.

Moreover, the attack area expands via HEMS and DR-systems in customer premises when these are implemented as a part of Smart Grid. Usually these solutions are internet-based and the actions of the customers' premises are only dependent on customers' behaviour. Without control possibility this is regarded as highly risky part of the chain. [54]

Proposed Solutions More weight to the cyber security already in design phase helps it to become more concrete part of the system. By doing this already at early stage will save time and effort, and results in maximising security. The complexity of the system increases all of the time and all aspects regarding safety is hard to take into account afterwards. [54]

European Network and Information Security Agency (ENISA) has constituted a group to identify and research the issue of cyber security concerning Smart Grids. For more details, report can be found [54].

6.1.4 DSO's tariff does not reflect real costs

Today's network tariff is an energy-based tariff structure including a fixed fee. This does not have enough cost correlation from DSOs point of view. Also customers suffer due to the fact that everyone does not pay according to the expenses they generate: an old tariff makes discrimination possible.

Discussion Tariffs are the only source of revenue for DSOs. The situation is peculiar now since over 50% of DSO's cost structure is comprised of building sufficient capacity, but the tariffs have fixed cost and the variable cost on depending energy usage, not power usage. [**?**]

Problem is that energy doesn't reflect the actual costs DSOs are facing. In future the gap between price structure and investments grows even further. This is due to the changes on how the grid is used. More microgeneration implies that the grid is used more in a "battery-like"-way, i.e. taking electricity from there when own consumption is not enough and feeding electricity to the grid if there's excess amount of it. This results that less energy is moved. If the tariff is energy-based, DSOs lose their revenue stream which is needed to cover the costs of maintaining the grid.

Another problem regarding issue is that customers experience discrimination. An illustrative example of discrimination is presented in figures 20 and 21, where consumption of two customers are examined. Distribution tariff for both are the same, based on 3 * 25 A main fuse. As the costs for DSOs are dependent on peak power, Customer 2 causes higher costs for DSO since its peak power is a lot higher compared to Customer 1. Nevertheless, as the tariff is based on energy consumption and not the power component, due to higher energy consumption Customer 1 pays more. [?]

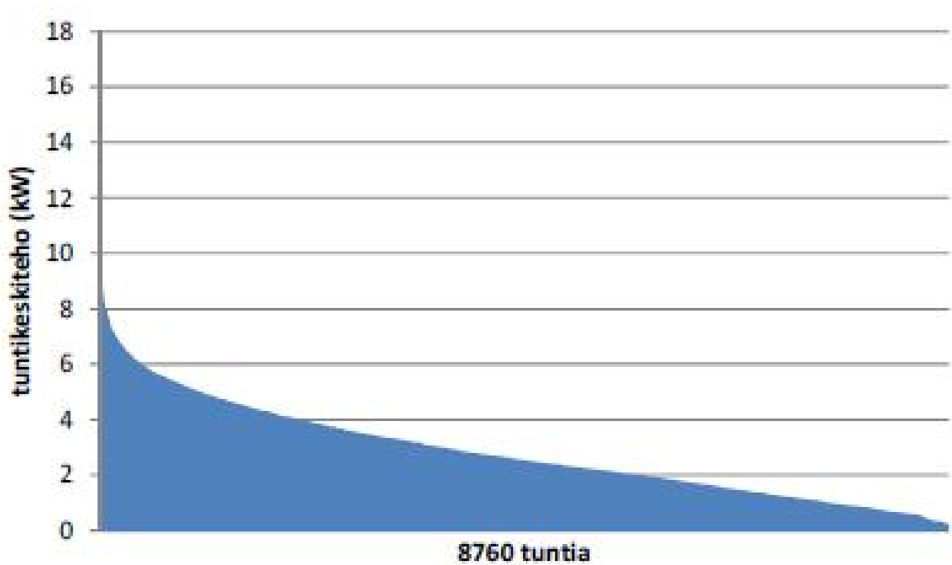

Figure 20: Customer 1: Yearly energy consumption: 24,9 MWh, peak power 12,4 kW. [?]

Proposed Solutions Different distribution tariffs are researched and studied to tackle this issue. "Power bandwidth tariff" is one potential tariff which has been proposed to solve the unfair situation. It is thought to be relatively simple for customers to comprehend since analogy can be drawn from the telecommunications business. Customers have an idea of this concept through their broadband internet contracts: the price depends on how much customer needs bandwidth. Essentially it is the same as the fuse size customers have now, but with more dense intervals in power scale. [78]

For DSOs bandwidth tariff would bring cost correlation: customers pay the correct price for their behaviour.

Even though bandwidth tariff would delete discriminations between customers, it has not been implemented yet. Customer's understanding may not be in such a

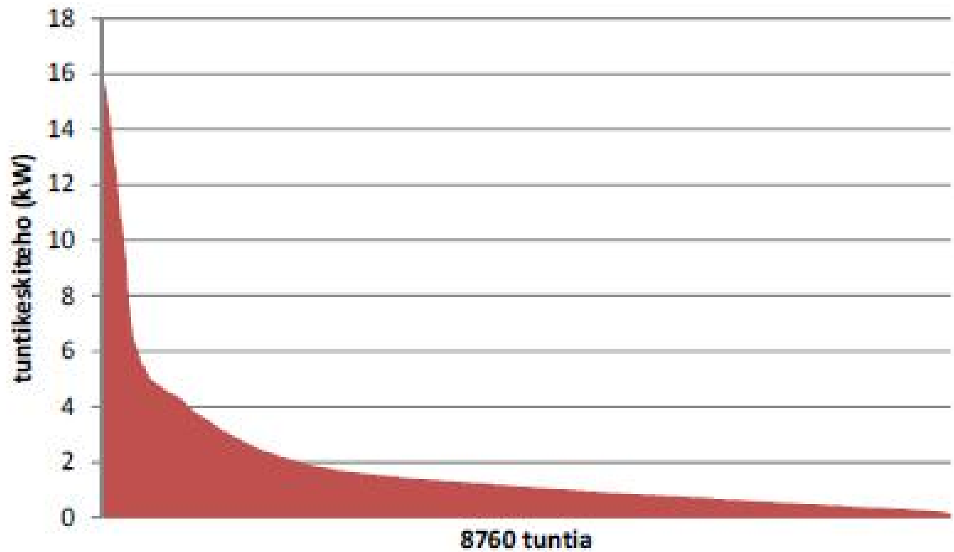

Figure 21: Customer 2: Yearly consumption 16,1 MWh, peak power 16,7 kW. [**?**]

good level as assumed. It is proposed that a new model is too radical compared to the old tariff which causes confusion among customers. Implementation should be done gradually so customers have time to adjust to the changes. [94]

Unease concerning the energy-efficiency is another potential threat. Now when both tariffs, transmission as well as electricity consumption are both energy-based, customer can realize on how one can save energy and therefore get financial benefit. Bandwidth tariff is seen as a potentially threat to energy-efficiency schemes. [84]

This reasoning does not take into account that with bandwidth tariff customer can make an impact to the size of ones distribution fee. As transmission fee is close to half to the total sum, this can bring financial incentives for customer to start being more energy-efficient.

More detailed studies about network tariffs can be found [1], [**?**].

6.1.5 DSO carries the risk for insolvent customer

In Nordics the DSO has the responsibility to sell electricity to a customer if one cannot find a retailer from the open markets. A risk from potential customer's insolvency is carried by DSO.

Discussion When designing the billing system the focus turns easily to question of risk management. Today, DSOs have an interesting role since it is required to deliver electricity to customer even if the customer is unable to get a contract with the retailer from markets. This can lead to a troublesome situation. If the customer is unable to meet its liabilities the DSO is financially responsible from the situation. The risk of this kind of insolvent customer is carried completely by DSO, whereas customer has no consequences for actions regarding the matter.

In a bigger picture when designing the future is to look at the mechanism of how the monetary transactions are done accordingly, where the right stakeholders carry the right risks.

If an actor is insolvent the sanctions should be dropped on the actor which causes the situation. Now it has been landed to the DSO without any compensation.

Proposed Solutions One way to solve this could be by paying the collaterals. This solution has drawbacks as well. With collaterals the market entry for the new, innovative start-up companies is made rather difficult. This isn't either the way on how we want the progression of the energy business to be heading. Still, more investigation on finding the healthy and sound solution to this incomplete situation is needed.

Another proposition is to transfer the distribution invoices to retailer, who then does the invoicing from customer. [84]

6.2 Customer – Retailer

Following issues regarding the relationship with customer and retailer were identified as a possible issues that needs solving or clarifying of the roles.

6.2.1 Vendor lock-in can reduce competition in markets

With increasing versatility of services provided, many of new services have a nature to be longer-term investments (e.g. solar panels, home automation). Lock-in through service contracts restricts customer's options in open markets, thus reducing competition.

Discussion Retailer can offer a variety of different services in the future. More detailed data from AMM expands the possibilities in product portfolio multi-fold, ranging from home automation to installing solar panels, possibilities are infinite. Basic energy contracts have smaller portion in the portfolio.

New technology solutions and devices are expensive with years of payback times. Contracts are adjusted accordingly, with longer commitments to the projects. Offering has to be done in this way for the products to be attractive.

It depends on how this is done. There can be a challenge considering the payback times of these new products, that the contract prolongs from what the customer have used to. This lock-in with the certain retailer can be seen as a challenge compared to the situation nowadays. For instance, these long-term contracts have changed telecommunications company and cell phone business' nature. With more strict and long-term contracts, the innovative start-ups have an extra barrier in order to penetrate to the market. Customers can suffer from this, as competition diminishes and large players have more strong dominance over the market.

On the other hand, longer contracts, when done properly, help customer to save money and learn about their energy efficiency. It is heuristic, long process that suffers if many parties participate in it. The learning curve of the customer is easier to evaluate when there is a longer relationship. [90]

This feature emphasizes in the future when the characteristics of customers are better known and therefore the custom-made solutions become more popular and widely used. From today's world the analogy could be subcontractors where using the same contractor brings benefits since these are longer projects where value is realized in long-term.

Proposed Solutions Consumer protection policies supervises customer's interests. This secures that the contracts and terms stay in reasonable levels. The contracts have to be made clear to both participants to avoid problems with interests. When agreeing to the fixed time period contract, a customer takes a conscious risk and gets benefits in return.

6.2.2 Dynamic tariff transfer the risk to the customer

Dynamic tariffs, like Spot-priced tariffs will become more popular in the future. [90] [87] [73] A Spot-priced tariff will transfer the risk of the market volatility to the customer. Customer does not have enough resources to take the advantage from Spot-tariff, and unpleasant surprises in electricity invoices might emerge.

Discussion As many of the conflicts with customer on the other side, this case originates from the level of understanding of a customer. What can be assumed on their knowledge. Many times the experts in the field don't see the normal people and their knowledge very clearly. How accurately a doctor for instance can describe what is wrong with patient? It comes from understanding the level of knowledge in the service co-creation, it ranges from telling you have a flu to explaining what is happening in the cell level in your body.

