LAPPEENRANTA-LAHTI UNIVERSITY OF TECHNOLOGY LUT

LUT School of Energy Systems

Degree Programme in Energy Technology

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SERVICE DEVELOPMENT OF A SERVICE PROVIDER IN THE NORDIC ELECTRICITY RETAIL MARKET

Examiners: Associate professor, D.Sc. (Tech.) Ahti Jaatinen-Värri

D.Sc. (Tech.) Salla Annala

Supervisor: M.Sc. (Tech.) Laura Poikela

ABSTRACT

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Service development of a service provider in the Nordic electricity retail market

Master's thesis

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Keywords: service provider, Nordic electricity market, service development, market changes

The aim of this Master's thesis was to examine new service opportunities for a service provider operating in the Nordic electricity retail market. Nordic electricity retail market will face changes in the near future that will substantially reshape the structure and the processes of the market. Central changes include data hub introductions in Finland and Sweden, 15 minute imbalance settlement period, installations of next generation electricity meters and the increase of flexibility services.

Market changes create the need for market participants to adjust their business processes. Empower IM Oy produces many services to market participants operating in the retail market, which mainly consist of electricity suppliers and distribution system operators. Along with the market changes, Empower has the opportunity to update its provision of services and expand is both in Finland and other Nordic countries. Such processes were searched in the study that would be suitable to be performed by a service provider. It was also discussed how Empower should develop its provision of services to increase business activities.

In the study, many business processes affecting electricity suppliers and distribution system operators were found that are about to change slightly or significantly through market changes. Such services were also recognised which could be relevant considering the expansion of service provision. Potential new services were discover to be produced towards electricity suppliers, distribution system operators and end users. Regarding potential services, the implementation and related benefits and challenges were discussed.

TIIVISTELMÄ

Lappeenrannan-Lahden teknillinen yliopisto LUT
LUT School of Energy System
Energiatekniikan koulutusohjelma

Tuomas Juntunen

Palveluntarjoajan palvelukehitys pohjoismaisilla sähkön vähittäismarkkinoilla

Diplomityö

2020

105 sivua, 16 kuvaa and 3 taulukkoa

Tarkastajat: Apulaisprofessori, TkT Ahti Jaatinen-Värri
TkT Salla Annala
Ohjaaja: DI Laura Poikela

Hakusanat: palveluntarjoaja, pohjoismainen sähkömarkkina, palvelukehitys, markkinamuutokset

Tämän diplomityön tavoitteena oli tutkia uusia palveluntuotantomahdollisuuksia pohjoismaisilla sähkön vähittäismarkkinoilla toimivalle palveluntarjoajalle. Pohjoismaisella sähkön vähittäismarkkinalla tullaan lähitulevaisuudessa näkemään muutoksia, jotka muokkaavat markkinan rakennetta ja toimintaa oleellisesti. Keskeisiä muutoksia ovat muun muassa datahubin käyttöönotto Suomessa ja Ruotsissa, varttitase, seuraavan sukupolven sähkömittarien asennukset sekä joustopalveluiden lisääntyminen.

Markkinamuutokset luovat markkinaosapuolille tarpeen muokata liiketoimintaprosessejaan. Empower IM Oy tuottaa monia palveluita vähittäismarkkinoilla toimiville osapuolille, joita ovat pääasiassa sähkönmyyjät ja jakeluverkkoyhtiöt. Markkinamuutosten myötä myös Empowerilla on mahdollisuus päivittää palveluntarjontaansa ja laajentaa sitä niin Suomessa kuin muissa pohjoismaissa. Tutkimuksessa etsittiin prosesseja, jotka soveltuisivat palveluntarjoajan tehtäviksi ja pohdittiin, miten Empowerin tulisi kehittää palveluntarjontaansa liiketoiminnan kasvattamiseksi.

Tutkimuksessa löydettiin useita sekä sähkönmyyjiä että jakeluverkkoyhtiöitä koskevia liiketoimintaprosesseja, jotka muuttuvat osittain tai merkittävästi markkinamuutosten myötä. Työssä myös tunnistettiin palveluita, jotka voisivat olla olennaisia ajatellen palvelutarjonnan laajentamista. Potentiaalisia uusia palveluita löydettiin tuotettavaksi niin sähkönmyyjille, jakeluverkkoyhtiöille kuin myös loppukäyttäjille. Potentiaalisten palveluiden osalta pohdittiin toteutusta sekä siihen mahdollisesti liittyviä etuja ja haasteita.

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In Helsinki, on 4th of May 2020

Tuomas Juntunen

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LIST OF SYMBOLS

Abbreviations

ACER	Agency for the cooperation of energy regulators
aFRR	Automatic frequency restoration reserve
AI	Anläggningsinformation
AMM	Advanced meter management
APERAK	Application error and acknowledgement message
AOF	Activation optimisation function
BI	Byte av identitet
BRP	Balance responsible party
BRS	Business requirements specifications
BSP	Balancing service provider
CET	Central European time
CONTRL	Control message
DELFOR	Delivery forecast
DR	Demand response
DSO	Distribution system operator
ebIX	European forum for energy business information exchange
EDI	Electronic data interchange
EDIFACT	Electronic data interchange for administration, commerce and transport

EGBL	European guideline for balancing
ENTSO-E	European network of transmission system operators for electricity
EV	Electric vehicle
FCR	Frequency containment reserve
FCR-D	Frequency containment reserve for disturbances
FCR-N	Frequency containment reserve for normal operation
FFR	Fast frequency reserve
HNR	Harmonised Nordic retail
ISP	Imbalance settlement period
ISR	Imbalance settlement responsible
LFC	Load frequency control
mACE	Modernised area control error
MGA	Metering grid area
mFRR	Manual frequency restoration reserve
MSCONS	Metered service consumption report
NBM	Nordic balancing model
NBS	Nordic imbalance settlement
NEMO	Nominated electricity market operator
NMEG	Nordic Market Expert Group
NRA	National regulatory authority

OTC	Over the counter
PRODAT	Product data message
PV	Photovoltaic
RE	Retailer
TSO	Transmission system operator
UTILTS	Utility time series
XML	Extensible markup language

1 INTRODUCTION

Nordic countries, with the exception of Iceland, form a common Nordic electricity market. It is a moderately large market area with around 15 million registered metering points. With the development of a common Nordic electricity market, all Nordic countries are also participants of what was the world's first multinational electricity market.

Nordic countries have been at the forefront of electricity market liberalisation starting in the 1990s. The deregulation of the electricity market took place in the 1990s in the Nordics. After the deregulation, states were no longer controlling the power market and the market was opened for free competition (Työ- ja elinkeinoministeriö). Electricity market was deregulated to enable development for a more efficient market, power exchange between countries and improvement in the security of supply (Nord Pool 2019). In 2014, there were around 470 electricity suppliers in the Nordics with 100 in Finland, 150 in Sweden, 170 in Norway and 50 in Denmark (EDIELfi; Svenska Kraftnät; Elhub 2019; Energinet 2019).

In Sweden, legislation concerning electricity trade and distribution in its current form has been around since 1997. Because the electricity grid is extremely expensive and it would be impractical to have two or more parallel grids, it is considered a natural monopoly and therefore the grid operation remained a regional monopoly even after the deregulation (Lundgren 2012, 1; 6). The legislation constitutes fundamental definitions about how the electricity production, distribution and trade is organised. One key determination in the electricity law is that grid operation is separated from other activities in the field. A juridical person that is in charge of grid operation is not allowed to practice production or trade of electricity (Svensk författningssamling 2018).

All Nordic countries either belong to the European Union or are part of the European Economic Area. Consequently, the national legal basis in each country is not too different from one another because it derives from EU regulations. This applies also for regulations towards the electricity markets, like the regulations concerning rights and obligation of market participants in information exchange. The Nordic market is interconnected through cross-border power lines, a common power market Nord Pool and imbalance settlement responsible eSett Oy, among other things. (Thema 2019, 3–4)

Finland, Sweden and Norway, are connected in the electricity market through a mutual imbalance settlement company, eSett Oy. The three transmission system operators (TSOs), Fingrid, Svenska Kraftnät and Statnett, set up eSett with the purpose to unify the balance settlement practices in the Nordic countries in order to further develop the Nordic market. In May 2019, eSett announced that Denmark will join the Nordic imbalance settlement in Q4/2020. The go-live has since been changed, as the recent commissioning plan has go-live date for capacity reserves in October 2020, and the go-live for imbalance settlement in February 2021 (eSett 2020). Denmark's TSO, Energinet, will become the fourth shareholder in eSett Oy with each of the TSOs owning a 25 % share of the company. (eSett 2019a; eSett 2019b)

Several significant changes are going to take place in the Nordic electricity market which will affect many aspects of market processes, responsibilities and harmonisation. These changes include completion of smart meter installations, central information exchange systems called data hubs for each Nordic country, 15 minute imbalance settlement period and a common Nordic balancing model. Market participants will face different requirements or encounter new possibilities in the 2020s, which in turn could provide opportunities for service providers to expand their service portfolio.

Empower IM Oy is a multinational company realising smart society through a variety of services, including customer-oriented energy market services and intelligent data platforms. It has customerships in Finland, Sweden, Norway and Denmark with respect to retail markets for electricity. The customerships include e.g. metering, invoicing and IT data solution services.

The aim of this study is to discover characteristics that are relevant regarding operation in the Nordic electricity market, with the Swedish retail market receiving special attention. This master's thesis was written for Empower IM Oy to assist and inform employees that deal with customerships in the Nordic countries, in Sweden especially since the Swedish market for Empower is the market with fewest customers. This study also aims to discover various ways for Empower IM Oy to expand its operation across the Nordics driven by the upcoming market changes. This study investigates primarily new service opportunities for retailers (RE) and distribution system operators (DSO) as they are the main market participants in the retail market. In this work, while discussing the Nordic countries only Finland, Sweden, Norway and Denmark are intended. Iceland is not part of the common Nordic electricity system and therefore not taken into consideration.

This master's thesis aims to achieve its research goals by answering three main research questions.

How do the future market changes affect the provision and development of services?

What are the processes that would have the most potential to be shifted under the operation of a service provider?

How should Empower develop its services to suit the expansion towards the Nordic markets?

The result shall be an account of potential services to be added to Empower's portfolio. These services are classified based on the role of the market participant and the country where the service would be pertinent. This thesis also provides a basis for future investigation for the services discussed.

1.1 Structure of the thesis

This thesis can be divided into two parts. The theory part, which comprises chapters 2–4, presents the market in general. In chapter 2, the main market participants and their general roles in the market are presented. Chapter 3 discusses some of the central market processes. The most significant future market changes in the Nordic retail market are presented in chapter 4.

The second part of the thesis comprises chapters 5–7 and focuses on the actual new business ideas and service development. Chapter 5 presents the current state of Empower's service portfolio. Empower's service portfolio can be considered extensive, yet it is concentrated on the Finnish market. The most straightforward way to contemplate new business opportunities for the markets outside Finland is to study the services which already exist in Empower's portfolio, and adjust them to suit different markets. The existing proficiency could help to build the services by allowing easier determination of business practices, and simplifying the identification of relevant requirements and potential challenges. Such a situation, where a current customer has activities in more than one country, yet Empower serves the customer only in one country, could well provide an opportunity for this type of action.

In chapter 6, ideas for new services are presented. The findings are first analysed on general level, as the overall description of each service is given. Relevant ideas and possibilities for service development are examined in closer detail. This includes a practical approach to the actual implementation of the service, what systems would be relevant and what the implementation will require.

Chapter 7 discusses challenges, benefits, country applicability and time scale related to the service ideas. It is reasonable to assume that there will be matters that turn out to be challenging when introducing new services to foreign markets. Therefore, it is essential that the most notable problems are identified so that one manages to consider methods to tackle them. However, it is important to also know which benefits the new services might offer, and where and when they could be introduced. Thus, the discussion part of this thesis considers the relevance of each service enhancement and provides an examination of the related matters. Chapter 8 summarises the previous chapters.

2 MARKET PARTICIPANTS

In this chapter, the market participants and their roles in the market are described. There are numerous participants that are active in the Nordic electricity market. The participants can be categorised into a few different groups depending on what their primary activities in the market are. These participants are:

- Electricity supplier, also called as retailer (RE)
- Balance responsible party (BRP)
- Distribution system operator (DSO)
- Transmission system operator (TSO)
- Imbalance settlement responsible (ISR)

The Nordic electricity market is strongly regulated by various laws, decrees and recommendations. The national regulatory authorities (NRA) which contribute to the regulations, such as national governments, supervisory authorities or cross-Nordic cooperative expert groups, are an integral part of the electricity market spectrum since the regulations strongly govern the operation in the electricity market. Thus, even though these entities do not actually participate in the market, they remain strongly connected to it. (NordREG 2019b)

NordREG is a cooperation between Nordic energy regulators about developing the Nordic and European electricity markets. Their work concentrates on legislatorial and institutional framework for promoting efficient and advanced electricity market in the Nordic countries. NordREG is a way for energy regulators to co-operate in analysing energy market issues, and taking common action to influence the development of the markets. NordREG produces recommendations and reports to achieve a more harmonised market and provides a platform for exchange of information and best practices. (NordREG 2019a; NordREG 2019b)

2.1 Electricity supplier/retailer (RE)

Trading electricity consists of purchasing and selling. An electricity supplier is a market participant that eSett (2019a, 20) defines as someone who “sells electricity to final consumers, purchases production or performs trade activity”. Its customers range from industrial customers to commercial businesses and households. A supplier usually buys electricity from an electricity exchange or directly from producers as an OTC (over the counter) deal. Nowadays a customer may choose its electricity supplier freely and the market price results from supply and demand. Suppliers also may have customers in multiple areas with different DSOs. (Sihvonen 2015)

Electricity supplier in its current form is a relatively new party that participates in the market. Before the deregulation that took place in the Nordics in the 1990s, the usual case was that within a geographic area there was a single electricity provider that sold and distributed electricity to the whole area. The entire chain, including production, transmission and delivery to customers, was operated by the provider. Electric companies were essentially monopolies that had no competition in any of the utilities. (Lundgren 2012)

The term deregulation in this context stands primarily for opening up competition in power production and retail. Discussions about deregulating the market started in Sweden in the early 1990s and eventually it was adopted in the legislation in 1996 as a result of a combination of national initiatives and claims from the EU. The idea behind deregulation was to increase freedom of choice for customers and to establish prerequisites for an efficient use of production resources (Energimarknadsinspektionen 2019). To further create additional competition for a well-functioning market, world’s first international power exchange, Nord Pool, was created between Norway and Sweden. In a few years the exchange expanded as Finland and Denmark joined the exchange in 1998 and 2000, respectively. (Lundgren 2012)

In 2018, there were all in all 129 active electricity suppliers in Sweden. The three largest suppliers, E.ON, Fortum and Vattenfall, had a combined market share of 46 % that grew 5 % from 2017. The total cost of electricity consisted of three main components in 2018. The largest share was taxes with 41.5 %, including both value added and electricity tax. The second largest was costs related to electricity trade with 36.7 %. The rest was made up from costs related to the distribution of electricity. (Energimarknadsinspektionen 2019)

Electricity suppliers offer a variety of different contracts for their customers. The most common ones are fixed-price contracts, contracts that follow the prices of Nordic electricity exchange (Nord Pool), mixed contracts containing both fixed and variable segments and assigned contracts where the customer does not actively choose a supplier. The most typical contract in Sweden is a contract where the price is related to the Nord Pool Spot price. Each Nordic country has an independent price comparison tool, which facilitates the comparison of REs' contracts. In Sweden, the comparison tool is accessible online at Elpriskollen.se. (Energimarknadsinspektionen 2020; Nordic Council of Ministers 2017)

A RE may sell electricity to metering points only if someone has taken balance responsibility for that point. If the RE cannot agree on a contract with a BRP, Svenska Kraftnät will nominate a BRP for the RE. Within a MGA (metering grid area), a supplier may have separate balance responsibility contracts for production and consumption with different BRPs, and the BRPs may be different between MGAs. A supplier must report to relevant DSOs the changes regarding its balance responsibility contracts, and vice versa if DSO receives this type of information from other parties. (Svenska Kraftnät 2019a; Sveriges Riksdag 1997)

A RE is obliged to deliver electricity to end users until an end user stops consuming electricity, other supplier starts the delivery or if delivery is stopped because the end user breached a contract with either an RE or a DSO. Before the contract expiration date, the end users must be informed that the expiration date is approaching so that the end users have time to agree on new contracts. A RE informs about this at least two months before the expiration date. (Sveriges Riksdag 1997)

2.2 Distribution system operator (DSO)

A distribution system operator distributes and delivers electricity from producers to end users. It has the responsibility to maintain the electricity grid in its own area and to provide electricity of good quality to the customers that have a grid connection. Each DSO has one or more REs that sell electricity to end users. To cover the costs related to grid maintenance, update and improvement, a DSO invoices its customers with grid tariffs. Because DSOs essentially are local monopolies, they are monitored by NRAs in all

Nordic countries to keep the DSOs' tariffs towards its customers and profits moderate. The DSOs' income is controlled by determining a framework for periods of 1–4 years for how much a single company may yield profit, i.e the maximum allowed income is regulated. (Energimarknadsinspektionen 2019; THEMA 2015)

The electricity grid is divided into three categories based on the voltage in the grid lines. DSOs operate the distribution grids with the lowest voltages. Distribution grids have both medium-voltage and low-voltage networks with voltages of 10-20 kV and 400/230V, respectively. In 2016 there were around 170 DSOs operating the distribution grids in Sweden. Sub-transmission grid with voltages of 40–130 kV serves as a link between transmission and distribution grids. In Sweden, the sub-transmission grid is owned and operated by a few regional DSOs, the four largest owning around 99.7 % of the grid. Each Nordic country has its own TSO that operates the national transmission grid with voltages over 220 kV. (Grahn et al. 2016)

Each Nordic country has such regulation in place that a MGA owned by a DSO is obliged to have a concession (Pöyry 2015; Sähkomarkkinalaki 2013). In other words, a DSO needs to have a permission to operate its distribution grid and to transmit electricity. In Sweden, the permission can be obtained by submitting an application to Energimarknadsinspektionen. This is to make sure that the DSOs are suitable to carry out grid activities and no unnecessary harm is caused to people or nature. A permission is required for all strong current power lines which have a voltage, current or frequency that can be dangerous for people or property. A concession can apply for a single power line or a geographic area. Granting concessions serves as a way to apply regulation to grid operation. (Energimarknadsinspektionen 2019b)

There are exceptions when a grid concession is not necessary and new parts of electricity grid can be built without a concession. These are all internal grids, like in an apartment building or in a factory. An internal grid is defined as a grid that is used to transmit electricity for own use. The grid cannot be too large or too difficult to confine, i.e., easy to determine where the internal grid starts and ends. Internal grids are typically smaller and owned by the party that operates in the location. (Energimarknadsinspektionen 2019c)

The Nordic countries have incorporated or will incorporate a supplier-centric model in the operation in the electricity markets which serves market harmonisation purposes (NordREG 2019a). This means that several responsibilities, like grid tariff invoicing and customer contact related to grid issues, will be transferred from DSOs to REs. A DSO’s role will thus move towards providing infrastructure services, like maintaining a well-functioning grid and security of supply. (Pöyry 2015)

2.2.1 DSOs’ responsibilities

There are many responsibilities in the Nordic electricity market that concern the DSOs. Nordic DSOs have been assigned the installation of smart meters for all end users. The meters’ requirements include, e.g., two-way communication for monitoring and control as well as a possibility to install communication with external technical equipment (Pöyry 2015) (Energimarknadsinspektionen 2017). Moreover, DSOs are responsible for metering the electricity consumption and reporting it to the suppliers and customers or to the data hub if such is operational (Pöyry 2015).