Is it easy to explain the vast variation of electricity prices to the customers. It takes a part of the risk of forecasting from retailer and brings it to customer. This can be a conflict, but also a possibility for the customer since now one really can contribute to the costs by getting the right signal from the markets. [90]

On the other hand, this service can be used to enable more services behind it. Customers lack time and desire to follow prices very accurately. Then retailer can provide additional service to do the demand response on behalf of the customer. Overall benefit margin to customer from this might become thin.

Proposed Solutions What is crucial on the subject is on how the dynamic tariffs are designed. The trade-off risk from constant priced tariff with premium against Spot-priced tariff has to deliver more value to the customer. Otherwise transition does not happen. Communication and clear information about benefits and the risks has to be explained to the customer in order to avoid unpleasant conflict situations. People like safety so the question is how much extra value it has to bring. Other incentives such as environmental values have to be taken into account. Retailers have to do very extensive market research to find a right marketing strategy.

6.3 Customer – Aggregator

In this section potential conflicts between customer and an aggregator are discussed.

6.3.1 Trade-off between convenience and benefits may not be sufficient

There is a trade-off between convenience and the benefits from shifting the loads to another time. Shifting loads have alternative costs, and benefit from this should be enough to be worth doing.

Discussion In Nordics the small-scale aggregation has some prerequisites to make business cases more viable. This comes from the fact that there are a lot of electrical heating installed in houses. Estimations of it has been measured to be close to 1200 MW: exploiting even a fraction can make a significant business. [27]

So far small-scale aggregation hasn't existed. In the past technical barriers have been on the way of exploiting this in large scale, the payback times of HEMS systems have been too long. This is connected also to the price level of the electricity, which has been low. Controlling loads have not been beneficial. Now the transition phase is on its way: technology has advanced and economies of scale has dropped the prices of devices to reasonable level. Energy consumption measurements have turned more accurate and real-time. Also developments in markets support demand response: dynamic tariffs are offered which enable the benefits from load shifting to customers.

With certain conditions small-scale aggregation is rational. For heating, it is easy to arrange without any harm done to the customer's comfort level. Situation changes drastically if aggregation is expanded to so called "white goods", i.e. appliances with large power in household level, stoves, washing machines, refrigerators.

General view is that going so deep to customer's everyday life is not possible. [77] [72] [80] The comfort level suffers too much compared to the savings achieved with behaviour manipulation. "In Germany political pressure is on this kind of things at the moment. We see this kind of action waste of taxpayers time and money. It will never happen." [77]

The trade-off between the money and the benefit seems to be the key issue. Electricity prices in the past have been a problem. It has been too cheap for the aggregation activities to take on hold. [74]

For larger customers it is easier to see the impact since the loads are much bigger and also convenience factors are not so relevant. Trade-off is done between saved money and causing fluctuations to process, either delaying or boosting certain part of the process.

Compared to small scale aggregation, discussing bigger scale aggregation has better situation business-wise, but a similar problem lies here as well. Through doing field work to acquire the control over processes, two comments come usually from customers:

1. People see that it is not worth to control the devices, since the saving is so small. An counter argument for this is that it would be beneficial to still take that sum, since implementing the devices is not very costly.

2. It is hard to show quantatively how much benefit one could get exactly, since the market prices vary year by year. Therefore selling of this kind of product can be tricky. [91]

Proposed Solutions Business cases for aggregation are viable, both in large scale and small-scale. Active role in promoting the idea for customer is solution for this to take on hold. It is still seen as a new thing and the practices regarding the implementation have not been established yet. When aggregation becomes more popular it has potential to grow at fast pace. [89] Also all the benefits from DR are not easy to see before doing pilots. "In one of our pilots the optimised load controlling resulted in more pleasant working environment. Compressor was controlled according to cheapest price hours, which are usually off-working hours. Now the noise disappeared during daytime. Employees were much more satisfied to the situation. One cannot find these benefits by doing only monetary calculations, but going out there and implementing the plan." [91]

6.3.2 Suspicion against giving away controlling possibility

When bringing something new and exciting ideas to the service business, the most important issue to put together is an aggregators' communication strategy. Customers can get anxious about giving the control away from them.

Discussion The potential service providers can see that there is not enough economical benefits for starting the collaboration. It is hard to establish trust between a customer and an aggregator. People are suspicious to give the control away from their own hands and the fairness of the dividend revenue from the loads can raise questions as well. In a sense this doesn't need to be conflict either. It just means that the trust has to be earned, and the contract has to be good enough in order to get the customer involved.

Also all the new ideas need assuring people how it really works, showing benefits clearly and where they form. The main point is that service should be effortless for them and the service delivers exactly what it promises. The service has to be very reliable from the very beginning. It was found that frustration can become too high if the service has reliability issues. It is crucial even in beta-phase to make sure the service does not experience too much uncertainties. [12]

Proposed Solutions The service offered has to be well-structured and designed to be as reliable as possible. "In future, customers need simple, functional overall solutions. They do not have time for solving the details. This service has to be offered to them as a package." [90] This means that the service portfolio has to be made comprehensible for a person who is not familiar with the energy markets.

6.3.3 Compensation for sold electricity is not sufficient

The trend for microgeneration popularity is rising. Amount of microgeneration can exceed consumption at certain times. In this situation excess capacity is sold to the markets. If the renewable energy is not subsidised, the prosumer gets the market price for its produced electricity. Customer might not understand the functioning of the markets enough and there is a risk that customer expects higher price than system price at that moment.

Discussion As the aggregation starts to develop VPPs, it might be that conflict emerges when prosumers see the fee of at what price is the aggregator willing to pay for the electricity. In a situation when there is good conditions for renewable energy production, it means that other microgenerators experience similar conditions as well. This generated overcapacity affects the system price by bringing it down. Without feed-in-tariffs, a single producer experiences this collapsed price. Selling excess production to the markets seems unattractive. [**?**]

The situation depends on what are the expectations of a customer for the produced electricity. Tariff prices are the ones that customer has accustomed to. Customer might expect to get the same price for the electricity he produces himself, which is not likely to happen. The tariff prices include the risk of the price volatility that a retailer carries, which means that customer might not be pleased to Spot-priced energy price.

Proposed Solutions Again, the root of this problem is the comprehension level of a customer. Problem would not exist if there would be clear understanding on how the price of electricity is formed. Teaching customers helps this process. Teaching is the best solution, but it is not realistic to expect this to happen. Therefore service providers can create services which take into account customers' interests by creating a variety of different services for different customer segments. Also communicating clearly the possible compensation sum before purchasing helps the general acceptance.

6.3.4 Resource Ownership can be seen as unfair

The ownership of the generation can have a variety of forms. Contracts and the allocation of the risks and benefits can cause friction between players.

Discussion After purchasing the microgeneration device, it is a question on how it is beneficial to arrange its cost. Ownership can be completely customers', it can be leased from retailer or ownership can be co-owned with another party. Prosumer starts to ponder the questions considering of the device's ownership and usage, how to get the largest benefit from it since single production units are usually too small for attracting buyers to energy.

Proposed Solutions Depending on the nature of customer and the size of the microgeneration plant, different solutions exist. This requires new approaches to the matter. New business models have developed for this issue. For instance in Denmark and Germany there is community-owned power plants or co-ownership of the utility with energy companies. [42] Co-ownership has proven to ease the resistance towards larger scale renewable generation projects.

6.3.5 Verifying the forecast consumption can be questioned

Consumers can have very unpredictable energy consumption, especially in households certain activities, such as going to sauna or doing the dishes can vary constantly. If load control concerns several different loads, showing the amount of load reduction can create a conflict. Customer's actions cannot be verified what would have happened without load reduction.

Discussion Doing load reduction or shifting by an aggregator may result in a dispute. This is because it is hard to show what would have happened without load control signals. This can be the case with customers which have highly variable energy consumption. [**?**]

Changing the consumers' consumption curve at certain level at certain time means that consumer can question on how much one could have used energy at that timeframe. If the load reduction calculations are done by comparing it to a reference curve, the reference curve can be challenged. Customer can argue that the peak shaving was bigger than aggregators' calculations show since during the load reduction period customer would have wanted to wash clothes and go to sauna. This is one reason why it is not easy to go to consumers everyday life.

Proposed Solutions Clear rules and boundaries about control signals erase this problem. If consumer can override the control signals there won't be disputes regarding what was left undone because of the load controlling. Applying control signal override-possibility to customer makes forecasting harder for the aggregator, and can result a obsolete system because of the customer's passive attitude towards aggregator concept. Also customer may see the service less interesting if it requires active participation.

6.4 DSO – Retailer

6.4.1 Different signals for load controlling

If DR is available through customer's load controlling, the control signal from market-side can be conflicting from the system-side.

Discussion Through AMR or HEMS it is possible for both actors to control customer's loads, but there can be the essential differences of the interests between

DSO and Retailer. DSO is responsible for keeping the system running within allowed limits, whereas the retailer wants to maximize the profit between sold energy and acquired energy from the wholesale markets. This can lead to problems since the lowest Spot-market prices does not always coincide with local network's power levels, creating unnatural power peaks and other unwanted features from the DSO perspective. [44]

Proposed Solutions By creating the market mechanism which would take into account the signals both from market-side as well as from system-side, the signal which needs the load reduction more will go through. In Section 5.4.1 the challenges with the market mechanism itself is discussed.

Also the signals might not be radically different always so the potential threat of this conflict can stay in small scale. In Chapter 7, the scale of this conflict, i.e. how much discrepancy in signals there has been historically in Finland, is examined.

6.4.2 DSO carries the risk from insolvent Retailer

Risk allocation is unequal between DSO and retailer, from the same reasons as in DSO and customer, see section 6.1.5.

6.4.3 DSO may lose the customer interface to retailer

Supplier-Centric Model has been discussed in politics considering the future developments of the markets. In Supplier-Centric Model customer would be only in contact with the energy retailer, no matter what is the case. Billing will be done only by retailer. This has caused resistance among DSOs. Losing the customer interface is seen as a danger: customer cannot get local, expert knowledge to problems regarding the grid. [**?**]

Discussion Regulation is leaning strongly towards Supplier-Centric Model. SCM is thought to be most customer-centric approach available: Customer has to contact only one party, has only one legal contract and receives only one invoice. Criticism regarding the model argues that benefits from the system are not enough compared to investments made: SCM requires very large-scale, reliable data systems with vast amounts of data transferring by DSO. In figure 22 basic structures of the two competitive market models are demonstrated.

Proposed Solutions Building a common large-scale data system requires strong guidance from regulation. This is due to the variety of opinions on how it should be solved. Market-based solution will be hard to get accepted since in order for this kind of data hub to work it requires that every party starts using it. [90]

6.4.4 DSO has possibility for market power in bottleneck situations

Synchronous load controls might cause bottlenecks to the grid. In order to avoid overload, the rules concerning priority has to be dealt with.

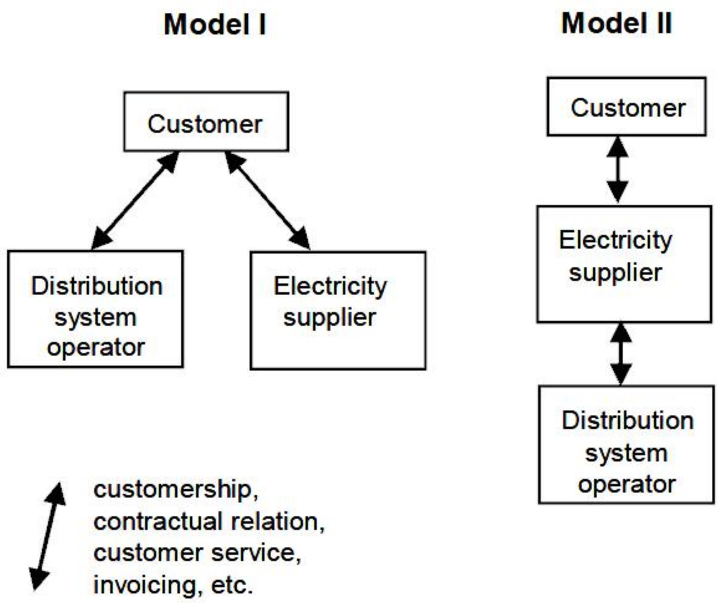

Figure 22: Present Market Model (left) and Supplier Centric Model (right). [55]

Discussion This conflict is relevant if the load control signals go through DSO for verification before taking action. DSOs role in verification is to ensure that the control does not cause danger to the grid stability. With this assumption, a scenario can be that certain area experiences power overflow if all the desired load control signals would be executed. Situation puts DSO to the difficult position, whether to decline some of the signals or no control is made during that time period. This distorts markets and is not optimal solution.

Possible Solutions Rules regarding prioritisation has to be formed in order to make the roles more clear. Bottlenecks should not produce discrimination, nor even a possibility to use market power for someone's own benefit.

6.4.5 More efficient data exchange causes costs for DSO

Data collecting and distributing it forward is DSOs task. Data processing will face more strict time limits in the future. This sets pressure to DSOs processes, whereas retailer benefits from this trend.

Discussion The pressure for the pace of data exchange is increasing, and even more so in the future. It is thought that it will be as frequent as in every 15 minutes. Data verification and distributing it forward puts strain to the DSO. It has to be done as cost-efficiently as possible. [84]

For retailer, it has positive effects. Data is available more instantly and can be used to its own processes in billing and distributing it to BRP.

Proposed Solutions If the pressure for faster data exchange comes from regulation, the compensation has to be enough to avoid unreasonably high costs which DSO faces. Cost investments for implementing efficient data exchange system can be hard to prefigure.

6.4.6 Use of electricity storages is not defined

Electricity storages can be used in benefit of DSO as well as Retailer. In order to avoid conflicts roles and responsibilities should be stated clearly.

Discussion Electricity storages and its ability of absorb energy at low price and feed energy during peak prices makes its characteristics similar to DR. In EURELECTRIC report two functional areas for electricity storages are identified:

- Energy Management – Decoupling the generation of electricity from its instantaneous consumption. (Arbitrage of energy)
- System Services – Services that are used to enhance the quality of service and security of supply in electricity power system. [53]

Areas confront each other. To use electricity to enhance quality of service means that storage does not participate in markets, which is distorting the competition. On the other hand, using the storage to do revenue through price fluctuations can cause problems to the grid through unnatural power flows.

Proposed Solutions Adapting new class of asset to the infrastructure always demands the role definition. Storage's capabilities to act as an generator or a consumer needs a set of rules. Comprehensive approach for all the costs and benefits storage cause need to take into account for integrating the electricity storages to the Smart Grid smoothly. [53]

6.5 DSO – Aggregator

6.5.1 DSO might be reluctant to share the data

There is no law that 3rd party may access the data received from Smart Meters. The DSO might be reluctant to give this data away, or is able to postpone the data transfer.

Discussion Data sharing is not DSOs core business, but it is required to collect the data. If it has to distribute the data to more parties than obligated by law, DSO might be reluctant to do this because it requires extra work.

So far, DSO has no obligations to share the AMM data to aggregator. This might hinder the entrance of the new actors to the field as agreements about data ownership are still open to discussion.

Proposed Solutions Either access to DSOs data has to be made more simple or an aggregator has to find another way around this obstacle, e.g. by measuring the data itself.

6.5.2 Aggregator can use market power to DSO

Aggregator can manipulate price of the DR higher than market price, if it offers DR services to DSO in order to avoid overcapacity situation.

Discussion This conflict has same characteristics similar to 6.4.4, where DSO might have possibility for using discrimination. Now the scenario is as follows: if there is no need from DSO to confirm the load control signal, an aggregator can raise the price of the DR to unreasonably high values. DSO has to buy it anyway in order to fulfil its duties regarding grid stability.

Synchronous control signals cause large changes in power flows which is against DSOs wish. If the signal for the load control comes only from market-side it results in ramped power flows.

Proposed Solutions If the system level signal could be brought into this, it would result in controlling the loads more evenly. Trade-off is that deregulated markets do not get full benefit from DR. Other solution is to make price ceiling for the services that are offered to the DSO. Thirdly, same solution as in 6.4.4 can be used. DSO can have right to limit the controls if there is danger situation.

6.5.3 Different signals for load controlling

The aggregation does not have differences concerning this conflict on this subject whether the aggregator is 3rd party or retailer. The main problem is that if the control signals come only from market-side, it might have coinciding effects on DSOs interests. This conflict is introduced in more detail in Chapter 7.

6.5.4 Aggregator may cause instabilities to the grid

DR can be implemented through several channels, like HEMS. Another channel for controlling loads is Smart Meter, which is owned by DSO. Controlling through Smart Meter DSO is part of the chain that is needed to execute switching of the load. With this control mechanism, DSO has understanding on the state of the grid at given time. If controls are made only by an aggregator without any verifications needed, DSOs lose the control and knowledge about what is happening in their own grid.

Discussion The reasoning on why DSOs are active in engaging load control through them is that it fulfils its task on ensuring the functionality of electricity markets. As DR will be an important part of the future's electricity field, promoting and helping to capture the benefits of DR is seen as a task for DSO to be part of.

How the DSO ensures the markets' proper functioning is to keep the distribution grid in balance, avoid bottlenecks and overloading of the grid components. From this point of view it is easy to see DSO's interest towards DR. DR devices cause impacts on grid's power flows. It is beneficial to sustain knowledge of the devices' behaviour. With signals coming to DSO-level about planned controlling schemes help DSO to be prepared to potential intensive situations proactively. The knowledge about the state of the grid remains in DSOs hands.

HEMS systems might cause imbalancing to the grid stability. Analogous control signals to loads always cause peaking of the power to the grid. Who will carry the responsibility of this action, if it causes emergency situations to the grid? If this is out of the DSOs hands completely, nothing can be done to stop it in a short time period. [75]

Proposed Solutions Collaboration with actors are strongly recommended. DR has to be in very popular before the load shifting has bigger impacts so it is not the burning issue. Nevertheless, it is beneficial for every stakeholder to make clear rules early enough.

6.5.5 Regulatory Bottlenecks for DR services

Regulatory framework can restrict the interest of DSOs to acquire DR services.

Discussion Depending on country, the regulation model for the DSO varies. Regulation in Smart Grid should be designed to take into account the new possibilities on deferring the grid investments, e.g. DR and electricity storages.

Today regulation does not support DR very efficiently. If DSO consumes peak shaving services, it reduces the need of physical assets. If regulation emphasizes stronger incentives for reducing operational costs with less focus on capital expenditures, DSO is uninterested on using DR services as an alternative solution for constraints. [6]

Connected to regulation and the nature of the role DSO has, it is hard to establish viable business model for DR services. According to Schulz: "In theory there can be a business model that you will sell DR services to DSOs. In Germany DSOs are struggling because there is a law that you have to buy the energy from small producers to the grid. In theory they are a good customer but in practice it will be a slower market to develop. This is partly because of the way DSO gets reimbursed. If they buy a new transformer they know exactly what to do, they buy this asset and they get their money back over time. If they buy software or IT service, the payback is not that easy since the approach is new. Regulation again: if there would be clear way how they would get paid for it, they would be good customers." [77]

Proposed Solutions As mentioned, a healthy attitude towards regulation and laws steer the development to the right direction. Regulation should encourage new, innovative business approaches.

6.6 DSO – TSO

6.6.1 Data Communication Interface is needed

DER demands interaction between DSO and TSO in order to keep the balance in the grid. Building interface is costly and views on how it is executed in practice vary among players.

Discussion Through DER, generation emerges in parts of the grid where it didn't exist before. In addition, this generation has different nature: more complex production patterns compared to the traditional power plants. A clear interface for DSO and TSO is needed and the operations models regarding it has to be created. At present there is none, because need for interaction hasn't existed. Before large power plants have stayed put. [76] Since there are several DSOs and several views on the outlook of the future, agreeing on interface common ground rules have proven to be difficult to solve.

Proposed Solutions It is crucial to get dialogue going between DSOs and TSO. Luckily, the actors have identified the importance of the subject. Rules about the responsibilities of reporting among actors has to be solved. [85]

6.7 Aggregator – Retailer

6.7.1 Losing market share to a new player

The most obvious challenge between these two players is that their customer segment can overlap. As mentioned earlier, if an aggregator decides to operate in markets, its role is exactly the same as the retailer. [48]

Discussion An aggregator can have different roles. From retailer's point of view, an aggregator can be an actor who helps customer to optimize the energy usage by reshaping the energy consumption curve. In this case, collaboration is needed in order to know what kind of changes there will be, considering the balancing settlement. Basically aggregator is an ICT service company to a retailer.

An aggregator can also be an actor in market exchange. The need for collaboration disappears and an aggregator becomes retailer-aggregator. Both actors can have same customer base, which means that competition gets better in electricity markets.

Proposed Solutions This conflict has only positive effects. Conflict creates natural development of markets closer to perfect competition. Penetration of aggregators to the energy business should be supported in order to enhance better market functioning.

6.7.2 Cost of forecasting errors

3rd party aggregator, which shifts energy consumption to different times than retailer forecasts can create a conflict situation.

Discussion Retailer's interest is to stay on the balance it has projected for energy consumption. Retailer has acquired the assumed amount of electricity from Elspot market. The margin between retailer's procurements and sales of energy has to be settled through imbalance power. The volatility of imbalance power prices cause extra risks and costs for the retailer. [36]

Proposed Solutions Collaboration with retailer is the minimum requirement expected from aggregation if an aggregator is not responsible for maintaining its balance.

6.8 Aggregator – Generator

6.8.1 Controllability of Base-load power plants and DER is limited

Base-load power plants, such as nuclear power plants are designed to produce steady generation output. With limited controllability to renewable production, scenario can be that at certain circumstances excess capacity may endanger the grid stability.

Discussion

Proposed Solutions Renewable production can be made flexible as well by introducing more intelligent controls where PV and wind mills can be dropped off from the grid in a controllable way if there is a surplus of production at some point of time. Also by introducing negative prices to the markets have the effect of restraining the overcapacity situations through better capacity design. Also DR balances out some of the threats that are introduced by uncontrollable production.