DSOs determine the grid tariffs for their customers. Commonly, the tariffs are based on a fixed and variable component where the variable component might change seasonally or within a single day for peak and off-peak times. Contracts where the price changes depending on the time are called time-of-use contracts and they contribute to incentivising demand response when the grid is constrained. Capacity charge, where the determining factor is one’s peak power during a time period, might also be included in the tariffs. In all Nordic countries, the distribution tariffs are required to be cost-reflective and non-discriminatory. (Pöyry 2015)

A DSO is responsible for the accuracy and maintenance of metering instruments. DSO also needs to fix eventual errors that occur with metering. In case of a meter failure or other issue causing incorrect values, DSO usually estimates the values that can be used for invoicing. Collection, correction and management of metering values are procedures that a DSO can outsource to a service provider, a so called delegate. The DSO is still considered liable for the metering service, unless the parties agree differently. (Svenska Kraftnät 2019a)

When a metering error occurs producing a missing or a false value, DSO has to within a reasonable time period examine the cause of the error, estimate the amount of energy, what time period the error intends and which parties are affected. These need to be reported to relevant parties as soon as possible, which usually include RE and BRP. DSO must report the correct value when after the value has been validated. In case metering values change after the reporting window, which in the Nordics is essentially 11 days, financial reconciliation is used to settle the financial imbalance. (eSett 2019a; Energimarknadsinspektionen 2016a)

In Energimarknadsinspektionen's instruction for metering, calculating and reporting, DSO's responsibilities considering metering are described in detail. Individual hourly time series for the previous day are reported every day. DSO reports to adjacent DSOs time series from its each exchange metering point by 8:00 AM. Time series for each production point are reported by 9:00 AM to respective RE, end user and, if the power exceeds 1 MW, to TSO. For each consumption point, the time series are reported by 9:00 AM to respective RE, end user if electronic communication is used, and by request to third party. Reporting of time series for profiled withdrawal points to REs takes place no longer than five days after the delivery period, and to end users by invoicing at latest. (Energimarknadsinspektionen 2016a)

DSO reports summarised values each day after the delivery day by 9:00 AM. Summarised values for MGA boundary points, production points per type of production and consumption points per type of consumption are to be reported to Svenska Kraftnät. Summarised values for profiled consumption points are reported to respective REs and BRPs, in addition to Svenska Kraftnät. For grid losses, values are reported to respective REs and Svenska Kraftnät. Additionally, consumption profiles for each area are reported to Svenska Kraftnät. In case of false values, DSO needs to correct and report them on the 12^{th} day after the delivery day at latest. (Energimarknadsinspektionen 2016a)

In Sweden, the law of electricity determines key components for DSO operation and finances. For example, grid tariff for each voltage interval has to be based on the DSOs' costs related to its electric equipment within that interval in the whole country. Grid tariffs for new connections are formed so that the DSO's costs are reasonably covered, taking the geographic location and dimensioned power into account. Smaller production facilities are promoted through advantageous grid tariffs. A production facility with power up to 1 500 kW is only subject to that part of a distribution tariff that includes DSO's costs related to metering, settlement and reporting. A production facility no greater than 43.5 kW does not need to pay anything for feeding electricity to the grid as long as the yearly consumption exceeds production. (Sveriges Riksdag 1997)

The law of electricity also describes the following responsibilities for a DSO. If a customer does not actively choose an electricity supplier, the DSO will nominate a supplier for the customer. DSO is responsible for informing TSO which party has taken balance responsibility for DSO's own procurement. If there's a disturbance with delivery, affected customers have a right to a financial compensation for the inconvenience form the DSO. (Sveriges Riksdag 1997)

2.3 Balance responsible party (BRP)

Imbalance occurs when the consumption and production are not equal, and it typically results from deviations between the forecasts and the actual consumption or production. In the electricity market, there needs to be a market participant that is responsible for the imbalances of a metering point. The term balance responsible party (BRP) is used for those market participants or their representatives that have such responsibility for one or more metering points. In principle, each market party is responsible for own imbalances until it delegates the responsibility to a party of their choice. A BRP has the task to balance the consumption with production or electricity trade for those metering points that it has balance responsibility for. (EU 2019/943)

A central part of a BRP's activities is the planning of deliveries. Active BRPs in the Nordics have signed a balance agreement with a respective national TSO which governs the BRP's responsibilities for trading, planning and forecasting (eSett 2019). In Sweden, a BRP must plan and forecast all production and consumption in its portfolio and report these to Svenska Kraftnät. Minimising imbalances with accurate forecasts and trading in the market is incentivised by invoicing imbalance costs from the BRPs. Imbalance settlement performed by eSett is used to calculate BRPs imbalances and to allocate costs caused by these imbalances to the BRPs. An RE may simultaneously have the role of a BRP in the market. (Svenska Kraftnät 2019a)

The balance responsible party performs its electricity procurement prior to the delivery. There are several aspects a BRP must take into account when planning the deliveries. The procurement is based on various prognosis and forecasts that the BRP receives or produces. Metered values that the BRP receives from the DSO give an account for the previous day's deliveries and form the basis for the planning of next day's procurement. Therefore, it is important that the metered values a BRP receives contain as correct information as possible. If the forecasts are based on incorrect or estimated values, it may lead to economic consequences in case the procurement deviates from the final balance. (Svenska Kraftnät 2019a)

The characteristics of the BRPs in different Nordic countries are highly similar due to having a common imbalance settlement practice. However, some unique features still exist. In Finland, it is possible to have a chain of open suppliers in which a BRP has a balancing contract with another BRP who then has the balancing contract with the TSO. A production unit may be considered normal or minor. If the unit is considered minor, it is not necessary to include the unit in the production plans. The limit in Finland is 1 MW, in Norway 3 MW, and in Sweden all production is considered normal. Unlike Finland and Sweden, where REs and DSOs must belong to separate companies, a company in Norway with fewer than 100 000 grid customers may possess the roles of RE, BRP and DSO simultaneously. (eSett Oy 2019a)

2.4 Transmission system operator (TSO)

The power system must be in balance at all times, i.e. the electricity produced has to correspond to the amount of electricity being consumed. TSO is the authority that maintains this balance. eSett (2019a, 4) defines TSO as the authority that "has the responsibility for the security of supply, for the real-time coordination of supply and demand in the power system, and for the operation of the high-voltage grid". The national TSOs in the Nordics are Fingrid, Svenska Kraftnät, Statnett and Energinet. The transmission grids operated by the TSOs are combined to cross-border power lines, sub-transmission grid and large production plants, providing the foundation to the entire power grid. (Svenska Kraftnät 2019a) (eSett 2019b)

Nordic TSOs are fully state-owned enterprises apart from Fingrid which is mostly owned by the Finnish state and the National Emergency Supply Agency (53.14 %), the rest being held by Finnish financial and insurance institutions. The TSOs are subject to own country's legislation, yet the legislation is quite similar, and the fundamental tasks of a TSO are the same in all Nordic countries. In Norway, the Norwegian regulations specify Statnett's responsibilities. These include frequency control, maintaining the balance of the power system, coordinating the operation of the power system and facilitating international power trade. Developing market-based solutions, e.g., for balancing purposes, serves the efficient utilisation and development of the power system. The Nordic TSOs manage the development and operation of cross-border interconnectors which requires comprehensive cooperation among the TSOs and regulators in other European countries. (Energifakta Norge) (Fortum 2019)

The Nordic TSOs have a central role in the design of the electricity markets. For example, each TSO is or has been responsible for developing and a centralised information exchange system, data hub, for retail market in their country. After the data hub is operational, the TSOs continues to manage it as a neutral facilitator. The regulating power markets are maintained by the TSOs. The connected electricity grid has the same frequency and therefore regulating the frequency is a common task for which regulating power market is used. TSOs are also enablers for the Nordic market harmonisation, as their operation is governed by European legislation which aims to create a more harmonised European electricity market. (Fortum 2019) (Fingrid 2019b)

2.5 Imbalance settlement responsible (ISR)

One of the key fundamentals in the electricity market is that there always needs to be balance between consumption and supply of electricity. Although preliminary plans are made carefully, imbalances in production and consumption emerge due to uncertainties in plans and unexpected failures in power generation, grid operation or electricity consumption. These eventual deviations generate the need for balancing procedures. To keep the grid in balance, TSO buys balancing power from the balancing market. With an imbalance settlement, the costs arising from adjustments to cancel out imbalances are allocated to the market participants that caused them. Hence, the main objective of the imbalance settlement is to ascertain financial balance after the delivery. BRPs are the actors that have taken the financial responsibility for the imbalance costs in the metering points. (eSett 2019a)

The Nordic imbalance settlement model launched in 2017 harmonised the imbalance settlement in Finland, Sweden and Norway. The main stakeholders involved are REs, BRPs, DSOs, TSOs, NEMOs and eSett. The relation of different stakeholders for the imbalance settlement is presented in figure 1. eSett is the common organ for the Nordic TSOs, including Denmark starting Q4/2020, that performs the actual settlement, invoices or credits the BRPs for balancing power and manages the settlement structure. eSett uses information from market participants to carry out the settlement. Imbalance settlement is done both for production and consumption balances with separate imbalance prices for the two balances. However, the Nordic Balancing Model (NBM) program has proposed a Single-Price model that would imply several changes towards the imbalance settlement model, e.g., single imbalance price, and that the new model would be implemented in Q2/2021. (eSett 2019a; Nordic Balancing Model 2019a)

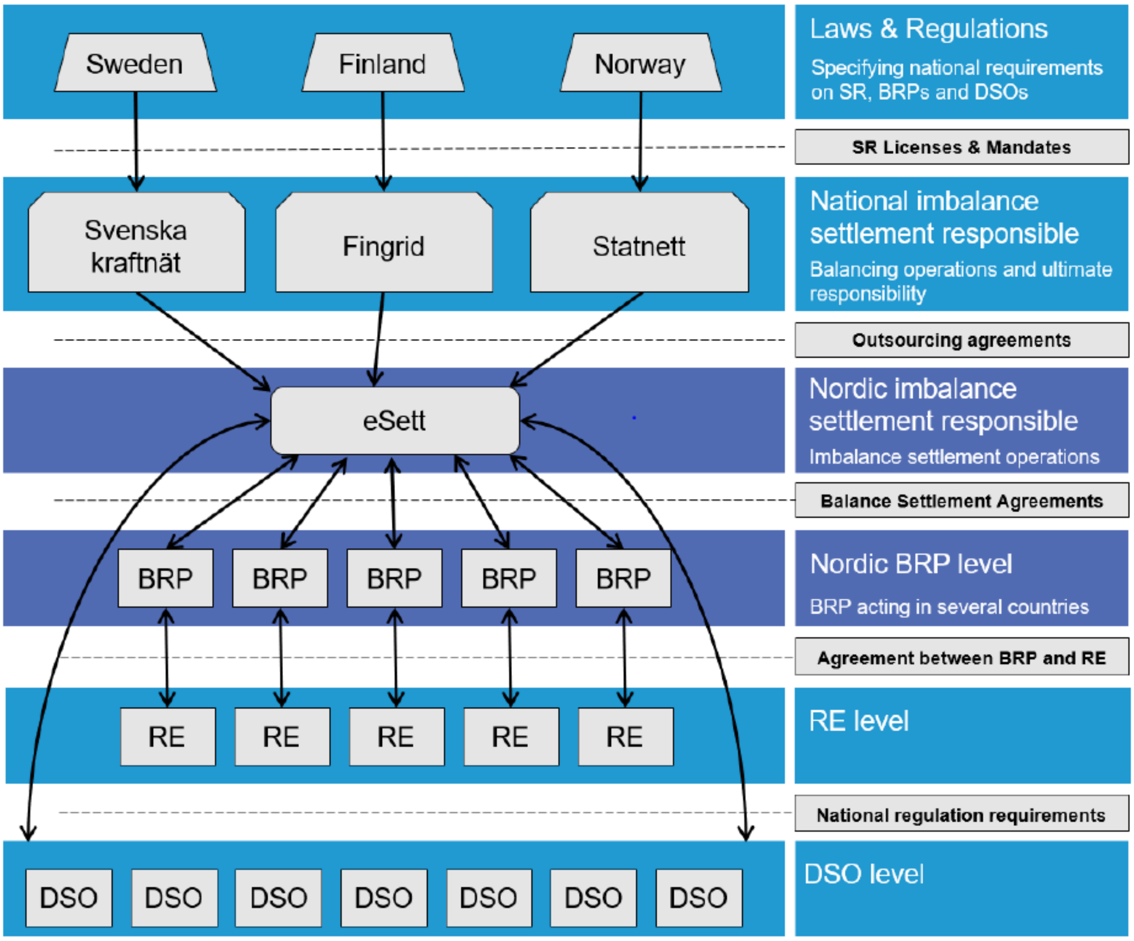

Figure 1. Relation of different stakeholders in the Nordic imbalance settlement model. (eSett 2019a)

Introducing the common imbalance settlement model provided several benefits in comparison to the old practices. eSett is now the only interface that a BRP communicates with. BRP also follows only a single set of rules that determine how to handle imbalance activities. The creation of eSett and the new settlement model was a step towards establishing a common Nordic end user market. Because the operational procedures have been simplified, acting as a BRP is easier so the number of BRPs increases, reducing RE's balance handling costs due to better competition. It is easier for a new RE to enter the market, as well as choose to act as a BRP instead. DSOs are incentivised to increase the quality of metering data because they are responsible for the data errors that remain in the imbalance settlement once the gate closure time has passed. A larger Nordic market will also be more likely to attract investors to improve market solutions. (eSett 2019a)

3 MARKET PROCESSES

3.1 Information exchange

Information exchange is an essential part for a well-functioning and efficient market. Market participants need various information in order to be able to carry out their retail and wholesale market processes. Hence, massive amounts of information are constantly exchanged in the electricity markets. Figure 2 represents how many different parties might utilise the same information but for different purposes, in this case metered data. To clarify and further harmonise the information delivery, Ediel standard was developed. Ediel means a standardised electronic information exchange between market parties in electricity and gas markets, and covers both XML (Extensible markup language) and EDIFACT (Electronic data interchange for administration, commerce and transport) formats. The standard is based on European and international standards to guarantee its validity for a longer period of time. Ediel is used to exchange non-real time information. (Svenska Kraftnät 2019; Nordic Market Expert Group 2019)

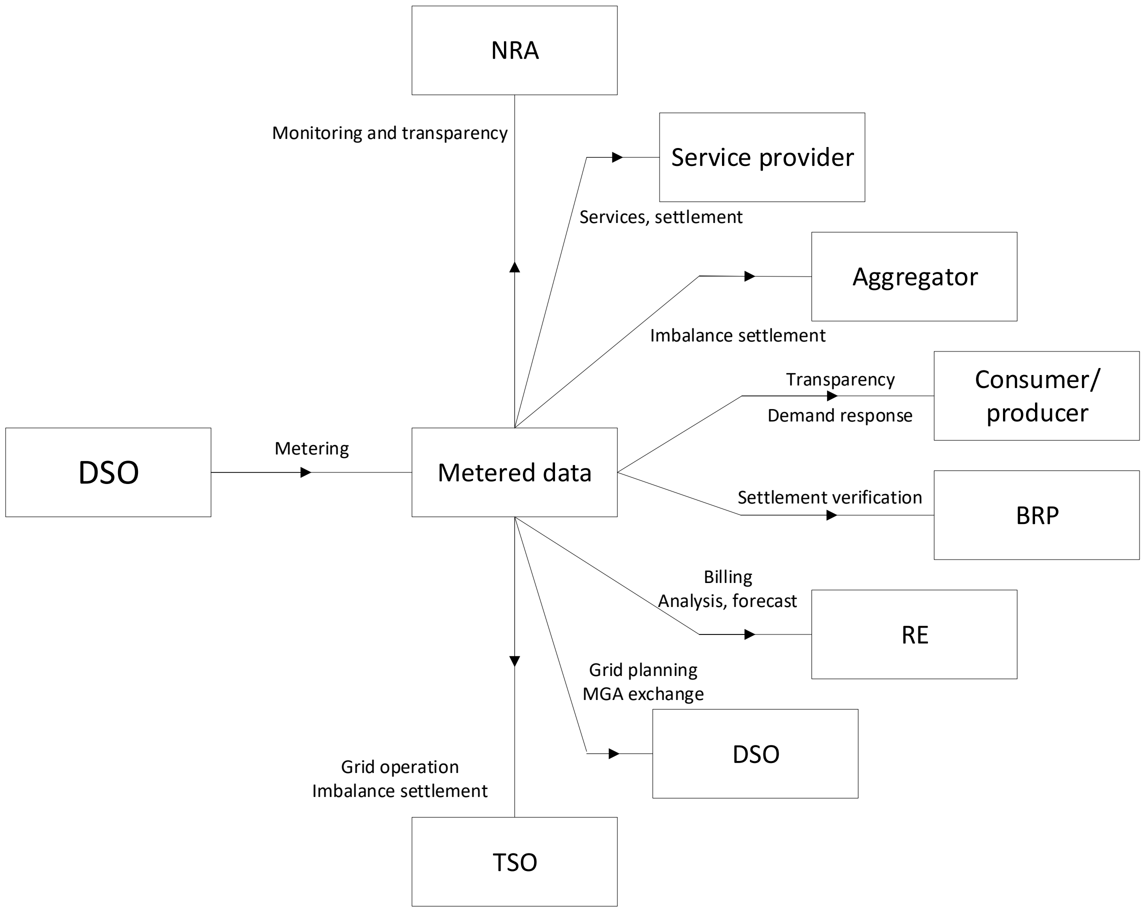

Figure 2. Distribution of metered data to different parties and their primary needs for the data. Adaptation from Thema (2017).