6.8.2 Demand Flexibility brings down the market price

Demand Flexibility presses down the market price and reduces the amount of peak prices. For generators this is not beneficial.

Discussion Peak prices come up when peak power capacity is ignited in order to meet the high demand. Peak generation units have high variable costs because it usually uses expensive fuel such as gas, causing the price to go up. In past demand has had little flexibility, so production has followed demand. If demand has flexibility, some of the energy consumption can be shifted to another time and the peak does not occur. Investing to peak power plants becomes less profitable if they are needed less. Also ones that are already built will experience the loss of revenue because peak generation units are not used as much as before.

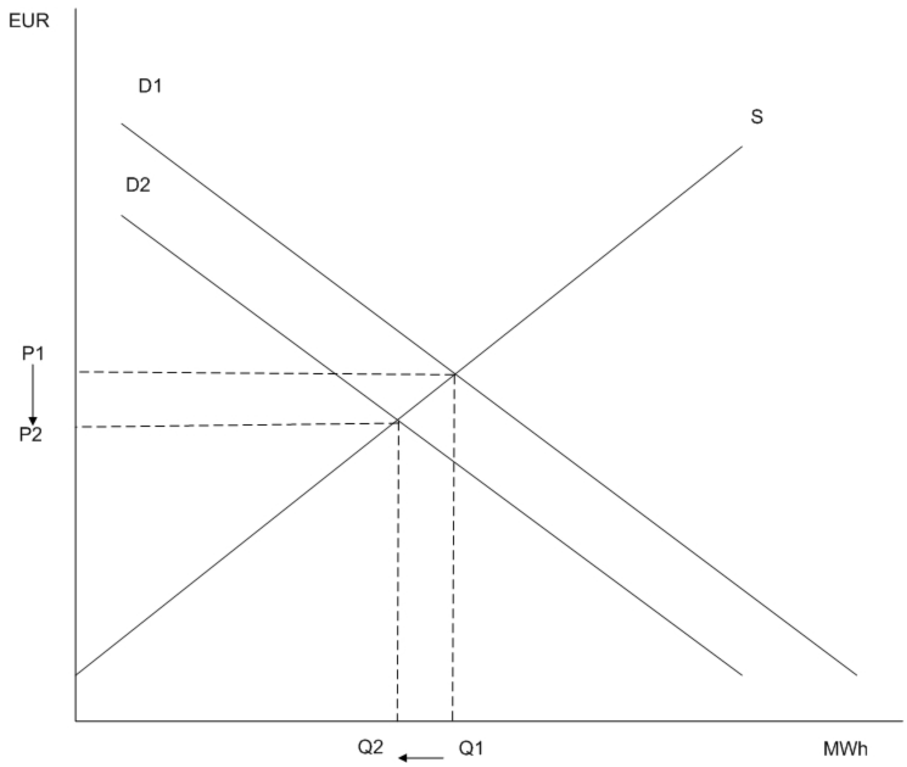

Figure 23: Demand shift causes the price to come down.

From simple demand-supply curve it is easy to show on how the DR affects the Spot-price. Investments to energy generation becomes less attractive.

Proposed Solutions Demand flexibility is beneficial for society. Issue is the relevance of this scenario: it can be a long time before demand flexibility is in such a large scale that it has effects on the market price. At the same time power plant investments are long-term investments, ranging from 10-20 years. Forecasting the payback time of these projects rapidly changing market environment has to be taken into account.

6.9 Aggregator – TSO

6.9.1 Regulatory framework to reserves are strict

TSO's requirements for different reserves can be very specific regarding the volume and the activation time. This can create a barrier for an aggregator to fulfil the requirements.

Discussion The current regulatory frame might impose too strict requirements on the volume or the availability of reserve power. Very detailed products fit better in traditional, large consumers or producers. Now, first solutions for aggregation services are emerging and supporting this kind of trend would be beneficial for the markets. TSO is in key position to help this kind of new solutions to take on hold. From TSO's perspective, an aggregator has an useful asset, so it would make sense to exploit it. At the moment it can be problematic for a small player like an aggregator to enter the market: critical mass needed is too large. It can be that it will be too hard to define the exact amount of capable reserve in the grid at the certain time. Reserves need to be ensured to be able to adjust accordingly, since the faults can be fast.

Proposed Solutions If there is a will to engage demand flexibility from small scale customers as well, changes in requirements is needed to enable it. TSOs could re-think their product portfolio and create products that can help aggregators to enter the market. It is beneficial to boost DR services further. DR has very positive effects on TSO's business, it helps to decrease costs that come from buliding reserve power and new cables. Reserve costs are expected to become multifold in the near-future, so there is definitely demand for a demand flexibility. [85]

6.9.2 Balancing destabilisation can cause volatility to TSO's balance sheet

If aggregator's actions create volatility in BRP's balance sheet, it can reflect to TSO as well.

Discussion TSO is responsible to keep the balance in its system area. This liability is delegated to BRP's who are responsible for the balance in the area they operate. Volatility in balance sheets from aggregator actions can reflect to BRP. If variation is large it can mix TSO's balance as well.

Proposed Solutions Communication through the different parties solves the problem. If there is efficient information exchange with aggregator, BRPs and the TSO, everyone could react to the situations caused by another party's actions. Magnitude of this conflict should be evaluated thoroughly, and the benefit what the expensive new information exchange brings should be larger than its costs. This might not be the case.

6.10 Aggregator – BRP

6.10.1 Restricting an aggregator's entry to market

Concerns about competition in the market for aggregating demand response are raised. If there is requirement for an aggregator to be in agreement with BRP about controlling the loads under BRP area, it can lead to a situation where BRP can resist this action. It is against competition standards.

Discussion BRP can have interests to obtain the boundary for an aggregator for restricting its market participation. This conflict depends on countries' regulations, but an example comes from France where the competition authority identified 3 reasons for BRPs to be against aggregator actions:

1. BRP might want to eliminate a potential competitor in the balancing mechanism, since a lot of BRP are electricity generators.
2. BRP is under developing its own demand response services. The French competition authority noted that several suppliers had their own service development programmes.
3. BRP might want to resist an aggregator entry if an aggregator action reduces its own customers' consumption. Consumption reduction reflects to BRP's revenue stream negatively. [25]

Proposed Solutions Regulators have to take proactive role to ensure a stable competition situation.

6.11 Generator – Customer

6.11.1 Own production diminishes the overall volume in markets

If customers start to evolve into prosumers, i.e. have own production, generators experience diminishing overall volume in market.

Discussion With promotion of DER, energy generation will increase in customers own premises. The overall volume that is acquired from the market exchange diminishes, which implicates that utility companies suffer revenue losses. Also with energy efficiency schemes that are promoted can decrease overall energy need which in turn brings energy consumption down. Third factor which affects to the energy consumption in the long run is the trend concerning energy-intensive industry. Industry has started to move away from Nordic countries to cheaper moving away from Nordic countries to cheaper price-level countries.

Proposed Solutions Transition should happen through markets. Then it is fair situation to all players, and utility companies take premeditated risk when initiating new power plant projects. Direction of the future should stay unchanged so that the utility companies and other actors can make longer-term plans and be sure that strategy applies throughout the whole asset lifetime. Uncertainty can hinder the decisions and create suboptimal solutions for society.

6.11.2 Distorting the Market with renewable subsidies

Wrong kind of incentives for renewable energy can distort the market's functioning and end up in non-optimal situation.

Discussion Incentives can have unintended and undesirable results consequences which do not lead to the action incentive-makers wanted in the first place. Therefore policy-makers have to be very careful in designing them. For instance, strong tariffs can create a wrong kind of incentive for the DER-owner to always produce energy as much as possible, regardless if it is needed or not. The signals from both system-level and market-level does not matter for the actor, since tariff guarantees certain sum per energy which is produced.

In a situation where there are lots of renewable energy production in the system, the generators without guaranteed tariff see the collapsed price resulting from overcapacity the system experiences.

Proposed Solutions Deciding on renewable energy subsidies policy-makers have to be particularly careful. Risk is that subsidies may distort the markets too much from equilibrium, causing unwanted features such as hazardous situations to whole power grid. Renewable energy should be put into the system through market-based solutions. If the markets let the price to go to negative, it would result better functioning markets: generators would have the incentive to restrict the production when it is not needed. Every actor should be exposed to the right signals and price levels, market's find more optimal equilibrium.

6.12 Collated Map of Potential Conflicts of Interests

Discussed potential conflicts and relationships are illustrated in figure 24. All the conflicts discussed above form a map where it is easier to see what players have similar interests and which players do not need to re-evaluate their position in markets. It has to be emphasized that the conflicts mentioned are only potential and many of them are not very serious. The point of the map is to reflect the opinions from the interviews and from literature what is the most common focus concerning subject.