Nordic Market Expert Group (NMEG) is an organisation whose task is to maintain and develop the Nordic Ediel standards based on available international standards. Each Nordic TSO has one or two members in the NMEG and the group works on enhancing cooperation on essential issues between the TSOs, thus enhancing cooperation with the Nordic countries. NMEG publishes documents online that offer detailed information to the data exchange and helps Nordic projects with standardisation issues. It also participates in European and worldwide organisations to discuss and promote Nordic position for data exchange standardisation. (Nordic Market Expert Group 2018)

One purpose of Ediel messages and standards was to create equalised data exchange in order to further enhance preconditions for a cross-border electricity market. EDI (Electricity Data Interchange) standard messages are widely used in the Nordic countries but with the upcoming changes, such as all Nordic TSOs adopting a centralised information exchange hub, the use of Ediel is also due to some changes. The operational data hubs in Denmark and Norway, plus the upcoming data hubs in Sweden and Finland, utilise information formats that differ from Ediel. Therefore, the role of Ediel standard will diminish in the near future. (Svenska Kraftnät 2019)

There are a few ways for market actors to handle communication with Ediel. The actor can use an own system that has an interface capable of handling Ediel messages that it sends and receives. Another option is to engage a service provider that provides either a system to be used for messaging or manages the entire messaging service for the customer. It is notable that the actor still holds the responsibility that the messaging complies with the guidelines. In Finland, each market party is required to have a message operator that manages the routing of incoming and outgoing messages. This service may also include other technical services, such as modifying the messages in order to achieve compatibility between different systems. (Svenska Kraftnät 2019a; Fingrid 2018a)

Ediel standard includes message types for three main areas of information exchange. PRODAT (product data message) message type is used for reporting about the structure at a metering point. The structure implies the information about an end user at a metering point and the contract that the end user has for the supply of electricity. Market processes like switch of supplier, start of delivery, change of metering equipment (from profiled to non-profiled) and updating of structure data are examples where PRODAT messages are currently used. The data exchange takes place between old supplier, new supplier and the grid owner. A single PRODAT message may contain information about one or more metering points where the change of supplier or move-in happens. A reliable acknowledgement processing is fundamental for an efficient PRODAT messaging. (Ediel Teknikgrupp 2019)

DELFOR (delivery forecast) message type is used for reporting bilateral trades and production plans. The message contains short term delivery instructions or medium to long term forecasts to be utilised in planning. The messages often specify schedules that have been requested by another party. The information is provided to another party to enable power production and deliveries in the most economical way. Meteorological information is also transmitted with DELFOR messages. (Message handbook for Ediel 2004)

MSCONS (metered service consumption report) and UTILTS (utility time series) are message types used for reporting metered values between TSO, DSOs, BRPs and REs to be used in planning or settlements. Generally MSCONS is used in Finland and UTILTS in Sweden for the same purpose. UTILTS messages also accomplish many of the tasks for which DELFOR messages are used in Finland. MSCONS and UTILTS messages may contain information about individual or aggregated metering values or time series for metering points. UTILTS message is also used to report consumption forecasts, or inquiries about missing metering values. The provided information may have direct relations to other business processes, like invoicing or balance settlements. (Svenska Kraftnät 2019a) (Message Handbook for Ediel 2002)

There are a few acknowledgement messages included in the Ediel standard. It is determined that an acknowledgement message has to arrive to the sender's EDI system within half an hour after the recipient has received a message. CONTRL (control message) message is a quittance that the EDIFACT format used in the message has been accepted by the receiver. A positive CONTRL message signifies that the data communication has been successful and that the syntax in the message has been correct. CONTRL does not however determine whether the message content has been correct. APERAK (application error and acknowledgement message) is intended for application level quittance management and possible error notifications. With a positive APERAK, the sent message has been successfully accepted by the receiver. An APERAK quittance is not sent automatically, but the sender needs to ask for it in the message. It is recommendable not to use both CONTRL and APERAK quittances simultaneously. (Svenska Kraftnät 2019a)

In Sweden, there are two kinds of lists in use to help ensure coherent information among market actors: AI-list and BI-list. AI-lists are standardised lists which are utilised especially between REs and DSOs. AI-list, where AI stands for metering point information (Anläggningsinformation), contains basic data about end users and metering points. It can be requested by an RE or a DSO to check if the data in the own system matches with the data in another actor's system, e.g., concerning the number of metering points. Differing information can then be corrected to match the given data and thus data quality in the own system is improved. Coherent data is a precondition for an efficient and automatised exchange of information. (Svenska Kraftnät 2019a)

BI-lists are, unlike AI-lists, only sent by DSOs. BI-list stands for change of identity (Byte av Identitet) and it is used for reporting when these changes occur because there's no PRODAT message for these cases. Changes may concern metering point ID, MGA or the DSO itself. The list that is sent to RE contains the current information of metering point ID, MGA and DSO and the date when the new information will be valid. A BI-list is a standardised way to report identity changes from DSOs to REs. (Svenska Kraftnät 2019)

3.1.1 Imbalance settlement information exchange

With the introduction of the NBS model, new reporting formats were adopted. Message formats DELFOR, MSCONS and UTILTS which were previously used in the imbalance settlement between the national TSO and BRPs & DSOs, were replaced by XML formats. These formats are based on the Implementation Guides and Business Requirement Specifications (BRS) from ebIX (European forum for energy business information exchange) and ENTSO-E. The reason behind the change were to harmonise data exchange formats with European practices and ebIX (European forum for energy business information exchange) and ENTSO-E (European network of transmission system operators for electricity are the only organisations that have such standardised documents that could be utilised in the NBS model. (Nordic Ediel Group 2019)

Information flows regarding the imbalance settlement process can be divided into three main phases: scheduling, metering & settlement and reconciliation phases. The scheduling phase takes place before the delivery hour, metering and settlement during and after the delivery hour. Reconciliation is performed once the settlement process is finished. In the scheduling phase the schedules are agreed and the regulation data exchanged between settlement participants. Metering phase indicates the retrieval of deliveries for each metering point. Imbalances are then settled accordingly in the balance regulation market. Finally, in the reconciliation phase the values for profiled metering points are calculated and the final imbalance settlement amounts established. (Nordic Ediel Group 2019)

3.2 Metering

Each location where electricity is consumed or produced has an electricity meter installed, apart from a few exceptions. Metering the electricity consumptions and productions of different end users or producers is of crucial importance to keep the power system in balance and to invoice each user correctly. Metering activities involve mainly the DSOs or service providers but the metering information is relevant to all market actors.

Nordic countries have switched or are going to switch into remotely controllable smart electricity meters, enabling new types of features in the retail markets like demand response services or various pricing models. Finland has since 2014 had at least 80 % of its smart meter base capable of hourly measurement and remote control (Pöyry 2015). Sweden finished its smart meter installations as the first country in the Nordics in 2009, however not all the meters support hourly measurement (Pöyry 2015). Norway finished the change into smart meters in the beginning of 2019 (NVE). Denmark plans to have changed smart meters for all metering points by the end of 2020 (Pöyry 2015). As for the near future, Sweden has made plans to install next generation smart meters by 1.1.2025 (Energiföretagen Sverige 2019b).

In Finland the meter base will start to arrive at the end of their lifetime during the 2020s, hence next generation meter installations will become relevant during this decade. DSO specific implementation is however difficult to define due to differences in meter lifetimes and the schedule of previous installations. The meter change is also affected by the chosen useful life for the meters and the investment spur of the control methods by the Finnish Energy Authority. (Pöyry 2017)

There exist three different main types of metering points in the Nordic imbalance settlement model. The three types are exchange, production and consumption. An exchange metering point measures hourly exchange between two grid areas. One MGA needs to have exchange metering points with all the proximate areas in order to establish correct balances. Production and consumption metering points measure electricity production or consumption in one specific location. There are some differences in the metering subtypes between the Nordic countries, i.e., some subtypes might be country specific and not in use in other Nordic countries. (eSett 2019a)

Consumption metering points have a few subtypes, some of them country specific. Consumption can be metered hourly and remotely which is the most favourable option. Sweden has two special types of hourly metered consumption which are interruptible consumption and large industrial consumers whose usage may exceed 50 MW. Norway is the only country having pumped and pumped storage consumptions specified. Finland differentiates production unit’s own consumption from its metered consumption as the only Nordic country. (eSett 2019a)

Not every meter is of latest technology and not capable of transmitting metering information at hourly time intervals. Hence, profiled consumption is utilised in which a usage pattern based on history, temperature and type of consumption is created. The parameters determine an approximate consumption curve which is used to predict hourly consumption for metering points that lack hourly measurement. These metering points are read after each delivery period which usually implies a month. In Sweden, profiled metering points are settled in profiled settlement, also called schablon settlement. (eSett 2019)

The power system is divided into different MGAs. Each MGA has one DSO that is responsible for metering production and consumption in the area and to report it forward. DSO’s distribution is limited to one market area. DSO calculates also the grid losses for its MGA. Metered grid losses for a single MGA are calculated by adding up metered values from MGA exchange, production and consumption. If profiled grid losses are separated from metered losses, also preliminary profiled consumption is taken into account in calculations. As for retailers, in Sweden there has to be one retailer within one metering grid area that is in charge of the losses in that area. (eSett 2019)

There are certain consumption points that lack metering entirely, e.g., street light and parking meters. For these points, consumption can be calculated when the usage time and installed power are known. Electricity consumption is the product of these two factors and it can be divided into hourly or monthly periods. This division also determines whether a metering point belongs to the daily hourly settlement or the monthly schablon settlement. (Svenska Kraftnät 2019)

Electricity meters are divided into five categories in regulations. The main division is between low and high voltage users but is further based on the type of end user, transformers and the power dimensioning in the metering point. Category 1 includes low voltage customers where measurement is done without a current transformer while those in category 2 have one. High voltage customers in categories 3–5 have both current and voltage transformers included in the metering installation and the division is based on the power dimensioning. Category 3 includes metering points with power under 2 MW, category 4 with 2–10 MW and category 5 with >10 MW. The division exists so that different requirements or recommendations can be released that affect specific categories and meters. The electricity meter categories are presented in table 1. (Energimarknadsinspektionen 2017)

Table 1. Electricity meter categories in Sweden. (Energimarknadsinspektionen 2017)

Category	Electricity meter characteristics
1	- Low voltage - No current transformer
2	- Low voltage - Current transformer
3	- High voltage - Both current and voltage transformer - Power < 2 MW
4	- High voltage - Both current and voltage transformer - Power 2–10 MW
5	- High voltage - Both current and voltage transformer - Power > 10 MW

Today, in Sweden there is no requirement that end users below the schablon limit of 63 A should have hourly measurement of their consumption. The standard meter currently in Sweden is a smart meter that is read remotely but which does not register hourly values. Energimarknadsinspektionen carried out in 2018 a questionnaire directed to DSOs in which DSOs were also asked about how many of their customers had their meters measuring hourly. Out of 40 DSOs that answered the questionnaire, 14 reported that all of their customers had hourly measurement. 7 of the 14 DSOs reported also that all of their customers have access to their hourly values either at a website or via an app. 21 of the 40 DSOs responded that less than 10 % of their customers had hourly metering. Judging by the answers, DSOs offer and maintain more hourly measurement than is requested from end users. (Energimarknadsinspektionen 2018) Although hourly measurement is getting more and more common, a great deal of end users still lack it.

There are currently plenty of projects ongoing in Sweden which aim to upgrade metering equipment for end users that lack hourly consumption. The largest group whose meters need upgrading are small household customers in category 1 with main fuse no higher than 63 A. For these customers, next generation metering equipment should be in place on 1.1.2025 at latest. Meters in category 2 with main fuses of 63 A or lower should be updated by 1.1.2030. Out of Sweden’s total of 5,4 million electricity meters, 5.3 million meters belong to category 1, 120 000 to category 2 and 13 000 meters in categories 3–5. Therefore, the change will affect the majority of metering points. (Energimarknadsinspektionen 2017)

Electricity supplier is involved in the process of calculating and reporting metered values for relevant market participants. The obligation is mainly on the DSO’s side but some of the duties concern the supplier, too. One requisition for an electricity supplier to automatically handle the messages containing metering information for an installation, is that it has details about how meter reading and settlement takes place. These need to be kept up-to-date, for example when a meter switch occurs. (Svenska Kraftnät 2019)

3.3 Balance settlement

The realisation of balance settlements is a central part of electricity markets. The starting point to all of this is having well-organised and reliable data available from the DSOs. This includes both structure and metering data. Structure data serves both settlement and invoicing purposes by enabling the distribution of metering data to individual metering and boundary points. DSO sends the metering data time series to each electricity supplier that has customers in its grid area. Additionally, it exchanges information with respect to boundary points at the grid edges. This is utilised to make sure that balances between grid areas are settled correctly. (Svenska Kraftnät 2019)

Profiled or schablon balance settlement in Sweden means settlement for a metering point that is not hourly metered. It is based on measured values at the beginning and the end of a delivery period as well as a consumption profile. According to these, consumption is calculated for each hour. Schablon balance settlement is done preliminarily before a delivery period and conclusively on the second month after the delivery period. DSO calculates the preliminary load profile shares for schablon settled metering points per each BRP and RE in the MGA. DSO uses load profile from Svenska Kraftnät, weather forecasts and final load profile shares from preceding year to conclude a forecast for the load profile shares and reports these to RE, BRP and Svenska Kraftnät. Svenska Kraftnät reports these forward to eSett per each MGA. (Svenska Kraftnät 2019a)

Whereas the preliminary shares are a forecast, final load profile shares are based on measured data from the metering points that are included in the schablon settlement. The final load profile shares represent the summarised consumption of each monthly measured installation that is schablon settled. The final shares are calculated per BRP and RE like the preliminary shares. DSO uses the final shares to perform MGA balance settlement. Svenska Kraftnät instead uses the shares to calculate reconciled energy which is the difference between final and preliminary load profile shares and it is calculated for each BRP’s deliveries. The calculation is done monthly on the third month after the delivery period. (Svenska Kraftnät 2019a) (eSett 2019)

Starting from 01.01.2020, the only settlement practices in Sweden will be hourly settlement and schablon settlement. The one settlement practice that is about to be removed is monthly settlement of hourly measured metering points. The practice was created to enable end users to choose a contract that requires hourly measurement, but which does not require DSOs to include them in the daily hourly settlement. To compensate REs for eventual extra expenses, a profile compensation would be used which essentially is a payment from a DSO to its REs. (Svenska Kraftnät 2019a)

Though settlement routines are usually reliable, errors may still occur due to metering flaws in consumption or exchange points, errors in reporting or balance settlement calculations, etc. The DSO is responsible for correcting false values and re-reporting them. eSett's gate closure, i.e. the time period until which metering values can be updated, takes place certain days after the delivery day, and it depends on the data being reported and the country. All DSOs report the initial metered data by 10:00 CET (central European time) on the second day after the delivery day, after which the DSOs may update the data. Finnish DSOs may update the settlement data until 0:00 CET on the 12th day, Swedish until 0:00 CET on the 13th, and Norwegian until 12:00 CET on the 13th day after the delivery day. In Norway, DSOs update the data to Elhub, the Norwegian data hub for information exchange, which in turn reports aggregated data to eSett. Finland and Sweden will adopt the same practice once their national data hubs become operational. (eSett 2019)

Changes to the metering values after the gate closure result in imbalance. A bilateral imbalance correction is a financial settlement between actors that settles the imbalance for the relevant actors. The main purpose of the correction is with minimal administration to neutralise the financial imbalances between parties as long as it's possible according to law and general agreements. (Svenska Kraftnät 2019a)

Imbalance correction may also be used to settle other types of issues. For example, if an actor like RE is not correctly structured at eSett's system, certain metering points cannot be settled towards the right RE. This will consequently lead to imbalances between market actors. A metering flaw may have consequences for BRPs, REs, DSOs and end users. The imbalance correction is performed afterwards to redress the imbalance between actors in a neutral way. The correction needs to follow the assumed realistic settlement approximately, yet minimise administration. The party that is responsible for the error, should cover the costs that remain. (Svenska Kraftnät 2019)

3.3.1 **Imbalance settlement responsibilities**

Each market participant has certain areas of responsibility concerning the imbalance settlement. TSO manages the physical balance of the system by adjusting production and import to correspond the consumption and demand, and calculates the imbalance adjustment volumes and prices. TSO submits structural information of MGAs and information per BRP to eSett, like production plans and accepted imbalance adjustments.

DSO operates the metering system and calculates load profile shares as well as the final reconciled energy. DSO then reports these to relevant market participants. (eSett 2019a)

BRP is the financial counterpart for imbalance settlement, adjustments and reconciliation, for which it needs a valid agreement with eSett. BRP plans its hourly deliveries and reports these to the TSO. BRP informs eSett about bilateral trades and which REs it has taken the balance responsibility for, plus verifies the data that it receives from eSett. (eSett 2019a)

RE needs to be registered at eSett for the participation in the imbalance settlement. For a successful registration, RE provides eSett with required information at least 14 days prior to entering to the market. RE is required to have BRPs in each MGA where it's active. An agreement needs to be made both for production and consumption in all MGAs. The relevant BRP is then responsible for the open delivery for the retailer in that MGA. RE starts the switch of supplier process and keeps its own contact information up-to-date. (eSett 2019a)

Many of the services performed by market participants can be handled by a service provider. The tasks are mainly routine which makes them reasonable to outsource to an outside service provider. When agreed upon between a market participant and an SP, SP is allowed to perform these tasks regarding the imbalance settlement system. These services might involve reporting settlement data, verifying eSett's calculations or updating structure information. (eSett 2019a)

3.4 Invoicing

Invoicing takes place regularly in the electricity markets, usually on a monthly basis. The principle is the same as in any service in the sense that the party offering a commodity or a service invoices the customer. A supplier invoices the end user based on consumed electricity, while the DSO invoices for the distribution of electricity. In addition to charging for the distribution, in the Nordics the DSO charges the electricity tax from the customer. In electricity markets it's not unusual that a single party charges all the necessary invoices from the end user. This may be either an RE, a DSO or a delegate party. Invoicing is a fairly routine-like process with similar tasks performed at regular time intervals so it applies well as an outsourceable process. (Svenska Kraftnät 2019a)

The DSO's incomes consist largely of variable tariffs for transmission and fixed charges based on the consumption point's maximum power or fuse size. Depending on the type of grid contract, the grid tariffs towards an end user may consist of transmission, power, subscription and administrative costs. In contrast to grid tariffs, RE's tariffs are not regulated but the price setting happens in the market in accordance with supply and demand. (Svenska Kraftnät 2019a)

Combined billing means merging the invoice from the DSO and the invoice from the supplier into a single invoice. In a supplier-centric model, the supplier is responsible as the customer's primary contact for delivering the invoice to the customer. The supplier, or a representative party, receives the information needed to produce, e.g., data for grid tariffs and sends the invoice to the customer. When the supplier performs the invoicing, a credit risk follows. The supplier bears the financial risk because the supplier must recompense the DSO regardless if the customer pays or not. (Svenska Kraftnät 2019a; Nordic Council of Ministers 2017)

NordREG has proposed that each Nordic country adopts combined billing, in which the supplier sends the invoice (Nordic Council of Ministers 2017). The Nordic countries are in different stages in the implementation and currently only Denmark has combined billing in effect. The Danish model has been developed towards a wholesale model, where the data hub includes all invoicing data, which REs utilise to invoice customers. Norway's Elhub does not yet include the functionality for combined billing, and the legislation does not consider it to be mandatory. The functionality can be added at a later stage to Elhub. Finland and Sweden do not yet have their national data hubs operational, and mandatory combined billing is yet to be introduced. In Sweden, Energimarknadsinspektionen has already suggested combined billing to be included in the Swedish data hub. (NordREG 2019a)

In Norway, combined billing exists if the DSO is willing to offer it. Often for vertically integrated companies, where a RE and a DSO belong to the same group of companies, combined billing reduces the amount of administration costs for invoicing. If the DSO decides to apply combined billing towards the RE in the same group of companies, the DSO must offer the service for all other REs within the MGA. (Nordic council of ministers 2017)

3.5 Customer processes

A retailer manages various business processes concerning their customers. Many of the processes are related to the delivery. The start, end, termination, and cancelling of a supply are different process variants, which are performed in accordance with the situation at hand. Verifying, updating and informing other parties about the customer or contract information is an essential part of a RE’s operation. The management of information exchange relevant for a RE’s each customer and metering point is necessary for each RE. For instance, a RE needs to be able to receive the metered data in order to invoice its customers. (Svenska Kraftnät 2018b; Energinet 2018)

A RE’s business processes face certain changes when the transition into the data hub era occurs. For example, a change of supplier process in Sweden has different features with and without an operational data hub. In the current model, when a customer signs a contract with a new RE, the RE informs the DSO. DSO then confirms the change of supplier process for the new RE and announces end of supply for the old RE. The new RE informs its BRP with the estimated consumption for the metering point. In a data hub environment, the same process is divided into two business processes in the BRS document. The first process is the new RE announcing the change of supplier to the data hub. If the process is successful, the data hub initiates the process that informs each relevant party, i.e., the new and old REs, the DSO and possibly a third party. (Svenska Kraftnät 2019a; Svenska Kraftnät 2020b)

4 UPCOMING MARKET CHANGES

4.1 Centralised information exchange system

A major change that is taking place in the Nordic electricity retail market is the introduction of central information exchange systems, so-called data hubs. Nowadays, the information in the market is decentralised among the market actors and the different information flows are incredibly numerous since each actor sends data to and receives data from multiple participants. There is a need for making the information exchange more efficient since the messaging network has become quite extensive. A data hub is a pivotal system which collects data from market actors and sends them forward or makes them available for others to retrieve. A data hub can be described as a service provided by a TSO for REs and DSOs, where the value of the service comes from the fact that REs' communication narrows from several DSOs down to one system operator (INTERRFACE 2020a). The change in information exchange is illustrated in figure 3, where the previous and new modes of operation are depicted. Many of the processes that the market actors have previously performed themselves, will be performed through the data hub. (EDIELfi 2019)

In all Nordic countries, the development and operation of the data hub has been allocated to the national TSO. In Sweden, the task for the development of the Swedish data hub, Elmarknadshubb, was given by the Swedish government to the Swedish transmission system operator Svenska Kraftnät. Elmarknadshubb is planned to be operational in 2022, and the deployment is planned to happen sequentially. Building a well-functioning central information system requires thorough software development, supportive legislation and good preparation among market actors (Svenska Kraftnät 2017, 1–2). Similar central data centres are already operational in Denmark and Norway, called DataHub and Elhub. Danish DataHub was first launched in March 2013, and in April 2016 a supplier-centric model was introduced. Supplier-centric model means that the electricity supplier is the customer's main point of contact in the market. Norway's Elhub was introduced to the market in February 2019. Finnish Datahub is under development and will be operational in February 2022, according to latest information by Fingrid (Fingrid 2019). The go-live dates of Nordic data hubs are presented in table 2.

Table 2. Go-live dates for the Nordic data hubs.

Country	Data hub go-live
Denmark	Version 1: Q1/2013 Version 2: Q2/2016
Norway	Q1/2019
Finland	Q2/2022
Sweden	Q4/2022

The data hubs in all Nordic countries include TSO as the system operator, as well as REs and DSOs as market actors who need to operate in the data hubs. Consequently, REs and DSOs get access to the hubs and need to integrate their messaging systems to be hub-compatible. BRPs do not have access to data hubs, however they are involved in some data hub business processes. For example in Denmark, BRPs cannot access the data for metering points which the BRP holds the balance responsibility for. In Norwegian Elhub, the business processes where the BRP is involved include e.g. query for settlement basis and receiving of data for imbalance settlement. (Elhub; Energinet 2015)

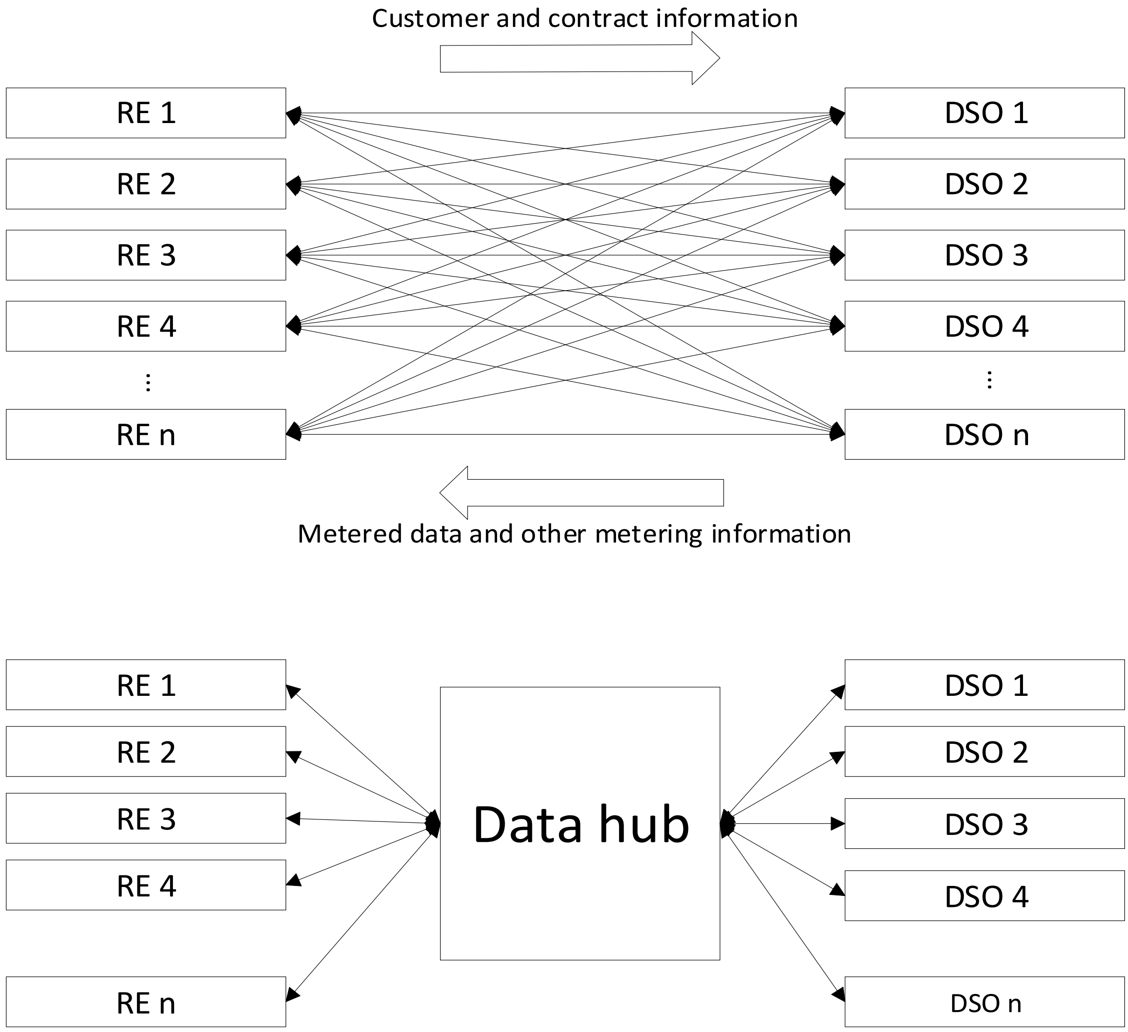

Figure 3. Messaging network before and after the introduction of a data hub.

The implementation of the data hubs is an important factor in facilitating and centralising the wholesale and retail market processes. NordREG produced a report in 2019 to find out by contacting the TSOs, what the situation looks like in each Nordic country at the moment. So far, only Denmark and Norway have successfully deployed data hubs, while Finland and Sweden are expected to have data hubs in a few years. In Sweden, the greatest challenge has turned out to be delayed legislation which to some extent inhibits the preparation of the market participants' IT systems. It is why the actors' focus has been on producing an inventory of their data and improving it. In Finland, the essential ongoing project phase is improving data in each actor's system and migrating it to the data hub. Denmark has been concentrating on the transition from profiled settlement to hourly settlement in 2018 and Norway's main areas of focus were finalising the development of Elhub and preparing for the go-live. (NordREG 2019a)

The plans in the near future are distinct from country to country. Energinet is going to work on fully integrating eSett and hourly settlement to the DataHub, eliminating profiled settlement and reconciliation in the process. Statnett continues working on the development of functionalities that enable 15 minute settlement periods. Shifting to 15 minute settlement periods will affect each country's data hub in the upcoming years, not just Norway's Elhub. Fingrid announced in September 2019 that the deployment of Datahub will be postponed to February 2022. The upcoming plans include improving and certificating data quality as well as performing testing activities. Sweden will work on to shift from developing a prototype to developing the actual hub. The focus will be on core functionalities since they are most likely not affected too much by renewed legislation. After the legislation is introduced, presumably in summer 2020, Svenska Kraftnät will coordinate the migration activities, like adapting IT systems and processes. (NordREG 2019a)

Ediel messages that are being used today for data exchange between market parties will for the most part no longer be relevant once Elmarknadshubb in Sweden and Datahub in Finland become operational. With the introduction of data hubs the primary message standard is no longer going to be Ediel. The European standard which the information exchange will be based on is called ebIX. In Finland, the Datahub interfaces have been determined from ebIX message definitions, and the documentation from Harmonised Nordic Retail (HNR) and Elhub projects. Elmarknadshubb and Datahub will also provide a domain to enable dialogue between market actors to facilitate better communication, just like Denmark's DataHub and Norway's Elhub. DataHub and Elhub base their interfaces on the ebIX format, too. (Fingrid datahub 2019)

4.1.1 Swedish data hub

The data hub under development in Sweden is called Elmarknadshubb. The Elmarknadshubb will include relevant information for different parties and provide a platform where these are available. Information about all metering points, customers and contracts will be included in the Elmarknadshubb. The introduction of Elmarknadshubb will enable operations that differ from the current ones. For example, an end user will only need to be in contact with electricity supplier who takes care of electricity contracts, handles relocations and the change of supplier, as well as invoices all costs from the customer. This will also mean that the Elmarknadshubb will be supplier centric. Unlike in Denmark, where the supplier centric model was introduced three years after the go-live of DataHub, in Sweden the supplier centric model will be deployed simultaneously with the launch of Elmarknadshubb. (Svenska Kraftnät 2017; Svenska Kraftnät 2019b)

With the introduction of Elmarknadshubb, some operations now carried out individually by market parties will be executed in the hub. Elmarknadshubb will provide a platform where updating of metering, customer and contract information, as well as reporting towards eSett and the Nordic balance settlement, are possible. Additionally, some of the responsibilities will shift from distribution system operators to suppliers, like handling customers' activities regarding all invoicing. Adjusting the IT systems to correspond the new system is required from all market parties. A transition period is currently ongoing where market parties are expected to accomplish tasks that are essential for the introduction of Elmarknadshubb. Before data about metering points and customers can be validated and brought into the new system, each party needs to produce an inventory of their structure data and improve it if necessary. (Svenska Kraftnät 2017; Svenska Kraftnät 2020b)

Elmarknadshubb is being developed to respond the future market's demands and to make new kinds of services possible in electricity market. There are several objectives and targets that drive the development of the Elmarknadshubb. Making things easier for the customers is hoped to increase their activity in the market, for example concerning the switches of electricity suppliers. The new model is expected to achieve preconditions for better competition and to make information exchange more efficient. Besides, the new model aims to stimulate the market by enabling innovation and new types of energy services better than before, for example those related to energy saving and flexible energy consumption. (Svenska Kraftnät 2017)

Svenska Kraftnät has proposed a plan to utilise sequential introduction of the Elmarknadshubb. The main reason behind this is to reduce the risk caused to the market by the deployment process. By dividing the deployment into different phases, the initial deployment process would be more reliable and the deployment could take place earlier than if the whole Elmarknadshubb would be deployed in one go. However, the proposal suggests that the supplier centric model will be introduced together with the Elmarknadshubb, meaning that most of the functionalities will be included in the first deployment (Svenska Kraftnät 2019b). The market actors and organisations as well as authorities seem to be positive about sequential deployment. 95 % of the opinions that Svenska Kraftnät got to its survey about sequential deployment were positive (Svenska Kraftnät 2019c).

By introducing a supplier centric model, a customer will have contact solely with an electricity supplier. In order for Elmarknadshubb to achieve this, for example following information or functionalities need to be part of the first deployment:

- Portals for both customers and market parties
- Register of metering points
- Handling of metering values, grid fees and tariffs
- Domains for various market processes, e.g., for relocation or switch of supplier

Conversely, following information is not mandatory for the initial deployment and therefore introduced afterwards:

- Balance settlements for metering grid areas
- Information to service providers (third parties)
- (Communication between parties) (Svenska Kraftnät 2019b)

Deploying functionalities separately allows that the first release of Elmarknadshubb covers fewer areas of focus and the total risk of failure is decreased. The processes that would be introduced later do not affect the deployment of supplier centric model and can be brought into the system later. Also, good quality of single functionalities can be better ensured and the process in itself could be more frictionless. A common feature among the processes that would be introduced later is that they benefit from having the Elmarknadshubb already operational. (Svenska Kraftnät 2019b)

Introduction of MGA balance settlements is suggested to be separate from the first release because errors in the settlements could result in significant economic consequences. By postponing the settlements, more attention can be placed on the matter. During the time Elmarknadshubb is already operational, the MGA balance settlements carried out by the DSOs can be calculated parallel in Elmarknadshubb to confirm the calculations. (Svenska Kraftnät 2019b)

As the electricity market will change profoundly with the introduction of Elmarknadshubb, it also means that new legislation needs to be adopted. The legislation will somewhat affect the functions of Elmarknadshubb, thus the planning and activities for Elmarknadshubb will be adjusted with respect to the legislation. The date for the introduction has however been delayed, and legislation is expected to come out in 2020. This delay is also one of the primary reasons that Svenska Kraftnät had to postpone the proposed date of deployment from 2021 to 2022. Upcoming legislation and regulation require that Elmarknadshubb will offer a portal for the end users. This is to enable the management of customers' consents directly between customer and Elmarknadshubb. Furthermore, the portal will help customers to make deliberate choices and to be better aware of their contracts. (Svenska Kraftnät 2018a) (Svenska Kraftnät 2019d)

Deploying a supplier centric model means that the responsibilities for different operations will somewhat change between the market parties. Preliminary plans imply that main operations for a DSO are:

- Perform grid services, such as new connections, coupling to and from the grid
- Gather, validate and confirm metering values
- Update Elmarknadshubb with metering point information, metering data, grid tariffs and grid fees for each metering point
- Manage grid balance settlement, construct documentation for grid invoicing and invoice grid costs to the electricity suppliers. (Dyrberg et al. 2018)

Main operations for an electricity supplier are:

- Announce customer to a delivery point, plus continuingly update customer and contract information
- Report supplier and balance responsible party to a delivery point
- Control metering values and grid costs (nätavgifter)

- Invoice customers
- Pay grid costs to a DSO. (Dyrberg et al. 2018)

Elmarknadshubb handles mainly the following areas:

- Hold register of and provide parties with metering point and customer information
- Aggregate metering values and grid-related costs for electricity suppliers
- Perform grid, schablon and correction calculations
- Facilitate communication between parties
- Daily distribution of balance settlement documentation to eSett. (Dyrberg et al. 2018)

Early documentation about upcoming processes related to activities in the Elmarknadshubb has been published in Svenska Kraftnät's portal for Elmarknadshubb. BRS-document (Business requirement specification) is a listing and description of activities between market actors and Elmarknadshubb. It is defined what kind of information exchange will happen, but not exactly how it will happen as the definitions will be released later. For example, until the introduction of Elmarknadshubb each DSO reports metering values to multiple actors with EDI messages. With Elmarknadshubb operational, DSO will register the values to Elmarknadshubb where these are available for respective market actors. (Svenska Kraftnät 2018b)

DSO will send metering information to Elmarknadshubb in a format that Elmarknadshubb requires. Messages include information ranging from actor and metering point ID to metering type, registration time and metering value. The message needs to be specific so that metering values for each point will be correctly registered. Each message to and from Elmarknadshubb requires an acknowledgement from the counterpart. Once message has successfully arrived and the DSO has received a positive acknowledgement, Elmarknadshubb will initiate distributing information to respective actors. Other actions that relate to the management of metering values in Elmarknadshubb are retrieving, requesting and ordering of metering values. (Svenska Kraftnät 2018b)

4.2 15 minute imbalance settlement period

The change of imbalance settlement period (ISP) from 60 minutes to 15 minutes is a change that affects all countries in the EU. European commission released the regulation act 2017/2195 in December 2017 that the change into 15 minute ISPs needs to come into effect in December 2020. The regulation act however allows a possibility to a temporary exception from the schedule if such is requested. The four Nordic system operators, Fingrid, Svenska Kraftnät, Statnett and Energinet have requested a postponement to the schedule, with the goal of introducing 15 minute ISP in Q2/2023. The planned introduction schedule is also included in the update roadmap for the Nordic Balancing Model. (Nordic Balancing Model 2019d) (Svenska Kraftnät, 2018c)

Shorter ISP is necessary for a number of reasons. The increase of intermittent weather-dependent generation amplifies the uncertainties in the production plans. If these uncertainties produce deviation during mornings when consumption increases, the grid balance weakens, creating the need for balancing energy and thus higher imbalance costs. The key objective with 15 minute ISPs is to establish as real-time motive as possible for BRPs to balance production and consumption, thus contributing to the system balance. With 15 minute intervals, some deviations that nowadays remain hidden will become visible. Deviations may remain hidden if during a delivery hour deviations occur in both directions, for example consumption falls short of the forecast during the first 30 minutes but exceeds the forecast in the last 30 minutes. In figure 4, this phenomenon is illustrated, and the figure shows how intraday trade with 15 minute intervals can contribute significantly to reduced imbalances. Having deviations more visible causes more expenses if the imbalance grows and thus gives more motivation for market actors to adjust their balances, consequently improving the quality of grid operation. Allocating costs for imbalances, as well as price setting for offering market flexibility are also improved with shorter ISPs. (Svenska Kraftnät 2018c; Nordic Balancing Model 2019a)