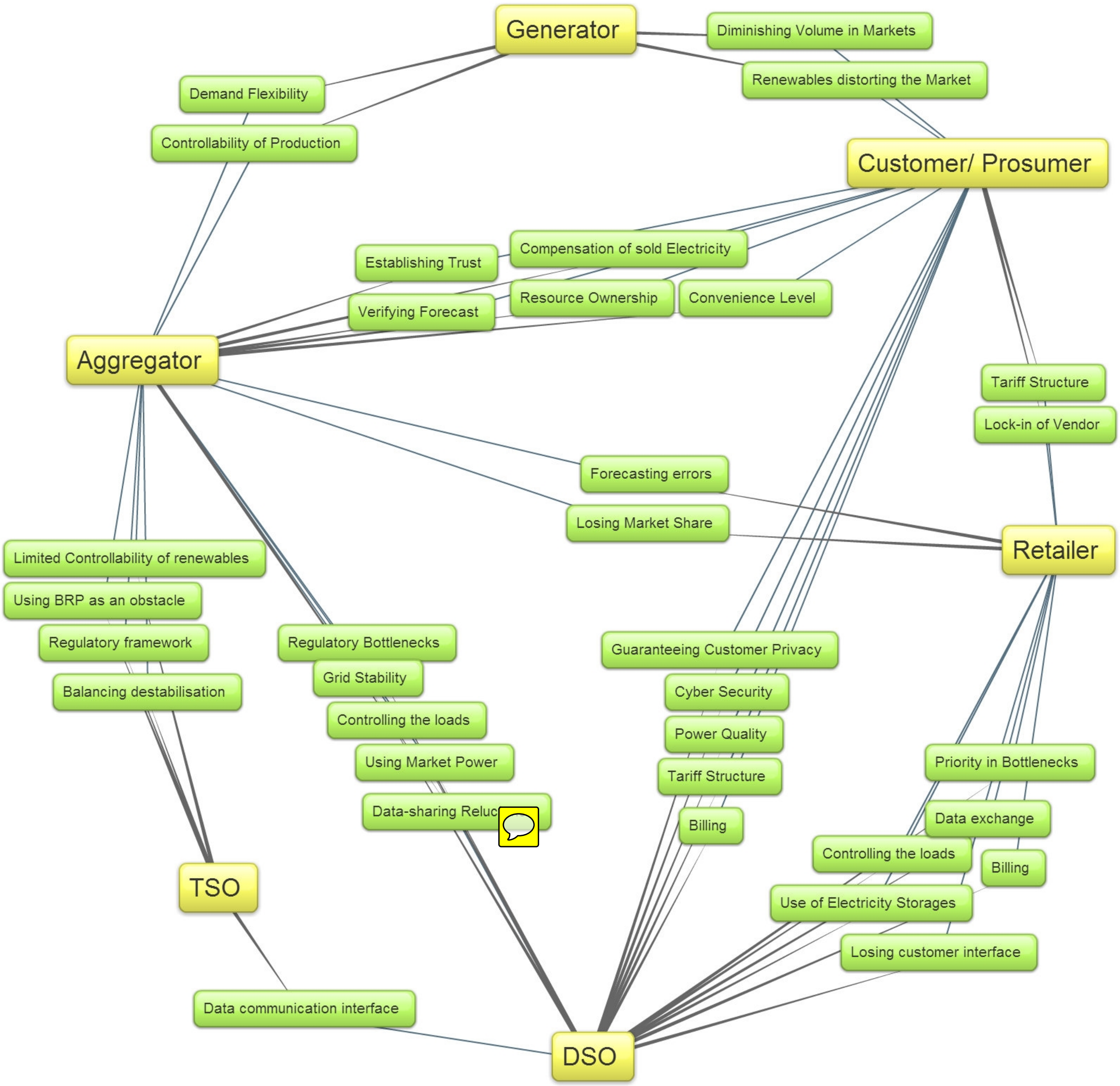

Figure 24: Map of Potential Conflicts of Interests.

7 Case study

7.1 Introduction

One of the main concerns in aggregator's emergence is the question of its effects on the grid. There can be a potential conflict of interest in aggregator business between the aggregator, who plays solely against the electricity markets, and DSOs, who would want to defer investments to the grid and have a predictable, smooth demand. It is suspected that aggregator's actions will raise the peak power, forcing the DSO to make additional investments on strengthening the grid against new peaks. Another negative impact can be the increased fluctuation in power flows. If fluctuation amplitude is large, the grid stability is harder to manage.

The aim for this case study is to give a clarification on what will happen to the grid if the aggregator will control the loads with market signals. In literature there has been two different views on how this will affect the grid:

1. This aggregator behaviour of controlling the loads will result more smooth load curves. It is a win-win-situation for both of the retailer as well as for the DSO. Retailer gets lower exposure to high prices and DSO will get lower congestions, lower losses and lower grid investments. [16]

2. Aggregator might create higher power peaks to the grid, since high demand aren't necessarily aligned with price peaks. This means that there will be a conflict of interest between these players. [1] [**?**]

This case study considers the relationship of these two players in future scenario where small-scale load controlling has a large share and is exploited in demand side response. Specifically the case examines what is the scale of the coinciding interests: is it just a minor difference in points of view or whether there will be a larger collision in interests. Or, does it cause any conflict whatsoever.

7.2 Background

In literature the situation has been discussed as potential source of conflict which should be solved proactively by creating rules and boundaries of who can do it and what is the mechanism and the price for it.

In figure 25 the interfering Spot price and feeder load are illustrated.

It is shown that the peak power and hourly spot prices interfere at 22:00, mainly because of the historical reasons on how the Nordic electricity markets have developed. Reasoning behind it is found when looking at overall system level. At 22:00 the demand isn't that high anymore: most of the public, commercial and majority of industry customers have stopped working at this point. But from historical tariff structures, the heating loads are turned on approximately at this time, which causes the interference locally in the grid. Also the consumption from private customers still exists. Together these two factors cause unnaturally high peak power. [40]

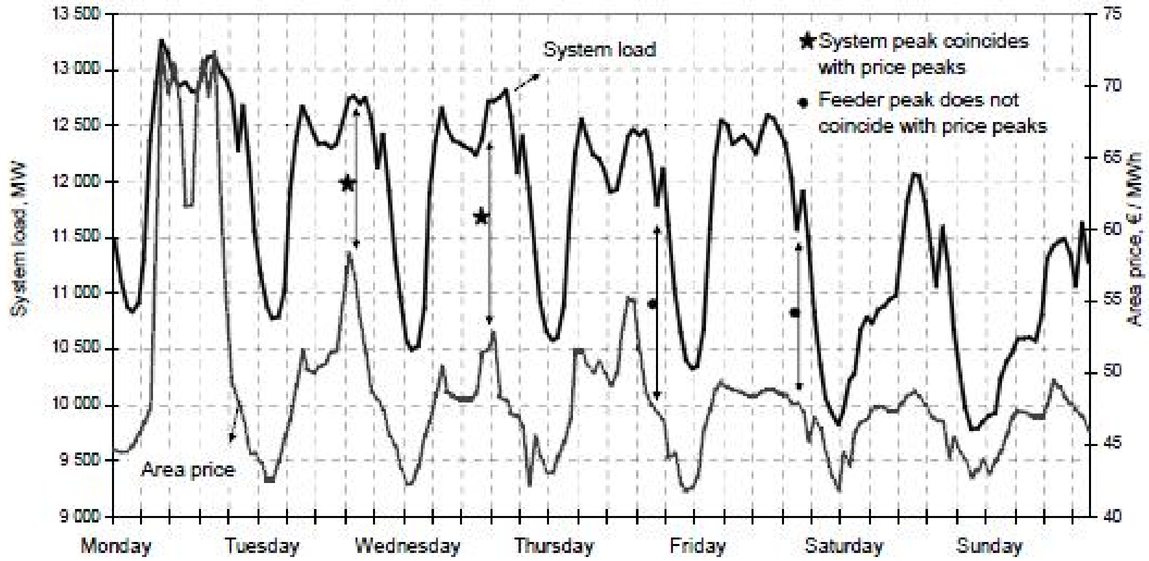

Figure 25: Hourly spot prices and powers on the time scale. [40]

In Finland, the utilization of small-scale demand response has been vastly researched. Characteristics of the country's electricity use makes it interesting: because of cold winters the electrical heating is a prevalent form of heating. Easy step to utilize it is to start by controlling the heating loads in houses. The electrical heating is rather popular in detached and semi-detached houses which are not built in district heating area.

The first step forward in this sector has been done recently. The Smart Meters can be used to do this controlling. A pilot project by Helen Sähköverkko Oy tested this approach to control the heating according to Spot prices has shown promising results. The technical aspects, the control signals for the meters have been reliable and the pilot is considered to expand further to reach 2000 customer by the end of the year 2012. [38]

Another way to do small-scale aggregation is through home automation. In September 2012 Fortum published a new service called Fortum Fiksu. If a house has a electric storage heating, is is possible to buy Fortum Fiksu when controlling system is installed to household. The controlling system determines the heating need every day and chooses the cheapest hours for it automatically. It is done in collaboration with There corporation who provides the ICT-systems to make the controls. [?] System also has connections to the future development. If the household has solar panels as well the system takes the own production in account as well and optimizes the consumption accordingly [39]

The case shows if there's potential challenges connected to this. It also shows the validity of services aggregator can sell to DSOs. One suggested service that aggregation will bring is Peak Shaving service, which can help DSOs to defer their grid investments further. The case will show whether this kind of service has enough demand to actually be economically feasible.

7.3 Assumptions

For the reasons mentioned in chapter 7.2., the created scenario has a following composition.

- An aggregator has a direct load control over electrical heating of the customers. The customers have agreed to give this controlling away from their hands with one condition: it shouldn't affect their standard of comfort, which means that the indoor temperature does not suffer for this.
- An aggregator operates only in Spot markets. The signal for the load control is fetched once a day from hourly Spot prices. An aggregator-retailer always chooses the cheapest hours for the heating that are needed that day, hedging does not affect on this process. This assumption is not so intuitive, but the hedging of the electricity doesn't have effect to this matter. Usually hedging is constant to a certain timeframe, which means that if there's a possibility to move physical acquiring of the electricity to the cheaper hours, it will always be profitable for the aggregator. [87]
- Case study is chosen to take place in a suburb of city of Turku in Finland. Characteristics of the area are optimal for the case focus: An area does not have district heating available and instead the households are heated mainly with electrical heating which helps to make the scenario quite close to reality.

Fortum's network calculating program gives the result that in this area there are 83 detached and 22 semi-detached houses with electrical heating behind one transformer. The potential of the area is vast for this aggregation and the impacts to the grid are apparent in this area. Information should be considered with reservation since the communication between customers and DSO is not perfect: it is not known if these houses have also some other sources of heating and if the houses are with direct electrical heating or with stored. With smart meters this data will be more detailed in future.

7.3.1 Data needed

In order to map the behaviour of system with dynamic tariff control, historical Spot prices from Nordics are needed. In this case study dataset consists of hourly Spot area prices in Finland from January 2010 until July 2012. Prices are available in Nord Pool Spot's webpage (www.nordpoolspot.com).

Determining the number of hours for heating needed per day, the outdoor temperatures are required. City of Turku kindly provided this dataset for the use of this case. Data was given with hourly temperatures of the timespan January 2010 until July 2012. From hourly values the daily average was obtained. The data was collected from Oriketo, which was closest weather station available, approximately 7 kilometers from Lieto.

Figure 26: A map of a case suburb.

The correlation with outside temperature and the heating need is needed to get some approximation of the system's behaviour. In this case the formula for the amount of hours per day is used:

$$f(T) = 3 + \frac{T - 13}{13}, T < 13°C \tag{1}$$

$$f(T) = 3, T \geq 13°C \tag{2}$$

This formula comes from empirical research and has been used in Helen Sähköverkko. [74]

With these datasets, the heating amount per day and the cheapest hours per day could be identified in daily basis in the timespan of two and a half years.

After identifying the cheapest hours, it was estimated that heating need stays the same compared to old situation and the graph was scaled to have equivalence with the situation experienced today.

7.3.2 Validity of using Spot-prices

A retailer-aggregator can offer different kinds services to the customer. Two possible pricing structures are introduced and explained why a retailer controls the loads according to cheapest Spot-prices no matter what contract model customer has.

Spot-priced tariff Retailer has access for the heating load and controls it by choosing the cheapest hours from Spot-markets, therefore reducing customer's electricity invoice. Spot-priced tariff transfers the price volatility risk from retailer to customer. From retailer's perspective, it doesn't matter at what time customer uses electricity. Transferring the risk to customer means that electricity are not usually hedged in this situation. Price offered to customer is a Spot price with fixed margin. If retailer would hedge the acquired electricity it would mean that margin would be unknown: the acquiring price is constant and sold electricity varies. If doing hedging, the retailer takes a calculated risk. [87]

Retailer still has to forecast the needed electricity one day ahead. This causes uncertainties to the retailer, independent from the tariff structure the customer has. With Spot-priced tariff, an extra variable is introduced to the forecasting: also the effects of demand response to customer's behaviour has to be estimated. The load dynamics has to be evaluated when acquiring electricity, how much the Spot price-dependence shapes the customer's consumption profile.