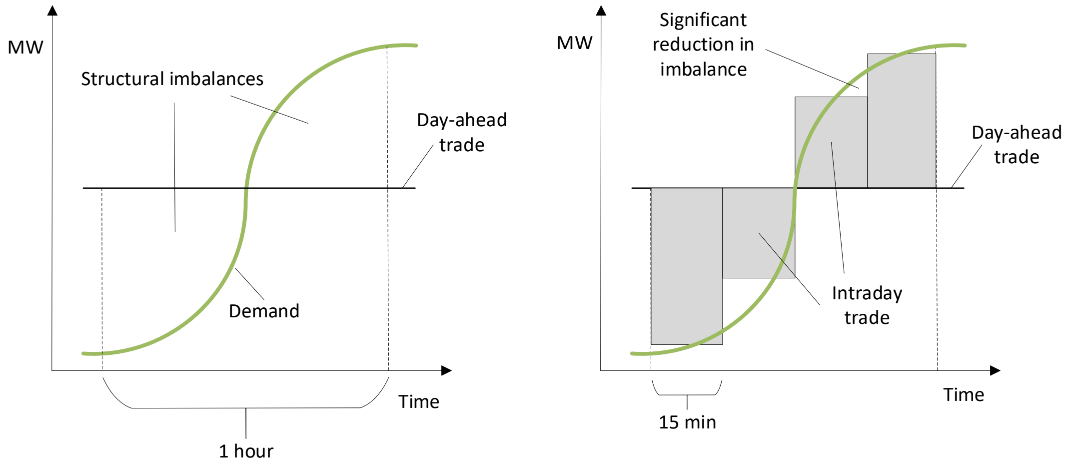

Figure 4. Reduction of structural imbalances with intraday trade in 15-minute time intervals. Adaptation from (Svenska Kraftnät 2018c)

The switch to 15 minutes time resolution affects the whole chain of equipment and systems. The meter, meter management systems, data communication and meter data processing (e.g., settlement) need to be compatible to handle shorter time resolution and more data. Also the national data hubs will have the feature to handle 15 minute time intervals. Therefore, investments from both DSOs and TSOs, as well as resources from IT vendors are necessary. The changes proposed by EU concerning principles of metering must be passed into national legislation, including which meters will need to have readings at 15 minute intervals. As of currently, the deadline Q2/2023 is only the TSOs' proposal, with no confirmed effective date. (Nordic Balancing Model 2019a)

Along with 15 minute ISPs, also intraday and regulating power markets will switch to 15 minute periods. Regulating energy market mFRR (manual frequency restoration reserve) will switch to 15 minute intervals whereas the regulating capacity market aFRR (automatic frequency restoration reserve) will for now remain in the hourly resolution. Day-ahead market will follow later in 2025, according to existing plans. 15 minute ISPs will require that metering equipment in exchange, production and large consumption points is capable of registering metering values every 15 minutes. Consumption of normal households or other smaller consumption points where schablon settlement is currently used will not yet be required to switch to readings with 15 minute intervals and therefore consumption patterns will remain in use. (Svenska Kraftnät 2018c)

Harmonised settlement period is fundamental for combining markets together. It enables coupling of balance markets, increases cross-border trade and further unifies European energy markets. 15 minute ISPs are already in use in some European countries, like Germany and Netherlands, but it will nevertheless be a great undertaking in many countries. The change into a shorter time interval has been commissioned because of the benefits it provides. These include increased capacity on interconnectors and better possibilities to reduce structural imbalances. Currently, the interconnectors that enable cross-border electricity transmission have restrictions that the hourly power adjustments are restricted to 600 MW. Switching to 15 minute ISPs allows continuous adjustment and therefore higher hourly total than 600 MW. In intraday markets, trading with 15 minute intervals offers a better possibility to reduce imbalances by trading closer to the delivery hour. (Svenska Kraftnät 2018c)

4.3 Smart metering

The guidelines for the new generation metering equipment were determined on European level by the European Commission in 2012 when it released recommendations for the installation of smart meters. The recommendations included functions like a customer interface for access to the consumption information, more frequent readings and remote controllability. These recommendations have then been revised and they form the foundation also for Energimarknadsinspektionen’s publication of the topic. (Energimarknadsinspektionen 2017)

As a part of the transition into a smarter and more flexible electricity market, the Swedish meter base is due for an upgrade. Energimarknadsinspektionen has determined in its publication new features that the next generation’s meters should have (Energimarknadsinspektionen 2017). Based on this, Energiföretagen Sverige has produced a recommendation for the industry. One of the new features is that the metering equipment includes customer interface that allows better information exchange towards the customer. The changes apply for all metering equipment but are most relevant for households since their meters approach the end of their both economic and technological lifetime. The new regulation comes into effect on the 1.1.2025. The previous extensive change of metering equipment happened after new regulation came into effect in June

2009 which included the requirement for monthly remote readings of consumption. (Energiföretagen Sverige 2019a) (Energiföretagen Sverige 2019b)

Energimarknadsinspektionen has specified the following seven functionalities that the new meters should have.

- Ability to meter every phase of active and reactive energy, voltage and current for both directions
- A customer interface for reading of near real-time metering information
- Remotely readable
- Convertible from hourly to 15-minute reading intervals
- Ability to record information of electricity outages, e.g., beginning and end of the outage longer than three minutes
- Update meter software and settings with remote control
- Turn off and on the power with remote control (Energimarknadsinspektionen 2017)

The reasons behind the new requirements and functionalities are related to the upcoming changes in the market. A transition into a fully smart meter base that measures with shorter time intervals contributes to a reliable and effective grid operation. The amount of micro production connected to the grid is going to increase and better meters facilitate the transition. Smart meters also encourage a broader customer participation to the market by creating some preconditions for modern services, such as demand response. (Energimarknadsinspektionen 2017)

The functionalities of new smart metering systems have also been determined at a European level. In EU’s directive 2019/944 on common rules for the internal market for electricity, the updated requirements for smart metering systems were published. The EU’s requirements do not go into technical details as much as Energimarknadsinspektionen, but determines also aspects related to data security and informing the end user about the utilisation of the whole potential of the meter, e.g., for the monitoring of energy consumption. In the Article 20 of the directive it is stated that:

- Smart metering systems need to accurately measure the actual consumption

- Smart metering systems shall enable final customers to be metered and settled at the same time resolution as the imbalance settlement period in the national market
- Pertinent EU data security regulations must be followed
- Regulations concerning final customer privacy must be followed
- Meters are able to record electricity fed into the grid from the active customers' premises
- If requested, metering values must be displayed to a final customer or an authorised third party
- Final customers need to be instructed about the full potential of the new meters in the management of meter reading and the monitoring of energy consumption. (European Commission 2019a)

Smart meter will not be a home automation system even if features besides metering and data exchange would be added to the meter (Pöyry 2017). The next generation smart meters will be intelligent sensors that enable more accurate, more versatile and more real-time metering. The intelligence however will mainly be in the information systems where the metered data is transmitted to. Different systems that utilise the metered data are information systems of DSOs and other market participants, e.g., service providers, and customers' own systems that utilise the metered data, such as home automation systems. (Pöyry 2017)

In Finland, the next extensive update of meters is expected to start in the 2020s. There is not yet a clear schedule or an official list of meter functionalities in place. In Pöyry's report, several functionalities for next generation meters are analysed and presented. The list has a great similarity to the Swedish requirements. The report proposes following minimum functionalities:

- Metering frequency of according to the ISP, 3–15 minutes
- Metering of energy, active and reactive power is all three phases
- Metering of momentary values; active and reactive power, voltage and frequency

- Metering of withdrawal from the grid and feed-in to the grid in all phases without summing up the values
- Registering of outages including the ones with duration of three minutes or less
- Capability of remote updates to the meter software
- Capability of remote disconnections and connections
- Local physical one-way data transfer route with update frequency of maximum 5 seconds. (Pöyry 2017)

4.4 Nordic balancing model

Nordic Balancing Model is the joint program of Nordic TSOs to update the balancing processes. The program aims to develop balancing processes so that they follow the European legislation and thus allow for the unification of Nordic and European balancing markets. Updating the current processes is needed to integrate and harmonise the European power market. The changes to be made also contribute to increasing the share of renewable energy in the power system and to improve balancing market efficiency, which contributes to reliable grid operation. (Nordic Balancing Model 2019)

The roadmap for the new model consists of various milestones that are scheduled to take place in the next 4–5 years. The most important milestones are presented in figure 5. The milestones in the Nordics include updated information on go-live for aFRR capacity market (Q3/2020), mFRR capacity (Q3/2023 at the earliest) and mFRR activation (Q2/2023) markets, as well as single price model (Q2/2021) and 15 minutes time resolution (Q2/2023). The plan is to concentrate on the Nordic area first before joining the European aFRR and mFRR energy activation markets. After the Nordic project is completed, the connection to the European aFRR and mFRR platforms is planned to take place between Q3/2023–Q2/2024. The objective that has been prioritised in the schedule is the go-live of 15 minutes time resolution that is scheduled to take place in Nordic countries in Q2/2023. It is necessary to have an automated mFRR activation market ready before shorter time resolution. (Nordic Balancing Model 2019a; Nordic Balancing Model 2020b))

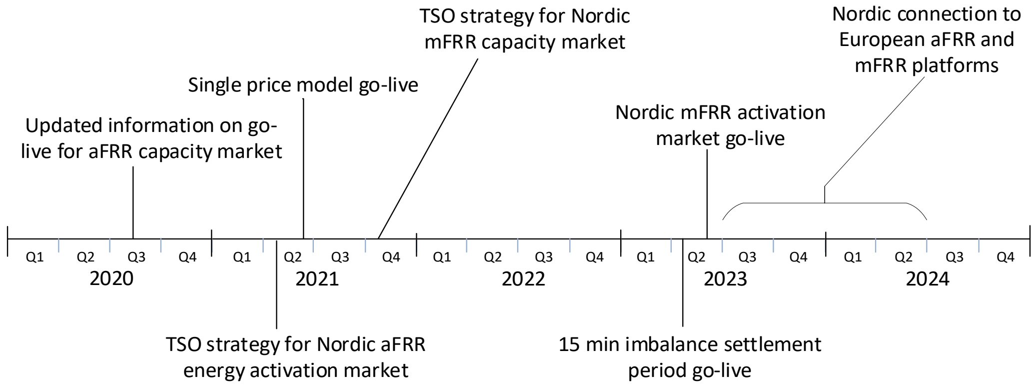

Figure 5. Important milestones of the Nordic Balancing Model project. Adaptation from Nordic Balancing Model (2019a).

The common regulating power market in the Nordic area is the mFRR market. Updating the mFRR market processes is relevant due to the market's important role for the functionality of 15 minutes time resolution. Several changes are needed to fill the requirements set by the European Guideline for Balancing (EGBL). There is a need for changes in TSO processes, product definitions and terms and conditions for market participation to allow for automation to be implemented. A full scale electronic ordering for the mFRR activations will be required, and Sweden is the only Nordic country not to have a tentative solution currently in place. Another feature is an activation optimisation function (AOF) which delivers orders for the scheduled activations automatically for each balancing area. After 15 min resolution is introduced, the mFRR standard product validity period will be shortened to 15 minutes which entails more frequent activations. (Nordic Balancing Model 2019b)

The NBM entails the transition to modernised area control error (mACE) based grid balancing. This means that a need for balancing energy, i.e., area control error, is determined for each load-frequency control (LFC) area but the activations are resulted from the AOF. The function facilitates an efficient and automated balancing while taking available bids, available transmission capacity and zonal balancing needs into account. The automated activations for both aFRR and mFRR will be based on mACE balancing. The Nordic mACE balancing platforms for aFRR and mFRR resemble the respective European platforms. Eventually, the Nordic balancing markets will connect to these European-wide markets, thus the similarity of the markets is advantageous. (Nordic Balancing Model 2019a) mACE based balancing offers multiple benefits in comparison to the current frequency based grid balancing. Participation to the market without the commitment to the capacity market will be enabled. Balancing service providers (BSP) will be able to leave bids to the market for non-contracted resources, i.e., which have not been procured in the capacity market, thus increasing the number of suitable balancing resources. The AOF algorithm enables the optimised use of grid capacity since it uses input data from all bidding zones. Furthermore, efficient exchange of balancing products and an equitable settlement between buyers and sellers will be secured. (Nordic Balancing Model 2019a; Nordic Balancing Model 2018)

4.4.1 Nordic reserve market

Reserve markets in the Nordic countries have been mainly national markets. Nevertheless, the Nordic countries have in use mostly similar reserve markets, which will also form the foundation of the integrated reserve markets across the Nordics. The reserve types can be divided into primary, secondary and tertiary reserves based on the sequence by which the reserves are activated. The primary reserve is called FCR (Frequency containment reserve), which quickly reacts to the changes in system frequency and works to contain it close to the normal operational frequency of 50 Hz. FCR is divided into FCR-N (Frequency containment reserve for normal operation) which is used continuously and FCR-D (Frequency containment reserve for disturbances) which is activated during large sudden changes in the frequency. The secondary reserve is aFRR, which is constantly used during the hours it has been procured for. The tertiary reserve is mFRR, which is activated manually if necessary. A new reserve type, FFR (fast frequency reserve), is being introduced to the reserve markets by Nordic TSOs. FFR would offer very fast response within a second to sudden frequency changes. The different reserves used in the Nordics are presented in figure 6.

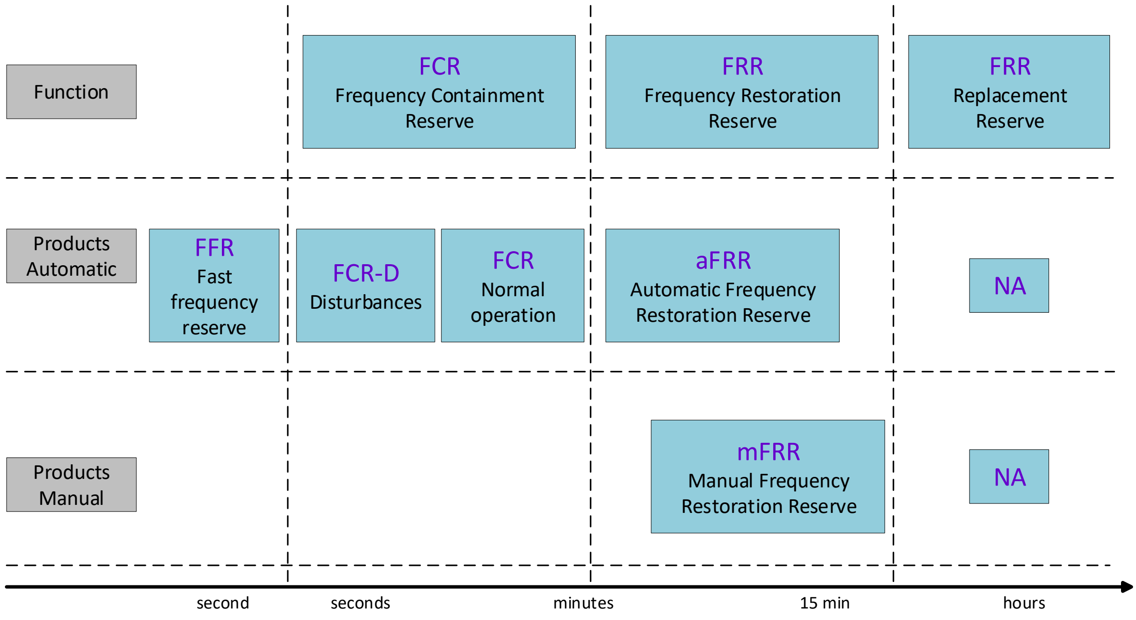

Figure 6. Different reserves used in Nordic countries. Adaptation from Fingrid (2019c).

The aFRR capacity market is the first balancing market that will be common across the Nordics. Nordic TSOs have been discussing about the details of the market and its implementation during 2019 and 2020, yet the discussions have not resulted in a common conclusion. Allocation of cross-zonal capacity and proposal for a Nordic aFRR capacity market have not been agreed upon, thus the matter will be decided by the ACER (Agency for the Cooperation of Energy Regulators). This might also have an impact on the proposed go-live date in Q2–Q3/2020. (Nordic Balancing Model 2020b; Nordic Balancing Model 2019e)

Activation of aFRR regulation is based on the grid frequency. A central control signal is sent from the TSO to the reserve component when the frequency deviates from 50,00 Hz during the hours when the reserve has been procured. The reserve then acts according to the signal, for example increasing or decreasing production. aFRR reserve serves to bring the frequency back to its desired value. General requirements for the participation in the aFRR market include successful prequalification, real-time measurement, electronic communication and endurance of the resource. aFRR reserve is procured by the TSOs for the hours where the changes in overall consumption are most significant during morning and evening hours. (Svenska Kraftnät 2019e; Svenska Kraftnät 2019f)

4.4.2 Single price model

As of today, a dual price model is used for the settlement of imbalance power. Switching from this to a single price model is necessary due to European imbalance settlement harmonisation as many European countries are already using the single price model. One challenge of the new imbalance model has been to determine conditions for dual-pricing in such settlement periods, where both up and down regulation is applied. In January 2020, the Nordic TSOs agreed that the dual-pricing is omitted altogether from the model, and that single pricing will be implemented for all imbalances. The TSOs propose the switch to happen by Q2/2021 as indicated by the stakeholders. (Nordic Balancing Model 2019a) (Nordic Balancing Model 2020a)

In the current imbalance settlement scheme, production and consumption balances are separate. A production plan is generated in the production balance, and the plan is subsequently used in the calculation of the consumption balance. Different pricing schemes are applied to the two balances, as dual pricing is used for production and single pricing for consumption. All of this is due to a revision in the new model. Production plans will cease to affect the balance of a BRP. Along with the introduction of a single imbalance price, separate production and consumption balances are merged into a one balance as well as a single BRP position is introduced. The imbalance price calculation will be changed to correspond the European version and reference pricing rules will be adapted. The changes are illustrated in figure 7.

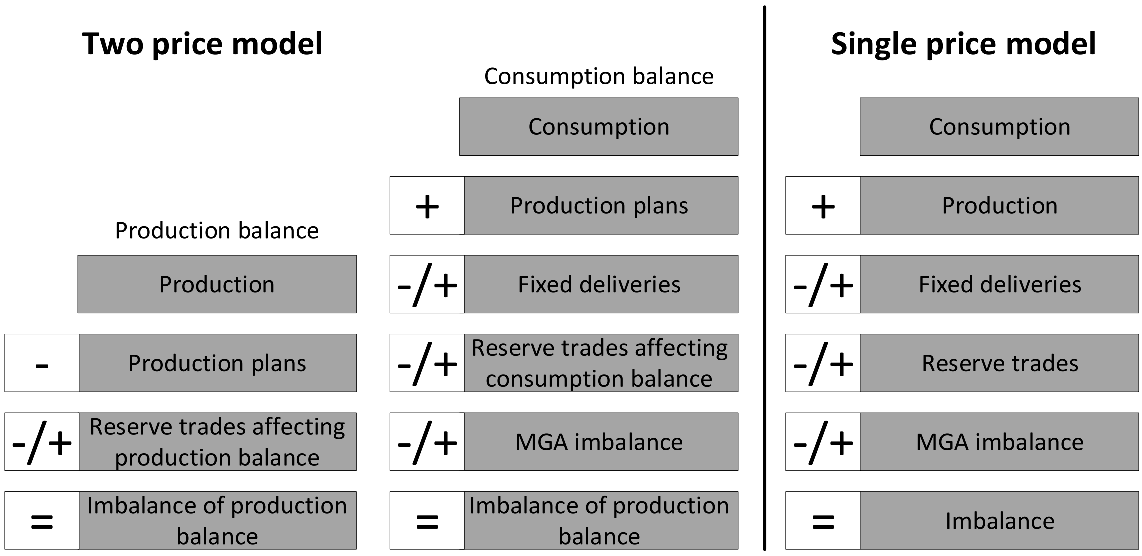

Figure 7. Presentation of current two price model and probable single price model. Adaptation from (Fingrid 2018b).

The switch from dual pricing to single pricing is closely related to how the BRP behaviour is wanted to be influenced. Currently in the Nordics, imbalances are calculated separately both for consumption and production. Imbalances for production are managed with the dual pricing, and imbalances for consumption with single pricing. Dual pricing serves to incentivise BRPs to keep their own balance, while single pricing incentivises BRPs to reduce imbalance that is disadvantageous for the system and create imbalance that supports the system. Also, with single pricing there are better preconditions that the BRPs actively take part to the TSO balancing. (Nordic Balancing Model 2019a)

There are two possible options for the single price model implementation schedule. First option would implement the single price model before the introduction of 15 minute ISP, whereas the other option is to introduce these simultaneously. The advantages related to this option include obtaining market efficiency gains, such as harmonised playing field for BRPs, incentives for market players to restore system balance, and not having to implement two changes at once. One drawback in this option is the TSO's operational concerns in some situations where power oscillation occurs. This might occur if self-regulation would overcompensate for the system imbalance or if the imbalance price incentives are misaligned from the TSO's point of view. 15 minute ISP would mitigate these scenarios, which is why the TSOs are partially in favour of the simultaneous launch of 15 minute ISP and single price model, regardless that it would postpone the positive market effects by one and a half year. (Nordic Balancing Model 2019c)

4.4.3 **Demand response**

Demand response covers the measures that help keep the electricity grid in balance by shifting consumption from peak consumption and price hours to hours with favourable prices. Changing the normal operation of a resource to serve the purposes of grid power balance control counts as demand response as well. Demand response is expected to gain more significance as the energy portfolio gets tougher to forecast due to weather dependent solar and wind power. Another issue is the inflexibility of the production that is characteristic to nuclear, solar and wind power. (Fingrid)

So far, smaller customers have had limited possibilities to participate in the balancing markets. In Finland, one possibility has been to choose time based tariffs, where electricity consumption is cheaper during night time. The cheaper night tariff is utilised by setting the electric storage heating to work during night time. Demand response could offer a new opportunity for smaller customers to gain financial savings. (Järventausta et al. 2015)

Increasing demand response in the Nordic power system has some hindrances but could also result in significant benefits. Customers' knowledge of demand response is quite low and therefore their interest towards DR has not risen properly. A number of households, e.g., in Sweden, do not yet have adequate equipment installed to effortlessly offer their flexibility to the market. There is also a shortage of services and contracts for those who want to utilise their flexibility, and comparing the existing ones is laborious. Furthermore, there are practical hinders that impede customers' operation in the market, like the lack of hourly metering or access to transparent prices. (Energimarknadsinspektionen 2016b)

Different market participants have distinct interests concerning the increase of demand response activities. For a TSO, demand response offers possibilities to control frequency and power balance by restoration reserves and additional flexibility to manage power shortage situations. An RE may utilise DR in procurement planning, offers to the balance market and to control own balance if having the role of a BRP. A DSO may benefit from a widespread DR both in long-time grid planning due to possibly lower design power, and in real-time grid operation by enabling lower maximum power in the system, e.g., in high demand situations. An end user could gain benefits by shifting electricity usage to low-price hours, by lowering own peak power and by taking full advantage of own micro production. (Järventausta et al. 2015)

There exist various resources where DR is suitable. In Finland, the greatest potential comes from electrical heating, which composes 4 500 MW, of which around half is controllable through AMR meters' load control relays. Other significant resources are for example heat pumps, air ventilation, cooling and larger consumption points like greenhouses. EVs will develop into a notable sector once they gain more popularity. The likely electrification of transport and heating through EVs and heat pumps is a double-sided issue; it will simultaneously increase the consumption in the connection points but also offer more flexibility resources to the grid operator. (INTERRFACE 2020b; Roadmap 2025)

Demand response pilots serve to test proposed market solutions in real life and to recognise potential advantages and problems. In Denmark, a project called EcoGrid 2.0 has studied the design, implementation and testing of a local flexibility market running parallel with the wholesale markets, consisting of 800 private households. Each household has either a resistive heater or a heat pump as an electric heating unit, a smart meter and the necessary equipment for communication and control in order to cease the operation of the unit. The units are controlled by aggregators, which combine the resources into a size large enough to operate in the wholesale markets, and optimize the usage of electric appliances for the customers. The aggregator operates with both the TSO and DSO markets, offering the flexibility of the customers to both markets. (Heinrich et al., 2020)

There are several important characteristics to be recognised in the EcoGrid 2.0. Firstly, the proposed local flexibility market operates parallel to the wholesale markets. The flexibility not used completely in the wholesale market could provide additional revenue in the flexibility market. Secondly, a comprehensive smart meter base is essential for the effective operation, since the communication and remote controllability of the loads are more effective. The smart meters measure not only flexible consumption, but also non-flexible loads and local energy production, e.g. PV (photovoltaic) generation, which provides the aggregator with important data for the optimisation. Thirdly, the EcoGrid 2.0 utilises the data stored in the Danish DataHub for obtaining historical information of the consumption. (Heinrich et al., 2020)

4.5 Flexibility market

The current flexibility market in the Nordic countries essentially comprises of different balancing markets. FCR-N, FCR-D, aFRR and mFRR markets provide resources for the grid balance control for the TSOs. The resources procured from various markets serve slightly different purposes and thus have differences in terms of type of activation, time frame and capacity, which create somewhat different requirements for the resources participating in each market. The national balancing markets are largely similar with each other, and the development is going towards a unified balancing market across the Nordics. (Fingrid 2020; Nordic Balancing Model 2019a)

The design of the upcoming and more accessible flexibility markets is widely discussed and piloted in cooperative projects among market participants. Two of the largest efforts in this regard are the European INTERRFACE and CoordiNet projects which have participants from 16 and 9 countries, respectively. INTERRFACE is a European project to design, develop and exploit architecture for a future TSO-DSO-Consumer cooperation, e.g., concerning the procurement of balancing energy and the provision of congestion management. The architecture together with digitalisation contributes to a more efficient and active grid and system management at both the transmission and distribution level, allowing more renewable generation to be incorporated into the power system. The project aims to facilitate the procurement of services such as demand flexibility, improve the cost-effectiveness and security of electricity supply through the optimising the use of distributed energy resources, and empower end-users to become active market participants. (INTERRFACE 2019)

CoordiNet has a very similar purpose as the INTERRFACE. The aim of CoordiNet project is to facilitate collaboration arrangements between TSOs, DSOs and consumers to contribute to a more secure and resilient power system. The analysis and definition of flexibility at every voltage level is emphasised in the project, which helps to remove barriers to participation, especially for customers and smaller market parties.

Standardised products for grid services and operation mechanisms are determined at EU level, which will be tested in test projects in different countries. Ancillary grid services determined in the project, such as demand response and storage, will introduce additional revenue to the providers. (Coordinet 2020)

The time scale of the implementation for the results obtained through aforementioned projects is several years away. Both of the projects have set up demonstration projects in participating countries to test the mechanisms defined earlier in the projects. The demonstration results will be utilised to assist in the design of the European coordination platforms for the provision of flexibility. (INTERRFACE 2019; Coordinet 2020)

4.5.1 **Aggregation**

An aggregator is a market participant that combines several consumers' consumption, production or storage into a larger portfolio. An independent aggregator can be considered as a new type of energy service provider, who is able to increase or decrease the consumption of electricity for a group of consumers (Büchner et al. 2019). Aggregation is necessary when a single resource is too small on its own. By combining these, the resources then become suitable for trading in various marketplaces, enabling the participation to the markets also for smaller customers. An aggregator could operate, e.g., in the flexibility markets, reducing its customers' consumption during peak and constrained periods or alternatively increase their consumption during low-price hours. This contributes both to the security of supply for the system and to the decrease in electricity costs for the customers while possibly avoiding network investments and upgrades. (Työ- ja elinkeinoministeriö 2018)

The aggregator could also be independent, i.e., the actor carrying out the operation is a third party who is neither the customer's supplier nor balance responsible. The introduction of aggregators or independent aggregators to the European market is supported by EU's directive 2019/944, according to which advantages obtained through aggregation should be enabled to final customers. A final customer should be allowed to enter an aggregation contract with an aggregator without an approval from his DSO or RE. The treatment of final customers participating and the market parties providing aggregation to the markets should be non-discriminatory in comparison to other parties, contributing towards an even playing field. (European Commission, 2019a)

The future market for aggregation might be harmonised across the Nordic countries. Nordic regulators have agreed that the regulatory framework and solutions to introduce independent aggregation will be explored from a cross-border point of view. A common solution would enable aggregators to implement their business models throughout the region, and promote more competition and innovation. The coherent approach is also aligned with the priorities of the Nordic Council's Electricity Markets Group. (NordREG 2020)

There are several issues regarding independent aggregation that will need addressing prior to its expansion across the electricity sector. Firstly, the market access for independent aggregators is not yet equal to other market actors, primarily to REs. Secondly, the financial responsibility for the energy imbalances related to aggregation activities is not clearly defined. Thirdly, compensation for unmatched positions, where the difference between actual consumption and the energy procurement for a RE is caused by an independent aggregator altering the consumers' demand, is not definite. Lastly, the measurement of flexibility, i.e., the verification that the flexibility occurred, needs to be reliable. (NordREG 2020)

4.6 Local energy communities

Local energy communities are a rather recent concept and therefore yet without a conclusive definition, though some definitions do exist. A renewable energy community is defined in Article 22 of EU's directive for promoting the use of energy from renewable sources, as a group of local shareholders, like households, that is entitled to produce, consume, store and sell renewable energy generated by own micro-production (EU Commission 2018/2001). The definitions also include that a renewable energy community is an association, a cooperative or other legal entity controlled by local shareholders and that is involved in DSO, RE or aggregator operations at local level. The community members essentially share the advantages in procurement and production of electricity with each other (Työ- ja elinkeinoministeriö 2018).

Customers, who actively manage their energy businesses and have their own energy generation, are called prosumers. The proposed legislative changes to establish local energy markets aim to strengthen the prosumers' position. Active prosumers would have better energy independency and control of their energy affairs, which would encourage customers to switch from a passive to an active role. Resources such as electric vehicles (EVs), excess photovoltaic generation and flexibility could be shared with the community members, but also traded to the market. Local energy communities are potentially new customers for the providers of various services, e.g. regarding energy efficiency, aggregation or trading. (Kilkki et al., 2018; Mendes et al., 2018)

An energy community may be local or decentralised. Furthermore, a local energy community may be within the boundaries of a property or may constitute of several properties, crossing the boundaries of a single property. Shareholders in the same real estate, like in an apartment building, could make joint decisions regarding energy choices, e.g., production with solar cells, within the real estate boundaries. The electricity generated within the real estate would then be shared between the shareholders, giving them economic benefits as the amount of electricity consumed from the grid decreases. An apartment building as a local energy community is presented in figure 8. (Työ- ja elinkeinoministeriö 2018; Nylund 2018)

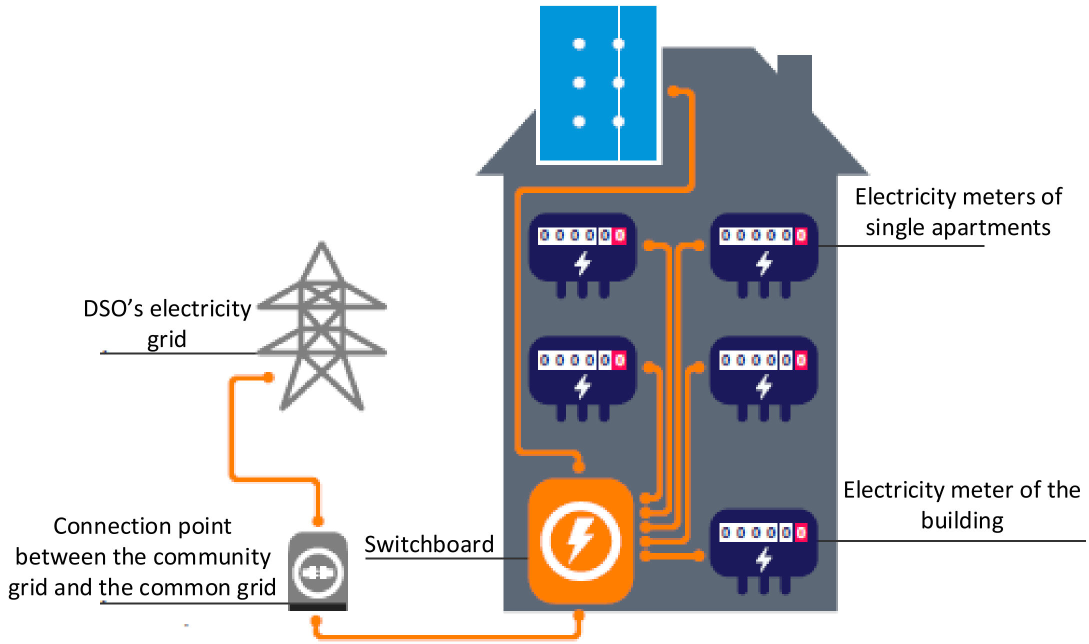

Figure 8. An apartment building as a local energy community. (Työ- ja elinkeinoministeriö 2018)

An energy community crossing the boundaries of a single property or properties is relevant when the favourable production site is located outside the property where it's generally either windier or sunnier. This kind of local energy community is presented in figure 9. There's often a need to build a small power line to connect the production site to the properties, which nowadays would also require a concession. This power line would combine all end users in question in order to take full advantage of the production resources. In the future, legislation might be changed so that such a power line would be concession-free, leaving the responsibility for the equipment maintenance and electricity quality and security to the community. (Työ- ja elinkeinoministeriö 2018)

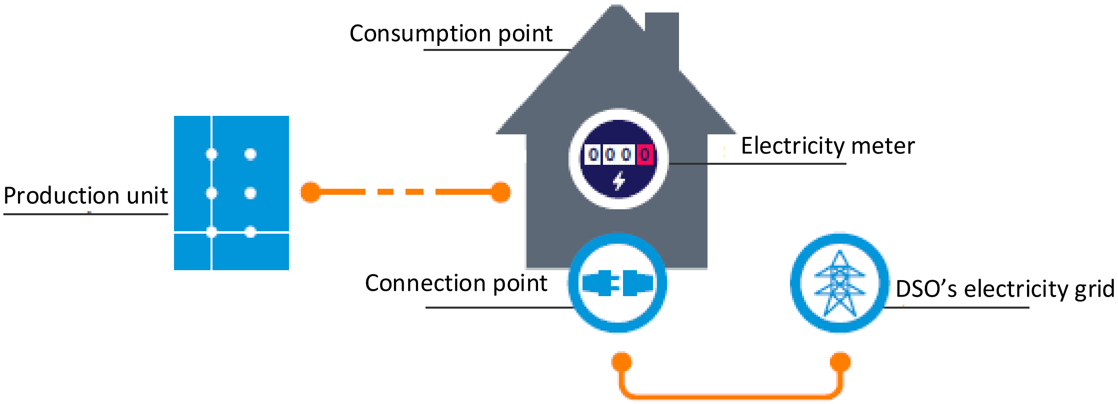

Figure 9. Local energy community crossing the property boundaries. (Työ- ja elinkeinoministeriö 2018)

The energy resources could also be decentralised, yet still belong to a local energy community. Community members may have production not only in the close vicinity of the community, but also geographically further away. Electricity produced elsewhere would then be utilised in a different location. For example, electricity produced by solar power in one's summer house could be consumed in one's ordinary apartment. Thus, greater unit sizes would become possible, making the investment more enticing through the economies of scale. The metering points for consumption, production and possibly storage are metered independently and the allocation of energy is calculated based on real values. This kind of arrangement utilises the common electricity grid, which obligates the members to pay for it accordingly. A decentralised energy community is presented in figure 10. (Työ- ja elinkeinoministeriö 2018)

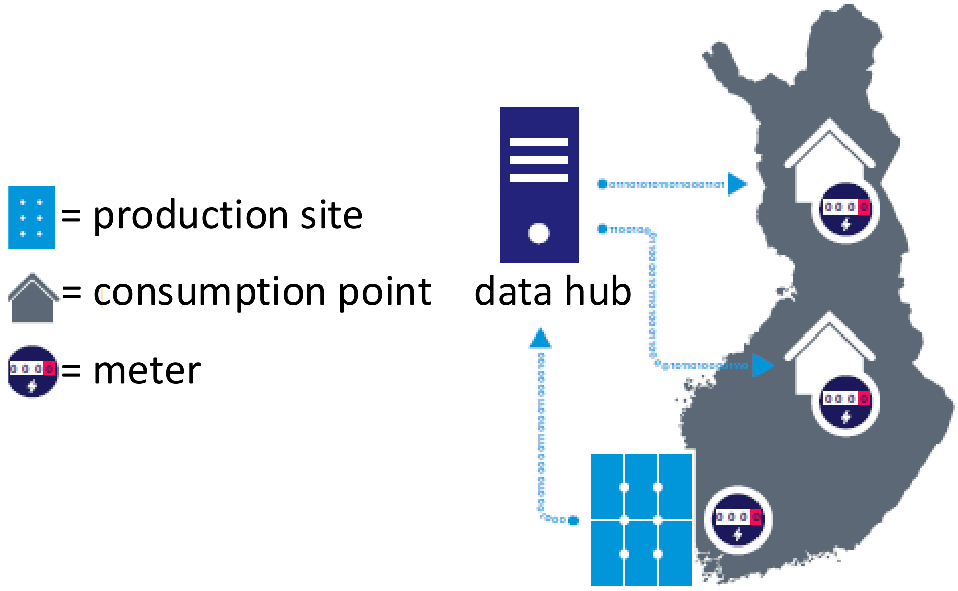

Figure 10. Decentralised energy community. (Työ- ja elinkeinoministeriö 2018)

A developing smart grid environment provides new opportunities for increasing security of supply. Energy storages, local energy production or utilising demand response could provide cost-efficient solutions for areas with a long grid length per customer. Hence, buying security of supply as a service and incentivising these services both for DSOs and customers should be made possible by future regulation (Partanen 2018). Such services include providing backup power, supporting restoration process, and islanding (INTERRFACE 2020a).