In this tariff structure, the signal comes from the Spot-markets. As the volatile electricity prices are exposed to customer, the retailer does not have interest regarding the point of time when the loads are on or off. Instead, the customer pays for the service: customer makes the contract which allows the retailer to control the loads, optimizing the usage to the cheapest possible Spot-hours. With Spot-priced tariff structure, using Spot-prices in calculations gives a realistic results about retailer's actions.

Fixed savings Another potential service imitates the contracts that are popular today. Customer has a fixed price for electricity, but a retailer offers a service where it can control the loads with certain boundaries and a customer gets fixed savings from the electricity invoice.

In fixed energy-based tariffs the risk for price volatility is at retailer's side. It implies that the retailer has an interest towards controlling loads in order to avoid price peaks and help to optimize the electricity acquirement processes.

Retailers are exposed to price and volume risks, caused by high volatility of the electricity markets. Different financial instruments can be used to minimise the exposure to these risks. Retailers try to lock the gross margin by hedging the estimated electricity need beforehand.

In figure 27 shows a simple example on how hedging can be done. For the Q1, the securing is started two quarters earlier, in the beginning of Q3. Hedging is done daily between two quarters, resulting the hedging level increase from 0 % in the beginning of Q3 to 100 % in the beginning of Q1. During Q3, a retailer secures daily a part of the electricity through forward product ENOQ1-10. During Q4, monthly forward products ENOMJAN-10, ENOMFEB-10 and ENOMMAR-10 are used to secure the other half of the needed electricity.

From hedging, the secured price level is constant for the whole time-frame in question. This results that if physical electricity acquiring from Spot-markets can be optimized to cheapest possible hours, it is beneficial solution for the retailer. [87] This is not so intuitive, but hedging does not affect to the function on how the

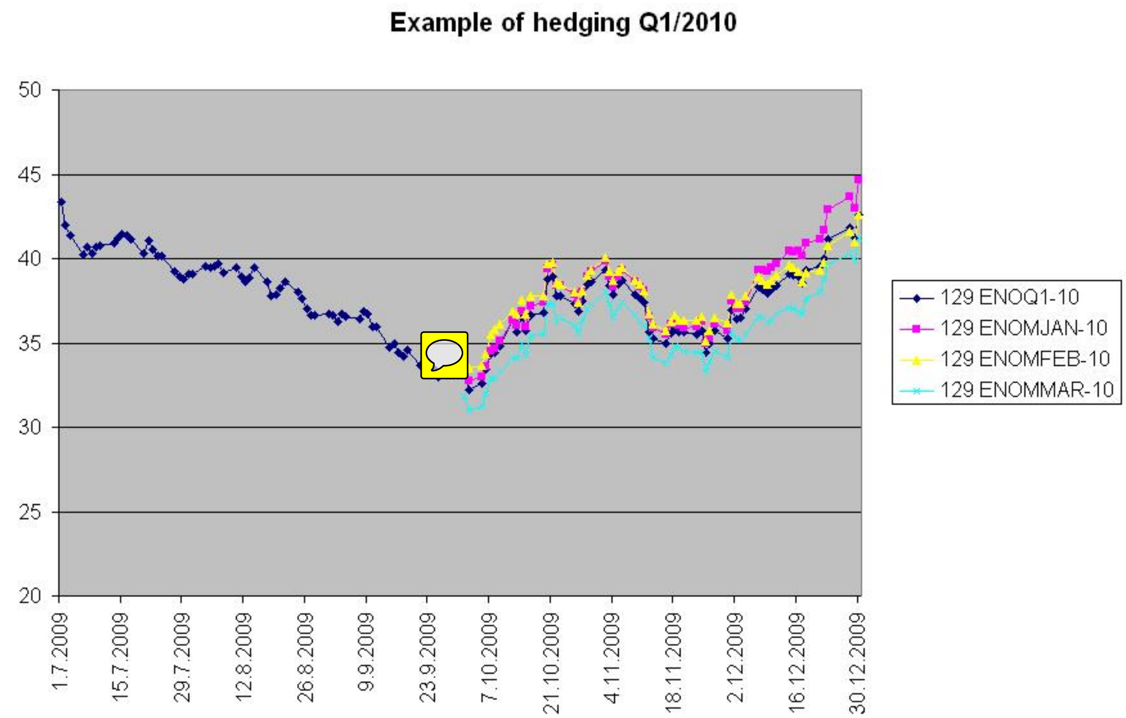

Figure 27: An example on how the hedging price is created for certain time period.

loads are controlled, if operating only in Spot-markets. Retailer always chooses the cheapest hours per day, regardless of the contract he has with a customer. Therefore Spot-prices are valid in simulating retailer's actions.

Obviously, this load control can be offered to other parties as well, e.g. DSO and TSO, but in this case study it is assumed that the control signals come only from Spot markets.

7.4 Analysis

This section covers the analysis and discussion of the findings. Analysis is done for the whole time-frame between 2010 – 2012 to see the overall effects on more intelligent control. Heating is needed most in wintertime, so section 7.4.2 concentrates on the effects that are experienced during winter, from the beginning of November until the end of the March.

Figure 28 clarifies the process on how the graphs are created. This process is repeated for every day between 2010 – 2012. Cumulative results give us insight on how the heating would have controlled in the past.

Calculations are shown in more detail in Appendix A.

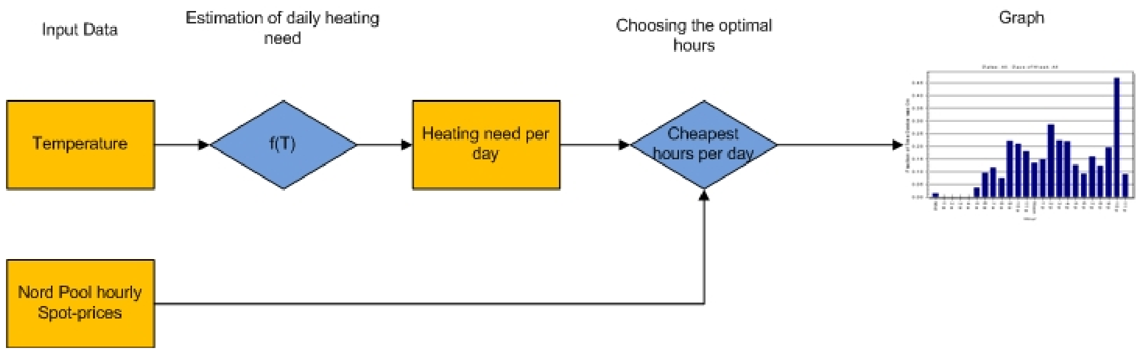

Figure 28: Aggregator behaviour simulation for one day.

7.4.1 Time period 2010-2012

Based on the calculations, an allocation in different hours of day could be created. Figure 29 presents the allocation of heating hours per year, i.e. cheapest Spot hours per day. From the graph we can see that shape of the curves are similar every year, with heating being used mainly very late at night. The heating need varies year by year, 2012 being warm causes diminishing heating hours. Interesting feature which Spot-based control introduces is the small cluster of cheap hours during daytime: between 12:00 – 16:00 a few hours would have been optimal to use for heating.

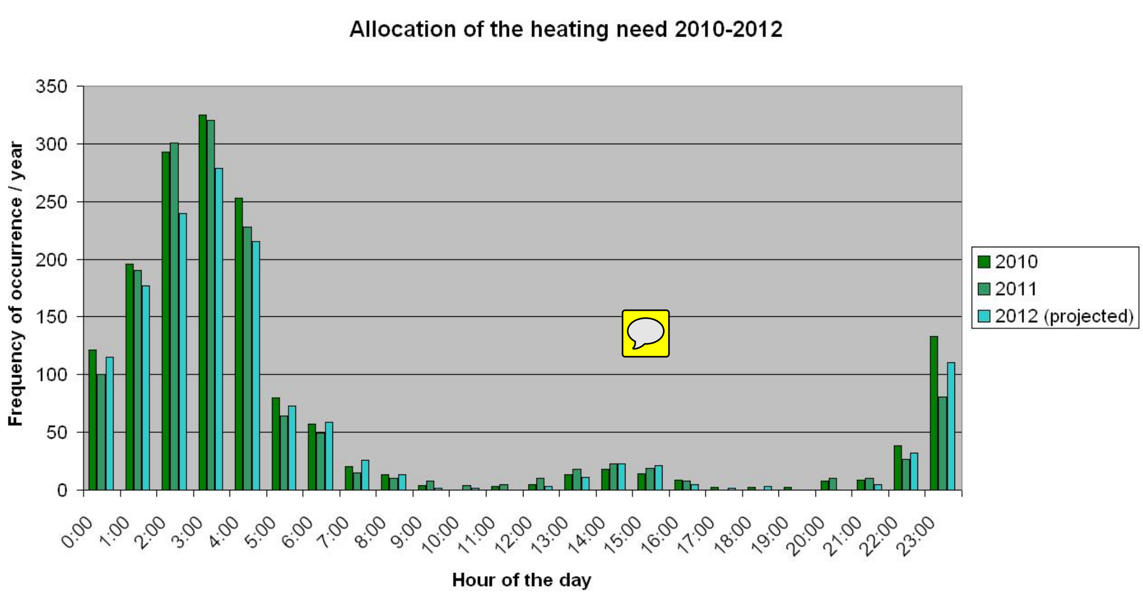

Figure 29: An average allocation of hours 2010-2012 (2012 extrapolated).

As it is shown, the heating hours are mainly in night time, starting from 23:00, peaking at 3:00 until fading approximately at 06:00. In normal households the consumption from other activities is rather small. Energy consumption for heating does not coincide with other consumption which implies that power peaks do not increase because of this action. Power peaks stay at the same level as before, but the 22:00 peak becomes rather exceptional than mundane. Price at 22:00 has not been very cheap historically, meaning that heating would not always be ignited at this time. Problem is that the DSO still has to design the grids to handle the worst case scenario, which is the 22:00 peak.

If the DSO would have an option to buy peak shaving services from these hours, it could defer the investments that come from strengthening the grid. In order to buy this kind of service, DSO should have an incentive to do so. More importantly, retailer has to make sure that DSO can rely to get the peak shaving when he needs it. Otherwise it becomes too risky for DSO to even consider this option.

7.4.2 Wintertime period

It is important to examine the most potential conditions for conflicts. This is in wintertime when the heating need and therefore the consumption of electricity is highest and the overloading risks of the distribution grid can be a potential threat. Winter is examined in more detail next. The wintertime in Finland is defined in literature to be between 1st of November until 31st of March. [41] The analysis of the discrepancies is shown in figure 30.

In graph 30 the difference is seen between the situation today and with aggregation against Spot-markets. Graph of optimised Spot-priced heating is an average from winters 2010-2011. The reference graph is a traditional consumption graph which is taken from a research of typical load diagrams, conducted in Finland and used generally. [41] The exact hour values of it has been redrawn from the drawing of the printed publication by the author.