EU's directive on common rules for the internal market for electricity determines several regulations towards the "citizen energy communities". Entering the community should be voluntary, and the members would be entitled to leave the community. The communities should be open for all types of actors, but the decision making should be in the hands of members that do not practise large-scale commercial activity. Communities should be allowed to operate in the market either directly or through aggregation. Equal and non-discriminatory requirements, rights and responsibilities should be placed on the communities, depending on which role the community has in the market. The directive gives the possibility to permit citizen energy communities to become DSOs as in the current regime, or closed DSOs, with respective responsibilities being directed to the communities. (European Commission 2019a)

4.6.1 Dominoes project

DOMINOES project is an example of a project which attempts to facilitate local market design. The project aims to create an architecture to connect active market resources to the providers of management, forecast and market services through energy community services. The project will demonstrate how active consumers can actually participate in the energy markets. Connecting the customers with different service providers serves to enable active market participation for the members of local energy communities. The project will develop architecture, which enables consumers and prosumers to operate with other market participants. Defining demand response and grid management services serves to support the implementation of the architecture. (Kilkki et al., 2018; DOMINOES 2020)

DOMINOES project will identify and examine the roles of related stakeholders in the local market concept. Consumers within a local market will interact within the community, and also towards the wholesale markets and DSOs. A key objective is to identify challenges and benefits that these interactions entail in order to solve these challenges and encourage the future implementation. The challenges are related to both regulatory and technical issues, while the benefits include e.g. financial benefits for customers and societal benefits from cleaner energy production. The findings discovered in the project will be explored more in demonstrations later on. (Kilkki et al., 2018; DOMINOES 2020)

4.6.2 FinSolar

A block of flats is a potential case for an energy community. FinSolar is an initiative with the objective to increase business activities and investments for solar power in Finland. The initiative involved various actors, such as businesses, housing companies and educational institutes, examining the profitability, regulatory environment and the provision of services with respect to solar power. The initiative found out that solar power is economically viable when it is used to compensate, i.e., reduce the amount of, bought electricity. (Auvinen et al. 2016)

For a small producer it is more profitable to use the generated electricity rather than sell it to the grid. The price obtained from the sold electricity is smaller than the price for purchased electricity. When using electricity from the grid, the price includes components for the transmission and taxes, which are not obtained when selling the electricity to the grid. Therefore, greater savings can be achieved if the produced electricity is used to replace the purchased electricity from the grid. (Auvinen et al. 2020)

Netting of the small-scale production promotes further the economics of investments in small-scale production, e.g. solar power. The electricity meters often measure electricity in three phases of the current, and production occurs evenly to all three phases. If the consumption however is not equally divided into the three phases, e.g. if electronic appliances use specific phases of the current, it may lead to economic disadvantages. For example, if solar panels produce 3 kWh within an hour, 1 kWh for each phase, and consumption during the hour is 0 kWh, 1 kWh and 2 kWh between the phases, the first phase results in net positive value, second phase net zero and the third phase net negative value. Therefore, 1 kWh is sold to the grid and 1 kWh bought from the grid because of the differences, causing economic losses. The netting of production would solve the issue by summing up the production and consumption of all phases within an ISP, and thus minimising negative economic impacts for the producer. (Auvinen et al. 2020)

A new allocation model for produced electricity could improve the profitability of solar power in a block of flats. A compensation model, where the energy produced by solar cells would first be allocated to cover the consumption of the building and the rest to participating households, would minimise the amount of sold electricity to the grid. The building’s electricity meter measures both the production and consumption of the building, and acts as the connection point to the grid. If consumption exceeds production, no electricity is sold to the grid, resulting in only savings and no income from selling. This model is presented in figure 11. (Auvinen et al. 2020)

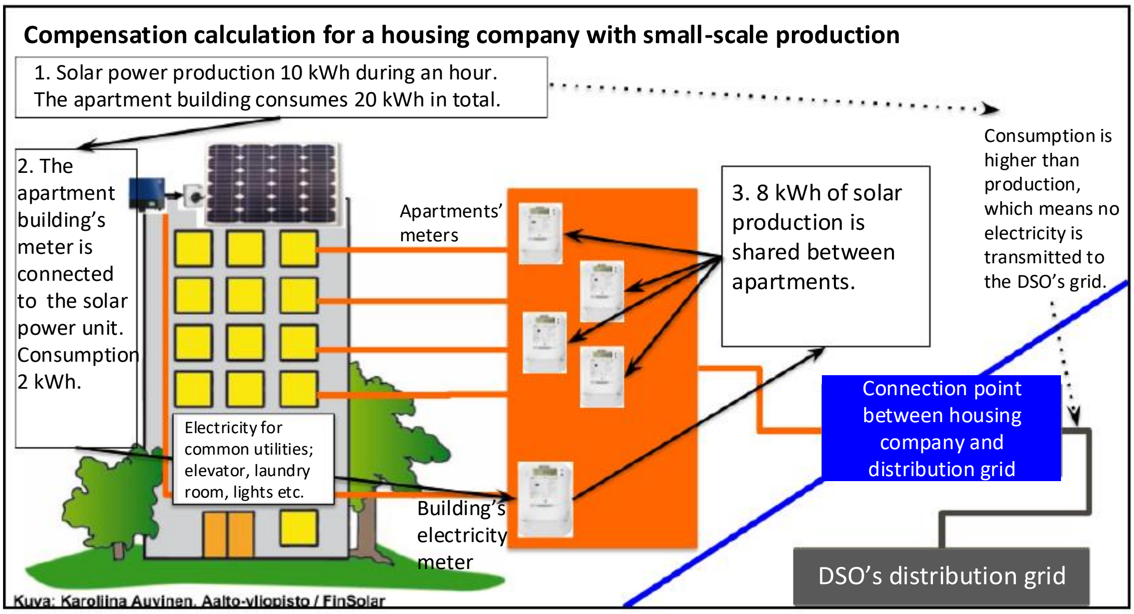

Figure 11. Compensation calculation for a housing company with small-scale production, translated from Auvinen et al. (2020).

Compensation calculation serves to enable small-scale energy production to be fully used by a community or a group of prosumers. The challenge related to small-scale production is that the produced energy cannot be entirely used to compensate the purchased electricity which would gain higher savings, but the surplus electricity is sold to the grid. A compensation calculation would allow the produced energy to be shared among multiple consumers, which essentially eliminates the selling to the grid. This is relevant e.g. for energy communities since the profitability of a solar power investment increases significantly if such a compensation calculation is allowed. The community would be connected to the distribution grid with a single metering point, and the metering points behind it would act as sub metering points. Currently, this type of compensation is not enabled by legislation in Finland, but guidelines set by EU strongly encourage that this will be possible in the near future. (Auvinen et al. 2020)

5 EXISTING SERVICES

Outsourcing some of own tasks to a service provider is a common way to steer the main focus towards one's core activities instead of having to concentrate on routine-like tasks. By doing so, cost-effectiveness, quality and flexibility are often improved. If a service provider performs similar activities towards multiple market participants, the costs per unit are lower in comparison to the situation where each actor would perform these themselves. The following chapters present some of Empower's most prominent services.

The transition into smart metering has greatly increased the amount of data that the DSOs or service providers receive. Consequently, the need to handle the data has grown as well. Reliable gathering and handling of metering information is essential for accurate invoicing and information exchange. Empower's metering processes include AMM (advanced meter management) services and quality services. AMM services cover measurement, reading, transfer and processing of the smart meter information. The AMM services may be offered to a customer as an independent service or it can be combined with, e.g. metering quality or balance settlement services.

Meter data quality control covers improving and validating the received metering data. Inevitable errors or deficiencies occur in the data, like missing values, anomalies in consumption or unsuitable statuses. These errors are analysed and corrected to the data management system and further the status and reliability are validated so that the data is suitable for invoicing. Quality management is usually a part of a larger service package, but can also be delivered individually.

Reliable and secure information exchange is a fundamental area for the whole operation in the electricity markets. Each party receives and transmits standardised EDIFACT and ENTSO-E messages. Empower IM Oy operates in the role of a messaging operator in the market. The services include transmitting messages, message conversions and archiving. Empower also realises testing and certification services for those market participants that need to verify their systems and messages. The benefits for using messaging services provided by a service provider encompass security, reliability, flexibility and cost-efficiency aspects.

Invoicing services offered by Empower consist primarily of providing invoicing data in a pre-defined way with the customer. The service package is modular so it can be tailored to suit each customer. The best end user experience is often created by invoicing on time with correct information since it may be the only contact between a supplier and an end user. Invoicing as a process is easy to outsource due to its regularity, routines and scalability. High quality is maintained by having personnel specialised to invoicing processes.

Balance settlements for both BRPs and DSOs are essential parts of business operations for the responsible parties. Establishing the financial balances between market parties requires reliable and accurate balance settlements. The settlements are carried out periodically with high repeatability according to precise regulations and schedules. Empower's services consist of maintaining correct balance structures, collecting the necessary data and performing settlement calculations and ensuring the coherence with eSett's official calculations. Usually balance settlements are a part of a larger service package that includes, e.g., metering services or balance management, depending on the market party.

Handling business processes in a data hub environment is an essential part of a RE's market activities. Processes like change of supplier, customer move-in, updating of customer and contract information, and retrieval of information from the data hub are examples of processes which either belong to a RE's area of responsibility or are necessary for the execution of RE's own processes. Operating with a data hub requires system compatibility with the data hub interface, meaning that suitable IT solutions constitute a notable part of the operation. Using systems or assisting services like message dispatching from a service provider could facilitate a RE's operation, e.g., by excluding the need of developing own systems. A service provider with multiple customers can put more effort into improving the IT solutions, thus enhancing the service even more. From a RE's point of view, it would make sense to involve a service provider in a case where the number of customers is low, but the costs related to the system improvements are significant. Empower accomplishes such services for a small number of REs in the two operational data hub environments in Denmark and Norway.

The implementation of a data hub is a great undertaking in the electricity markets, and it includes a lot of work for market parties. Topics such as improving structure data and migrating it to the data hub require a great deal of attention and knowledge about how to perform it in practice. In this respect, Empower IM helps several market parties to prepare for the data hub. A natural follow-up would be to handle these concerned parties' business processes in the data hub environment after its deployment, as the cooperation with these parties already exists.

Empower IM is also a system provider for the electricity markets. Different systems for the management of metering data, customer information and messaging are an integral part of Empower IM's business. Providing systems for market parties places Empower IM in an advantageous position, as system development can be customised according to the future needs, such as proceeding as a service provider in foreign markets.

There are a few systems that play the biggest role in the services Empower IM provides. The functionalities and capabilities of these different systems largely determine which services Empower IM can produce. The most relevant systems are:

- EnerimIXS, information exchange system. Conversion and dispatching of messages.
- EnerimEDM, energy data management system. Management of retail market services.
- EnerimEMS, energy management system. Management of wholesale services.
- EnerimSMS, site management system. Management of site information for customers' metering points.
- EnerimCIS, customer information system. Invoicing and customer data management.
- EnerimSMP, smart meter platform. Technical management of meters.

6 SERVICE DEVELOPMENT AND IMPLEMENTATION

In this chapter, ideas for future services are considered. Moreover, it is discussed how Empower could implement these services and what the services would consist of.

Future market changes affect the way services are provided. A service provider generally has to make some adjustments to their services to correspond to the new requirements resulting from e.g. legislative acts directing the modes of operation. Restructuring the services is simultaneously an opportunity to discover improvements to the existing services or establish completely new ones.

Services offered by a service provider should always aim to provide benefits for the customer, such as freed resources, financial savings or increased income through an enlarged portfolio. These aspects should also be considered when new services are planned. The strongest incentives for DSOs to make changes to the ways they operate are often financial. Changes could also result from legislation, e.g., better security of supply may require investments to meet the requirements. In this chapter, some scenarios for additional services are considered.

Future opportunities in DSO services in the Nordics are strongly influenced and encouraged by the European efforts, such as the *Clean energy for all Europeans* package. The security of supply is a key concern when integrating new technologies and increasing amounts of renewable and decentralised energy production into the electricity grid. EU regulation 2019/943 and directive 2019/944 both determine the general principles and describe various objectives and measures to reach these objectives. Empowerment of consumers into market participation, demand response, smart metering and DSOs' procurement of services, e.g. flexibility services, are central measures described in the documents. (European Commission 2019a; European Commission 2019b; Lang et al. 2019)

6.1 Invoicing services

NordREG has recommended that mandatory combined billing through a customer's RE should be introduced in each Nordic country (Nordic Council of Minister 2017). In Finland and Sweden, where national data hubs are under development, supplier-centric model along is to be introduced to the market alongside the data hub. Billing processes will be included in both data hubs, but operating through the data hub with invoice lines is considered as an option rather than a mandatory way. In the respective BRS descriptions the billing processes have been described, though the processes might be subject to some changes. (Sähkömarkkinalaki; Svenska Kraftnät 2020b**)**

Empower IM currently produces invoicing services for REs in Finland, Norway and Denmark. REs' invoicing activities will increase in the future through the supplier-centric model, which offers a possibility to enlarge invoicing services, especially if and when REs are responsible to perform combined billing. As for Finnish market, it is natural for Empower IM to develop invoicing services to correspond the data hub environment, since there are a great number of customers to whom invoicing services are already being produced.

6.1.1 Invoicing services for Sweden

In Sweden, the go-live date for the data hub has been postponed from the initial date to Q4/2022 mainly due to the delay of legislation. A law for the Swedish data hub does not exist yet and the Swedish electricity law has not been updated with respect to the Swedish data hub, so official legislative framework is still lacking. This means for Empower's potential future invoicing services that there are a couple of scenarios which could realise. Either the invoicing process through Elmarknadshubb becomes mandatory like in Denmark, or it becomes merely an alternative. The DSO could still provide REs the invoicing information using some other way. This will be more closely determined once the legislation comes out but now it is reasonable to explore services for both scenarios.

Invoicing services for the time before Elmarknadshubb constitute a relevant area of development. Out of a RE's perspective, combined billing offers an advantage for the customer service because more relevant invoicing data is on the same invoice. Switching to a combined billing model earlier would enable utilising this advantage earlier as well, and the advantage could be even stronger if only few REs adopt this before the data hub. Thus, potential customers for such a service could be found which in turn could encourage service providers like Empower IM to offer this service early, given that eventually combined billing will prevail.

Swedish data hub is being developed to include all the data which the invoicing bases on, such as metered data, information of DSOs' tariffs (also called products), and information for energy tax and VAT (Svenska Kraftnät 2017). DSO uploads their own tariffs as invoice lines to the Elmarknadshubb for the metering points in its MGA. These invoice lines may intend a cost or a remuneration concerning a customer's grid usage, or single payments like outage compensation. Elmarknadshubb distributes the invoice lines to the RE which is registered for the metering point. RE uses this information to form a single invoice towards the customer. (Svenska Kraftnät 2018b) (Svenska Kraftnät 2020b)

6.1.2 Implementation

The most straightforward way for Empower IM to develop and implement invoicing services is to forward grid invoicing data to REs. In this service, Empower IM receives grid invoicing data which is converted into a format that a RE's invoicing system supports and transmitted to the RE. This service might also include combining sales and grid costs, i.e. RE's and DSO's shares, into a single invoice.

In combined billing, RE invoices grid costs on behalf of a DSO. For combined billing during the time before data hub, RE would receive invoicing data straight from the DSO. After the deployment of data hub, RE receives this data either from the DSO as before, or from data hub where the invoice lines have been uploaded by the DSO. Finland does not require that operating through data hub is necessary. For Sweden, the regulation is not yet in place whether it is mandatory to utilise data hub for invoicing processes or not, but the documentation resembles the Finnish. Therefore, a reasonable assumption would be that operating through the Elmarknadshubb is an option, not a necessity. Norway's Elhub does not include invoice lines, so grid costs are obtained directly from DSOs. Danish model is likely not changing anytime soon, so in this regard service extension occurs through obtaining more customers.

Empower's role in the invoicing activities is to act in an intermediary role to handle raw data. Incoming grid invoicing data is received from DSOs or a data hub, then converted and reported to the RE according to RE's definitions. DSO's invoices are converted into a format which the RE's own system supports, and sent to RE so that the payments towards DSOs and invoices towards end customers can be completed. In addition, if

Empower provides metering data validation for the RE, Empower has all the raw data to produce combined invoice data for the RE's customers. The grid invoices are combined to sales invoices as agreed between Empower and RE, and then forwarded to the RE's system for end user invoicing. The information flows are presented in figure 12.

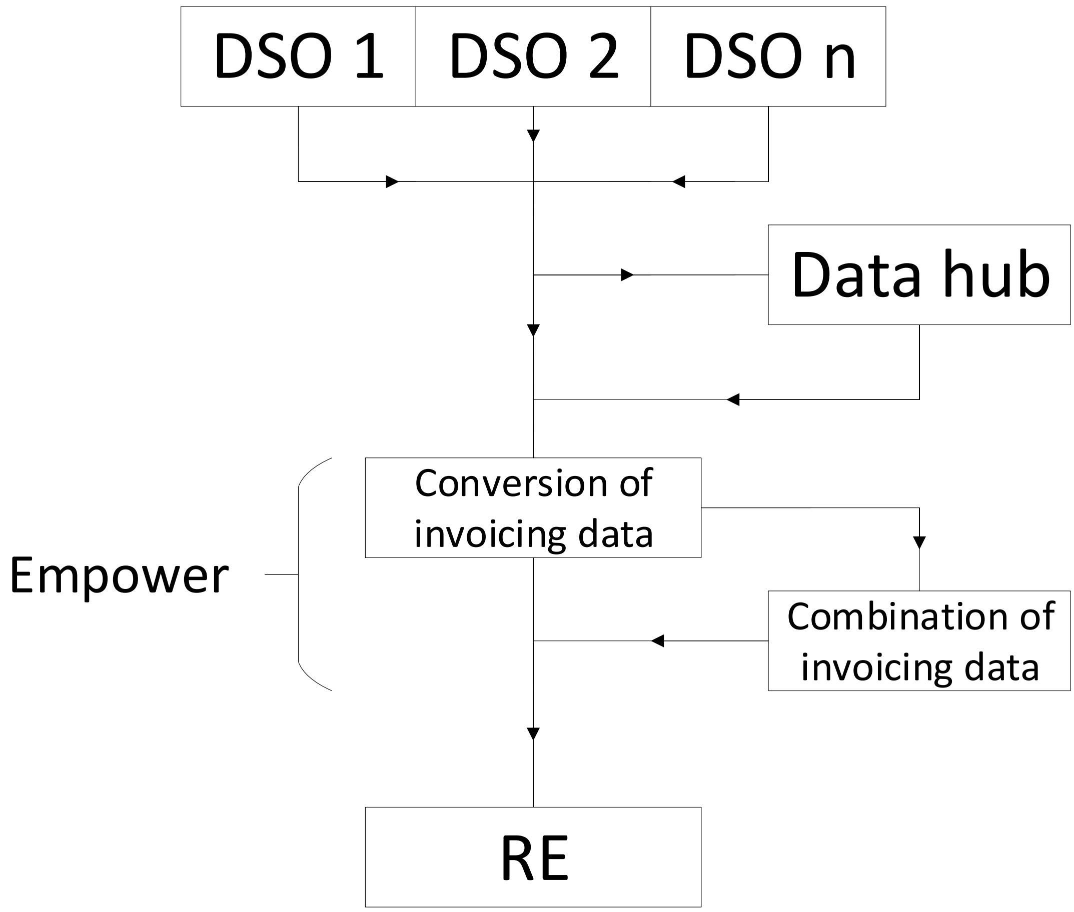

Figure 12. Provision of invoicing data to REs in a supplier-centric model with combined billing.