From graph it can be seen that Spot-priced control changes the consumption curve radically. The heating hours shift to a later in the night. The traditional curve start heating already from 21:00, peaking at 23:00 and fading at 06:00. Spot-priced control has a tendency to begin heating at 23:00, peaking as late as 03:00 and fading at 05:00.

The peak power is likely to shift later in the evening. As it was mentioned in the introduction of the case study, the 22:00 evening peak is seen as a problem for the DSO point of view, what we can notice from the traditional consumption curve. This peak hour shift actually serves also the interest of the DSO since now it doesn't coincide with other consumption.

Standard deviation is defined as follows:

$$\sigma = \sqrt{\sum_{i=1}^{n} \frac{(x_i - \bar{x})^2}{n}} \tag{3}$$

where

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{4}$$

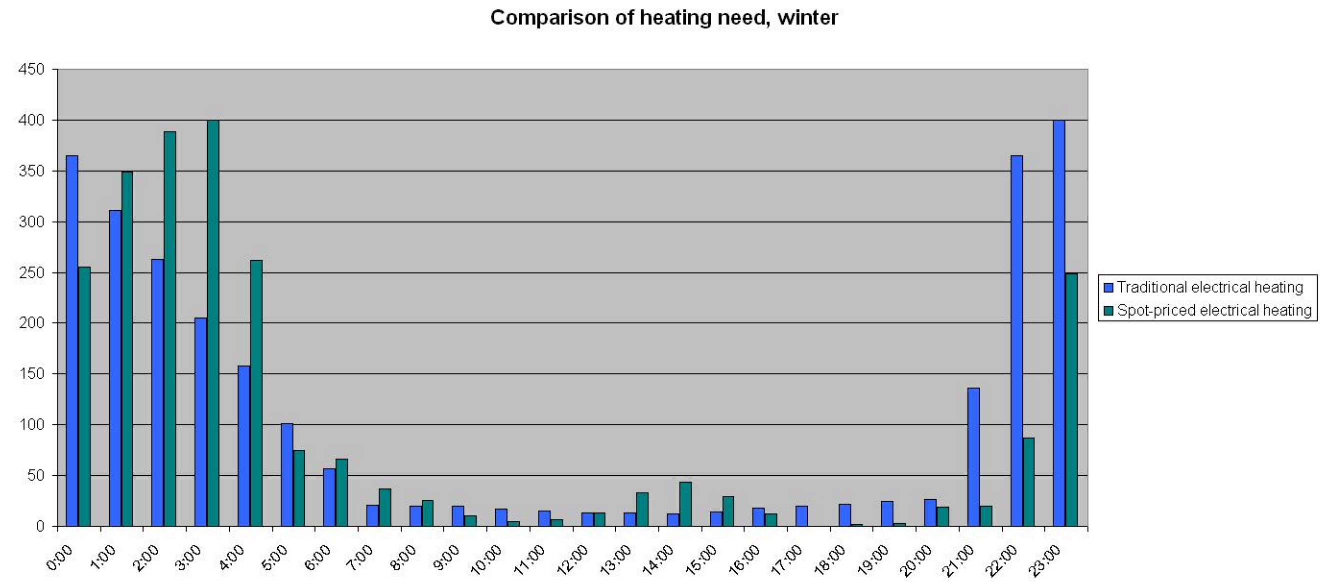

Figure 30: Change in detached house consumption curve (graphs standardized).

7.4.3 Monetary value of the service

This kind of control compared to traditional methods include large financial benefits, which can imply that it would be viable for the DSO to offer this kind of services to retailer with some dividend from the profits.

Estimations used for this is for the whole potential customer base in Fortum's network in Finland, which is approximately 50 000 customers. With 8 kW heating resistors, the monetary difference between traditional heating usage (turning the heating on at 22:00 until thermostat switches it off) and cheapest Spot-hours per day were examined. The results are presented in table 4.

Year	Spot average old	Spot average new	Difference	Heating need	Potential revenue
	EUR/MWh	EUR/MWh	EUR/MWh	hours/year	EUR
2010	52,30	48,10	4,20	1611	2 707 000
2011	48,13	43,30	4,83	1497	2 892 000
2012 (extrapolated)	30,29	27,92	2,37	1600	1 520 000

Table 4: Yearly differences in average spot prices and amount of potential saving.

Putting together small savings, in the whole network area the total revenue cumulates to very significant amount of money.

7.4.4 Fluctuation in Power Flows

A feature that is interesting for the DSO is the smoothness of the load curves. Frequent on and off-switching of large sized loads is not desirable as it causes variety of problems, ...FIND RESEARCH AND INSERT.. for instance. Also large variation in the amplitude of power flow means that utilisation rate of the cable is low, causing suboptimal investment for the grid.

On analysing the results, with very simple algorithm that takes into account just the cheapest hours per day, this trembling effect becomes more common. This was expected since intuitively the 3 to 9 cheapest hours in Spot are not always next to each other, whereas storage heating is started at the same time always until the thermostat turns it off. This kind of system behavior dampens when considering the subject at the distribution network level. The direct heating and other heating systems without the possibility to large scale storage possibility does exactly the same as the Spot-priced heating.

Further investigations on the effects of this flashing are needed, what are the implications of it to the grid, if any.

7.5 Results

7.5.1 Conflict situation

This case suggests that there is no conflict between aggregator and DSO, compared to the situation today. Of course the problem still remains that the cheap price in Spot prices coincides the evening consumption power peak as mentioned in [40], but closer exploration of the historical prices show us that most of the time electricity isn't necessarily cheap enough at 22:00 for an aggregator to put the loads on. The loads tend to be turned on at 23:00, continuing to rise and peak at 03:00. The interference with other consumption is reduced quite drastically. From this result it can be stated that even though signals come only from the market-side, it is win-win-situation for the both parties. With these estimations mentioned in 7.3., 2 major findings can be presented:

1. With Spot-priced control, the peak hour appear later at the night.

2. With Spot-priced control, the majority of the heating hours are shifted even later in the evening, resulting less interference to the other consumption.

7.5.2 Monetary effects

From analysis we get the result that in Fortum's network area the business case is viable, bringing savings for customer as well as for facilitator. The problem with this is in the category as in penetration of larger scale DR schemes as well: is there enough incentives for a customer to accept this kind of arrangement, if the saving potential is rather small, varying from 56 to 30 euros per year.

Another question, whether this would be done, is the retailers' interest for creating this kind of service. In order for customers to benefit fully from this the

Spot-priced tariff is a requirement. What this is resulting is that the retailer moves the risk to the customer. Usually these tariffs have the certain margin to cover the forecasting errors from actual consumption, but the risk of using or not using the electricity during expensive hours is transferred to the customer. What this means is that as long as the fee for retailer is energy-based, it doesn't make a difference on what hour the customer uses the electricity. Retailer acquires the electricity from Spot-markets and hedging is not needed. Only reason for the retailer to get interested in this is the competitive advantage over others for creating a product which helps the customer to save money and therefore making it look more attractive. 3rd option is to generate a product which would engage a part of the savings to the benefit of the retailer. This solution would acquire some agreements with a customer for the dividend of the sum.

7.5.3 Criticism

By going through the calculation process and estimations certain aspects that affect the result are discussed.

Sadly there were no AMR data available from the suitable targets, so still the analysis were done by using the estimation consumption curves. These are not accurate for several reasons. First of all, they are approximations to start with, and another, how people use electricity has changed. Still, they give good enough estimation about the nature of reality.

The calculations were done with simple model where heating were done by switching the heating resistors on and off. In reality the resistors can be controlled with more intelligence, by turning the heat on in parts and with different power.

Another estimation where aggregator-retailer only operates in day-ahead spot markets restricts the results. In reality the retailer can, and will act in other markets as well, like in intra-day. Alas, in past it has been noted that Elbas markets have been remarkably less volatile than Elspot-markets. [35] This might suggest that the main area of business for aggregator-retailer still is in Spot-markets. More detailed research on the business cases in Elbas-markets can be read from Valtonen et al [35].

The formula is always an attempt to depict reality. Even though the formula used (1) is empirically tested to have a relatively good approximation, it obviously has its restrictions and is exposed to error since heating need is a complex concept with a lot of variables.

In the case a direct control over heating is used, the customers do not have a right to override the signals. By removing the customer's behaviour reduces parameters, but what is the case when in reality it is possible to tamper the temperature. This simplifying procedure is acceptable, since the heating need is scaled to be constant at both cases: if they have got along well before nothing has changed. But, in reality an aggregator-retailer should take this into account that people might not be too keen to give all the control over to another party.

Rounding of the heating need hours to integers was done, in order to determine the amount of cheapest hours per day. This results to small variation of the indoor temperatures. It was needed partly because of the reason mentioned above, the aggregator puts on the heating for an hour or not.

The temperature dataset was lacking the dates 2.5.2010-6.5.2010.

The case study gives a hint to the direction that the situation turns to win-win situation for the DSO and aggregator. It could be useful to examine the effects on the grid in more detail when there will be real, more detailed AMR-data available.

Nevertheless, the estimations and approximations done are valid and do not affect the precision of the result too much.

8 Conclusions

As the fast evolving market environment changes, it has a huge impact on the actors nowadays to react to new challenges. As there are only guesses on how fast the market will change, it means that the players have to proactively try to foresee the new dynamics and try to establish their changing role in new environment. This change brings a lot of potential conflicts of interests in the future as the roles and responsibilities are to be re-evaluated.

It also means that different actors have to make vast strategic decisions on which way they start to steer their position. This can cause a more fragmented and positioned energy markets to europe, and in shorter term, in nordics.

As the energy markets in nordics has some strange anomalities with certain parts regulated and other parts more open to competition, as the timeframe moves shorter these responsibilities and parts of the market processes can be re-engineered in order to fulfil this goal of optimization of the energy markets.

References

[1] Perälä, S. *New Network Tariffs: Economical Effects and Possibilities for Demand Response.* Tampere University of Technology, 2011.

[2] Aalto, J. *Development opportunities for smart metering services in private customer interface.* Tampere University of Technology, 2012.

[3] Wilks, M. *Demand Side Response: Conflict between Supply and Network Driven Optimisation.* Pöyry, 2010.

[4] Kalatie, S. *Sähkön markkinahintaa selittävät tekijät.* Lappeenranta University of Technology, 2006.

[5] Kilpailuvirasto. *Kilpailuviraston vuosikirja.* 2007.

[6] Six, D, Fritz, W and Kessels, K. *Potential Barriers and Solutions for Active Demand: a Qualitative Analysis.* ADDRESS, 2010.

[7] EURELECTRIC *Smart Grids and Networks of the Future.* 2009

[8] IEA *Smart Grids: Technology Roadmap.* 2011

[9] Timmerman, W., Huitema, G. *Design of Energy-Management Services - Supporting the Role of the Prosumer in the Energy Market.* 2009.

[10] Shandurkova, I., Bremdal, B., Bacher, R., Ottesen S., Nilsen, A. *A Prosumer Oriented Energy Market* ImProsume 2012.

[11] European Task Force for the Implementation of Smart Grids into the European Internal Market. *DSO as Market Facilitator.* 2012.

[12] Heiskanen, E., Matschoss, K., Saastamoinen, M. *Asiakkaan näkökulma älykkään sähköverkon lisäarvoon.* Kuluttujatutkimuskeskus, 2012.

[13] Eisenmann, T., Parker, G., Van Alstyne, M. *Strategies for Two-Sided Markets.* Harvard Business Review, 2006.

[14] Hagiu, A., Wright, J. *Multi-Sided Platforms.* Harvard Business School, 2012.

[15] Kirschen et al *Factoring the Elasticity of Demand in Electricity Sales.* IEEE Transactions on Power Systems, Vol 15, No 2, May 2000.

[16] Lambert, Q. *Business Models for an Aggregator.* KTH, 2012.

[17] NordREG *A Common Definition of the System Operators' Core Activities.* 2006.

[18] Timmerman, W., Huitema, G. *Design of Energy-Management Services - Supporting the Role of the Prosumer in the Energy Market.* 2008.

[19] Ackermann et al *Distributed generation: a definition.* 2000.

[20] Jussila, Sinikka. *Use of electricity storages in Smart Grids.* Tampere University of Technology, 2010.

[21] Viljainen et al. *Vision for European Electricity Markets 2030.* Lappeenranta University of Technology, 2011.

[22] van Werven, M.J.N. et al *The Changing Role of Energy Suppliers and Distribution System Operators in the Deployment of Distributed Generation in Liberalised Electricity Markets.* EC: DISPOWER project, 2005.

[23] Bröckl, M. et al. *Harmonization of the Nordic electricity retail market - benefits and challenges.* Gaia Consulting, 2012.

[24] Partanen, J. et al. *Jakeluverkkoyhtiöiden tariffirakenteiden kehitysmahdollisuudet.* Lappeenranta University of Technology, 2012.

[25] Bird & Bird Energy Newsletter *A recent opinion of the French competition authority highlights concerns about competition in the market for aggregating demand response.* September 2012.

[26] *The Nordic Electricity Exchange and the Nordic Model for Liberalized Electricity Market.*

[27] Segerstam, J., Junttila, A., Lehtinen, J., Lindroos, R., Heinimäki, R., Hänninen, K. & Salomaa, P. *Sähkön kysyntäjousto suurten loppuasiakasryhmien kannalta.* Energiateollisuus ry, 2007.

[28] Häppölä, J. *Nordpool spot volatility modeling and option pricing* Aalto University, 2011.

[29] Christian Mugele, Svetlozar T. Rachev and Stefan Trück *Stable Modeling of different European Power Markets.* Universität Karlsruhe, 2005.

[30] Ronald Huisman, Christian Huurman and Ronald Mahieu *Hourly Electricity Prices in Day-Ahead Markets.* ERIM Report, 2007.

[31] Gaia Consulting *Nordic electricity peak prices during the winter 2009 – 2010.* 30.9.2010

[32] Amundsen, E. S., Bergman, L. *Why has the Nordic Electricity Market worked so well?* University of Bergen, 2005.

[33] Von Der Fehr N-H., Amundsen, E. S., Bergman L. *The Nordic Market: Signs of Stress?* Article, 17.3.2005.

[34] Bergman L. *The Nordic electricity market - continued success or emerging problems?*

[35] Valtonen, P. et al. *Business process of the electricity retailer in smart grid environment.* SGEM 2012.

[36] Valtonen, P. *The role and business potential of customer load control in an electricity retailer?s short-term profit optimization.* Nordac conference paper, 2012.

[37] Ruska, M., Similä, L. *Electricity markets in Europe: Business environment for Smart Grids* VTT, 2011.

[38] Nousiainen, M., Seppälä, J. *Hyödyt irti etäluennasta.* Presentation in Energianmittauspäivä-seminar. 29.9.2011.

[39] *There tuotteisti yhdessä Fortumin kanssa uuden kuluttajapalvelun, Fortum Fiksun.* Newsletter, 12.9.2012. Available: http://www.therecorporation.com/en/node/150

[40] Belonogova, N. *Effects of Demand Response on the Distribution Company Business.* Nordac conference paper 2011.

[41] Suomen Sähkölaitosyhdistys r.y. *Sähkön käytön kuormitustutkimus.* 1992.

[42] Wolsink, M. *Wind power implementation: The nature of public attitudes: Equity and fairness instead of 'backyard motives'.* Renewable and Sustainable Energy Reviews, 2005.

[43] Ikäheimo, J., Evens, C., Kärkkäinen, S. *DER Aggregator Business: the Finnish Case.* VTT, 2010.

[44] Belonogova, N., Kaipia, T., Lassila, J., Partanen, J. *Demand response: Conflict between Distribution System Operator and Retailer.* CIRED conference paper, 2011.

[45] European Smart Metering Alliance. http://www.esma-home.eu/glossary/

[46] Setiawlan, E. A. *Concept and Controllability of Virtual Power Plant.* Ph. D. thesis, 2007.

[47] ERGEG *Position Paper on Smart Grids: An ERGEG Conclusions Paper.* 2010.

[48] Lehto, I. *Mikrotuotannon liittäminen yleiseen sähkönjakeluverkkoon.* TKK, 2009

[49] Gulich, O. *Technological and Business Challenges of Smart Grids.* LUT 2010.

[50] Top Team Energy *Innovation Contract Smart Grids Headlines of a public private partnership and Innovation Agenda* 2012.

[51] Ng, M-Y. *Drivers for Smart Grids.* Presentation, ABB, 2009.

[52] Nobelius, D. *Towards the sixth generation of R& D management.* Internal Journal of Project Management, 2003.

[53] EURELECTRIC *Decentralised Storage: Impact on future distribution grids.* An EURELECTRIC report, June 2012.

[54] European Network and Information Security Agency. *Smart Grid Security: Recommendations for Europe and Member States.* Deliverable, 1.7.2012.

[55] Annala, S., Honkapuro, S., Viljainen, S. *Customer in electricity market.* LUT, 2009.

[56] Olsson, H., Yalin, H. *Market concepts and regulatory bottlenecks for smart distribution grids in EU countries.* Uppsala Universitet, 2011.

[57] Chr, N. *A general market for flexibility services for both DSO, TSO and others.* NORDAC Conference paper, 2012.

[58] EURELECTRIC *The Role of DSOs on Smart Grids and Energy Efficiency.* January 2012.

[59] Nord Pool Spot *No. 19/2011 - Nord Pool Spot reduces gate closure on Elbas in Germany.* 31.3.2011.

[60] North European Power Perspectives *The Role of The Nordic Power System in a Truly Integrated Pan-European Electricity Market.* Presentation, 2012.

[61] $http://ec.europa.eu/energy/gas_electricity/index_en.htm$

[62] Supponen, M. *Factors that influence the targets and criteria for electricity interconnector investments.* European University Institute Working Paper, 2012.

[63] Lundin, M. *Market integration – how a power exchange faces the challenge.* Presentation in Fingrid's Sähkömarkkinapäivät, 2011.

[64] EURELECTRIC. *Decentralised storage: impact on future distribution grids.*

[65] European Commission. *Recommendation on preparations for the roll-out of smart metering systems.* 9.3.2012.

[66] Bjørndal, M. *Electricity Market Developments in the Nord Pool Area.* Presentation 8.3.2012.

[67] $http://www.fortum.com/projects/solar-economy/pages/default.aspx$

[68] Tuovinen, K. *Retail Competition in the Nordic Electricity Markets.* Helsinki University of Technology, 2009.

[69] European Commission. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the committee of the regions: Making the internal energy market work.* 15.11.2012.

[70] Linnarsson, J. *Kapacitetsmarknad.* Presentation in Elmarknadsdagarna 8.11.2012.

[71] Linnarsson, J. *Quantitative assessment for a European Capacity Market.* Presentation 19.6.2012.

[72] Päivärinta, Joonas. Development Manager, Helsingin Energia. Interview in Helsinki 27.7.2012.

[73] Segerstam, Jan. Development Director, Empower. Interview in Espoo 28.6.2012.

[74] Heine, Pirjo. Electric Grid Expert, Helen Sähköverkko Oy. Interview in Helsinki 28.8.2012

[75] Seppälä, Joel. Customer Relationship Manager, Helen Sähköverkko Oy. Interview in Helsinki 28.8.2012.

[76] Hiekkala, Juha. Development Manager, Fingrid Oyj. Interview in Helsinki 31.8.2012.

[77] Schulz, Thomas. Chief Operating Officer, Entelios AG. Interview via phone 1.8.2012.

[78] Hänninen, Kenneth. Director, Energiateollisuus ry. Interview in Helsinki 20.8.2012.

[79] Salomaa, Pekka. Director, Energiateollisuus ry. Interview in Helsinki 20.8.2012.

[80] Kiviluoma, Juha. Senior Scientist, VTT. Interview in Espoo 22.8.2012.

[81] Matilainen, Jussi. R& D Manager, Fingrid. Interview in Helsinki 4.9.2012.

[82] Sederlund, Jarno. Customer Manager, Fingrid. Interview in Helsinki 4.9.2012.

[83] Merkel, Marcus. Senior Advisor to the Managing Director. EWE NETZ GmbH. Correspondence via email 29.8.2012.

[84] Söderlund, Bengt. Regulation Coordination Manager, Fortum. Interview in Espoo 12.9.2012.

[85] Jäppinen, Jonne. Fingrid. Interview in Helsinki 12.9.2012.

[86] Iso-Tryykari, Mikko. Business Development Manager, Fortum. Interview in Espoo 17.9.2012.

[87] Vaitomaa, Janne. Development Manager, Fortum. Correspondence via email 23.7.2012.

[88] Nora, Markus. Analyst, Energiamarkkinavirasto. Interview in Helsinki 18.9.2012.

[89] Rintamäki, Mikko. Managing Director, Elfi. Interview in Helsinki 7.9.2012.

[90] Wickström, Anders. Development Manager, Fortum Markets. Interview in Espoo 20.9.2012.

[91] Häkli, Jukka-Pekka. CEO, SEAM Group. Interview in Helsinki 19.9.2012.

[92] Eriksson, Egil. Senior Advisor, Fortum Power and Heat Oy. Interview in Espoo 31.10.2012

[93] Nordblad, Karl-Henrik. Senior Advisor, Fortum Power and Heat Oy. Interview in Espoo 31.10.2012

[94] Lehto, Ina. Advisor, Energiateollisuus. Interview via phone.

[95] Saarinen, Jarmo. Head of Long-term planning, Fortum Distribution. Interview in Espoo 15.11.2012

A Appendix A

List of the interviewees:

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- Lehto, Ina. Advisor, Energiateollisuus. Interview via phone.
- Saarinen, Jarmo. Long-term Planning Manager, Fortum Distribution. Interview in Espoo 15.11.2012
- Tenschert, Walter. Managing Director, Energie AG Oberösterreich Netz GmbH. Correspondence via email 15.11.2012.