The potential service could be customised for each customer according to their needs, provided that all the necessary functionalities exist. The source of information, type of conversion, possible combination of invoicing information are pieces that constitute the service. The extent of the service also determines which systems Empower would use for the provision.

6.2 Nordic reserve market services

Reserve market is currently the source of flexibility into the Nordic power system. More comprehensive flexibility markets are on the horizon, but the flexibility services revolve mainly around the various reserve markets. Therefore, a useful approach to gain ground in the future flexibility markets as a service provider would be to get foothold in the Nordic reserve markets first. Successful operation in the reserve markets in each Nordic country would be an advantageous starting point to expand the services towards the eventual flexibility markets.

Empower IM currently produces reserve market services for its industrial customers in Finland. The services consist of trading services for the Finnish reserve markets, including aFRR, mFRR and FCR markets. Participation in these markets unlocks an additional stream of revenue for the customers. The provision of these trading services requires knowledge of the market and its regulations, communication ability between different parties and systems that can handle the information flows.

Reserve markets across Finland, Sweden, Norway and Denmark have a lot in common. Therefore, the services currently produced by Empower IM in Finland require only moderate adjustments and development to suit markets in other countries. Aspects like compatible messaging interface, technical requirements and bidding practices need to be addressed in order to suit the other Nordic markets.

The aFRR market in Sweden, as in the rest of the Nordics, is increasing in volume. For example, the number of hours per week for which reserve is procured, has increased from 61 to 94 between Q3/2019 and Q2/2020 (Svenska Kraftnät 2020c; Svenska Kraftnät 2019f). This indicates that balancing needs are on the rise, although the total Nordic volume in MW has not increased since Q3/2019. The increased needs provide opportunities for market parties to join the aFRR market or to expand their provision for those who are already active on the market. Therefore, special emphasis should be placed on the aFRR market when trying to enter the Swedish reserve markets.

Svenska Kraftnät has determined a set of terms which regulate the procedures in the aFRR market. A new set of terms comes into effect on the 1st of May 2020, and in the document principles for different aspects are described. This document is especially important for a party who is trying to enter the market, since it can be used to discover which parts of the processes need to be modified in order to establish suitability for the Swedish market. (Svenska Kraftnät 2020a)

In Swedish aFRR market the predominant resource type has been hydropower. Hydropower is a very suitable resource for frequency control, as the power production is easy to adjust by adjusting the amount of water that flows to the turbines. Participation in the aFRR markets is financially attractive as the can income derives from two sources. Svenska Kraftnät procures the capacity for aFRR once a week for the following week. The capacity is compensated for accepted offers accordingly, plus additional compensation is paid for the hours, when the resource is activated. For the latter, compensation is based on Nord Pool’s up or down regulation price. (Svenska Kraftnät 2018d)

6.2.1 Implementation

Expanding the reserve market services into Sweden, Norway and Denmark is a viable option to establish new services. With high similarity and ongoing activities to harmonise the Nordic regulating power markets, the market environment is opportune to expand to other countries. The already well-established services of Empower IM in Finland provide a competent starting point to succeed in acquiring new customerships. There is also a project under way within Empower which aims to build system readiness for reserve market services in other countries. The readiness includes message conversions through EnerimIXS for different environments as well as operational updates and business transactions in the EnerimEMS system.

The key role of Empower IM is to act as a facilitator for market participation for customers, who in reserve markets are typically owners of larger assets, like energy businesses or industrial activities. Services will be enabled for all the reserve markets which suit the customer. A convenient method to expand reserve market services would be to find industrial customers among Empower’s current customers who have or are planning to have activities in more than one country. This way, the service can be deployed instantly once the operational capabilities have been achieved, and having a familiar customer could facilitate the start-up.

The central part of reserve market service routines consists of communicating with the market interface, i.e. delivering the bids towards the market and the accepted bids to the resources. However, before the customer's resource can be offered to the market, some analysis needs to be conducted about aspects like selected marketplaces, etc etc. In this pre-deployment analysis, Empower can offer market insight to determine the optimal approach and technical solutions. In the analysis, the profitability of different markets is also addressed to ensure the best financial approach.

In the daily operation, Empower's control room conducts the preparation, dispatching and reporting of the market bids for each reserve market service. Based on selected markets and the nature of resources, possible reserves for near future are planned and formed into market bids. The EnerimEMS system is used to manage reserve market services for all the Nordic markets. The planning, scheduling and reporting is performed through the system. When the market bids are ready, they are sent to the market interface through EnerimIXS which converts the message for the interface in question. The trading results are sent to the EnerimIXS, which forwards them to EnerimEMS and towards the resources.

For Sweden, Norway and Denmark, it is more likely that in short-term the service revolves around market solutions rather than the technical activation, since the market solutions require little to no physical presence. In Finland, where the activation commands are also delivered by Empower to some resources, Empower has workforce to install the necessary control equipment to adjust the load. This manpower is lacking in the other countries, so Empower would need to employ partners to accomplish the technical part.

6.3 Services related to energy communities

When the concept of renewable energy communities, as proposed by the European legislation, becomes feasible, it could open possibilities to provide new services for the communities as well as the DSOs. There are a few features that come with the concept of energy communities which the DSO may be obliged to enable towards the communities. The establishment of energy communities entails certain advantages to the community members e.g. through netting of small-scale production or compensation calculation, but it could also be advantageous to the DSOs through avoiding upgrades to the grid infrastructure.

6.3.1 Netting of small-scale production and compensation calculation

European legislation is promoting the retail electricity market towards a more customer-friendly model. Topics, such as netting of small-scale production and compensation calculation, both benefit the end user and encourage the investments in small-scale production. The retail market might evolve so that DSOs in the Nordics are obliged to offer these if requested by the end user. The DSOs could develop these additions themselves, or the functionality could be offered by a service provider. Engaging a service provider is even more reasonable if a DSO already has outsourced some parts of the management of metering data.

Netting of small-scale production and compensation calculation both revolve closely around metering process. Central aspects are e.g. meter reading, validation and management of metering data. The party which performs the regular management of metering data, could also run the necessary calculations to provide the two ancillary services. EnerimEDM can manage large amounts of metering data, so the development would mostly consist of creating the algorithms to the system. Considering the DSOs, for which Empower currently produces the management of metering data, netting of small-scale production and compensation calculation would be a reasonable addition to the service.

The calculation is realised with a software that uses metering data from the small-scale production site and consumption points in the energy community. This can be run in an energy data management system after the metering data is retrieved from the electricity meters. The produced energy is first allocated towards the common consumption, e.g. in case of a block of flats towards the electricity consumption of elevator, laundry room and lighting, and then towards participating consumers (Auvinen et al. 2020). Empower has an energy data management system where a large amount of metering data is continuously handled, and the only large necessary upgrade would be to build the algorithm for the calculation.

The compensation calculation can also be utilised to allow and correctly allocate the charging of EVs in energy communities. In this case, sub metering points would be involved to measure the consumption of the EV charging. The party which manages the metering points within the community, would make the necessary adjustments to their system to allocate the consumed energy correctly. The calculation software would deduct the EV charging from the common consumption of the community and allocate it to the owner of the EV. (Auvinen et al 2020)

6.3.2 Cooperation with energy communities

In order to be able to offer electricity of good quality and security to its customers, a DSO needs to improve its grid infrastructure. Particularly less cost-efficient investments are those that are directed to sparsely populated areas with long grid length per customer. These are less attractive investments from the DSO’s point of view, and therefore other solutions could be also considered.

Establishing energy communities could replace the upgrades towards the grid infrastructure. Such a solution could be a cooperative effort of both a DSO and a service provider. The DSO could procure and install the equipment needed for local energy production, and the service provider could be responsible for the control and management of local grid, market services and energy data management services.

Should a community develop so that it has large enough resources to contribute e.g. to the grid balance, it would include benefits to both the community and the DSO. The resources could be used to participate in flexibility or even reserve markets to gain revenue to the community and increase the profitability of the investments. On the other hand, the DSO could be the party which procures the resource from the market and uses it to its own purposes, such as congestion management or peak load control.

6.3.3 Implementation

The energy community services are enhancements to the metering data management services already in production for DSO customers. Before the implementation, there should be an agreement between Empower and the DSO that the enhancements may be applied when necessary. The Empower’s system which will be utilised is EnerimEDM.

The system needs to be developed into being capable of performing the required calculations and allocations. Other than that, there are no major changes to be made. The daily routines of Empower should increase only little in comparison to the present, given that the calculations run automatically in the EnerimEDM. The introduction does however mean that the management of sub-metering points will increase, as these are seen as behind the single connection point to the grid.

Energy community services are effectively services where a DSO is an intermediary party, and the community is the real beneficiary. Nevertheless, the DSO's general market role is to act as a neutral electricity distributor, so neutrality applies in this case as well. Upon request by the community to apply netting or compensation calculation into practice, Empower would as the responsible party for the metering data management to make adjustments to own system to implement the request. Both Empower and the DSO should keep up to date with the state of affairs regarding energy communities to avoid discrepancies.

6.4 Flexibility services

When a new flexibility market is introduced to the Nordic electricity market, it opens up the provision of services to a completely new market. The new market will enable participation for a wider range of customers, which in turn incentivises involvement in the market from a service provider's point of view if there is a large number of potential customers. A suitable role for Empower would be a facilitator to the market participation. This role would resemble Empower's role in many of the current customerships where Empower operates between the market and the customer.

The flexibility markets are likely going to include a role called flexibility service provider. Customers may agree on a contract with a flexibility service provider who will facilitate the market participation. A flexibility service provider generates load management commands while taking into account the customer's needs and limitations, market requirements and the limitations of a DSO flexibility interface. The DSO interface is an interface which flexibility service providers may use to communicate load management messages to the customer resources. DSO's responsibility is the technical realisation of the commands. (Repo et al. 2020)

Demand response offers a tool that provides different benefits for each market actor. A DSO could take advantage of demand response in long-term grid planning and in real-time operation to control peak loads, in normal and exceptional situations. Grid power control will need more attention as the power balance could be more fluctuating in the future, and demand response offers one way to address the issue. A Consumer obtains benefits from minimised energy costs. A RE could increase its market portfolio by adding demand response resources and gain extra revenue, or use the resources to minimise own imbalance. (Roadmap 2025)

As there could be benefits for multiple market participants from entering the future demand response markets, Empower should investigate opportunities to develop services for DR related activities. The role of flexibility service provider could suit Empower since the main task is enabling customers' participation to the flexibility markets.

Load management and demand response for customers could be realised either through meter's load management relay or by providing near real-time information to be utilised by other systems. If the electricity meter is equipped with a load management relay, it can be used to transmit load management commands to control the electricity use of appliances. Providing near real-time information could be realised through a standardised interface that would enable data transmit to customer's devices, such as home automation systems. Transmitting near real-time information to the customer could be utilised, e.g., for demand response activities. (Pöyry 2017)

6.4.1 Implementation

In the future energy markets, end users will have expanded possibilities to participate in energy generation and flexibility activities. Service providers, such as flexibility service providers are envisioned to enable the end users' participation to the markets by acting between the end users and the markets. Empower IM is currently producing market services to its industrial customers where it operates between the customer and the market, so a similar way of operation could be opportune.

INTERRFACE market model has flexibility resources connected to the TSOs and DSOs through a flexibility register, markets and market interfaces. Flexibility resources are kept in a register, which is connected to the markets through a single interface. The most relevant markets are considered to be congestion management and balancing markets. TSOs and DSOs are connected to the market through a coordination platform, since the markets will provide resources for the needs of all system operators. A simplification of this model is presented in figure 13. It is worth attention that the real connections between system operators, market interfaces and flexibility resources are more complicated, but the figure serves to represent the idea of Empower IM's possible service provision in the market. (INTERRFACE 2020c)

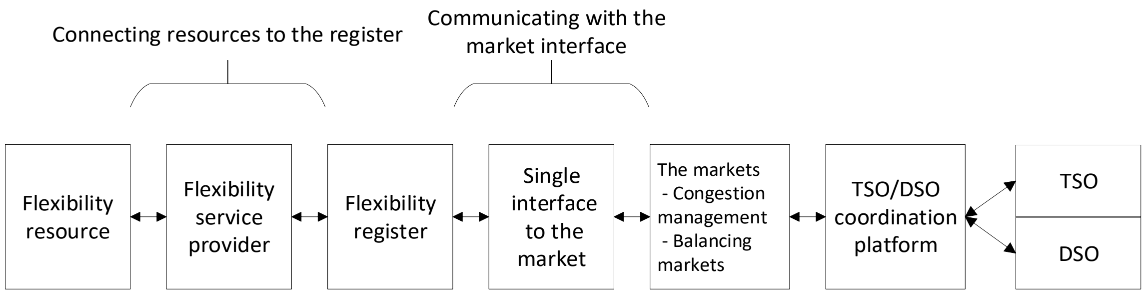

Figure 13. INTERRFACE market model and potential domains for Empower's service provision. Adaptation from INTERRFACE (2020c).

Empower could provide services to the active customers participating in the market activities in two domains. Firstly, the resources need to be connected to the market which is envisioned to be through a flexibility register, which could potentially be a national data hub. Secondly, it is necessary to offer bids to the market in accordance with the end user's intentions. The services could be offered separately, or combined when Empower performs the communication through the whole information exchange chain.

6.5 Aggregator services

Aggregation serves to enable market participation for active consumers and prosumers. Active consumers and prosumers profit from aggregation by achieving wider opportunities to give value to their resources, such as small-scale production, storage or EV charging. The flexibility of end users can also be better utilised through aggregation. An aggregator acts as a party that connects the end users to the markets. The legislation concerning aggregation and independent aggregation is due to a change. The Clean Energy Package from the European Union includes reforms for aggregation through eliminating market barriers and giving new rights for customers to contract aggregator services (NordREG 2020). This opens up possibilities for service providers like Empower to consider the development of aggregation-related services for the future.

There could be two valid options for Empower to be involved in aggregation activities. Either Empower would obtain the position of an independent aggregator, or collaborate with another party to produce aggregation services. So far Empower has not had any position in the markets but concentrated solely on the provision of services to market parties. In this regard, collaboration with another market party could be the primary scenario.

Aggregation requires technical solutions to connect end users to the market. Firstly, a solution is needed to communicate with the market interface and the relevant parties, like the TSO. Secondly, there is a need to gather data from the resources to create forecasts for the available capacity to be included in market bids at each time. Thirdly, the allocation of control commands to the resources is essential for the execution of accepted bids.

If Empower would collaborate with another party, one viable option would be that Empower would conduct the market integration and the communication with the market. The collaborating party would be responsible for the control of the end user resources, such as allocating and delivering control commands to them. This type of service model would resemble current business models where Empower is the market facilitator, and therefore a good strategic choice to consider.

6.5.1 Implementation

The future aggregation market might have two types of independent aggregators; BRP-style aggregators who are responsible for their imbalances, and BSP-style aggregators who merely sell products in the balancing markets and has its balance responsibility taken by a separate BRP (NordREG 2020). As the strategic choice for Empower has been not taking balancing responsibility, BSP-style independent aggregator is the likelier choice. Whether Empower would collaborate with another market actor to produce aggregation service or not, Empower obtains BSP position in both scenarios.

A scenario, where Empower's responsibility would be to conduct the market integration for e.g. flexibility markets, would be faster and easier to implement because it would eliminate the need to deliver commands all the way to the end user. The development would focus solely on communicating with the market interface, studying the market mechanisms and conveying messages to the collaborator who manages the execution of flexibility activities on end user level. The collaboration would be initiated once a suitable customer for the service would be found. Ideally, the customer would be one that has a lot of controllable resources, such as a municipality or a property investment company. This collaboration is presented in figure 14.

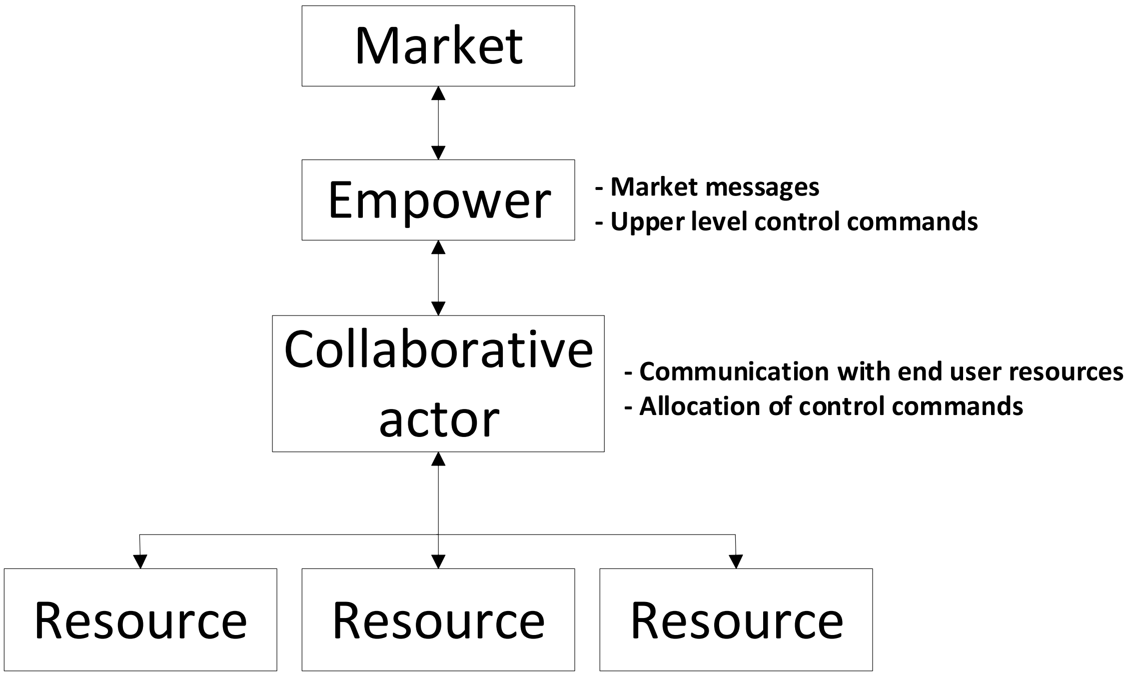

Figure 14. Service model, where Empower collaborates with another market actor.

If Empower would act independently in the aggregation markets, solutions for the entire process chain would need to be developed, including the market integration. Particularly the allocation and delivery of commands to individual assets is challenging if the resource pool would be large. Furthermore, a solution would be needed to verify that the action has been realised correctly. This whole development would require more resources and time than the collaboration approach.

6.6 Metering data management service

The volume of metering data will multiply through the shortening of ISP from 60 to 15 minutes. Moreover, the metering functionalities of next generation smart meters are proposed to be more numerous, including metering of active and reactive energy, voltage and current in all three phases. These upcoming changes signify that metering-related processes will need to be adjusted to suit the new requirements. Empower's current metering-related services for Finnish customers are comprehensive. The services cover the entire chain from the metering device all the way to final validated metering data to be used in grid balance settlements and invoicing. The three main areas of this chain are AMM, metering quality control and balance settlement services. The metering data management process is presented in figure 15.

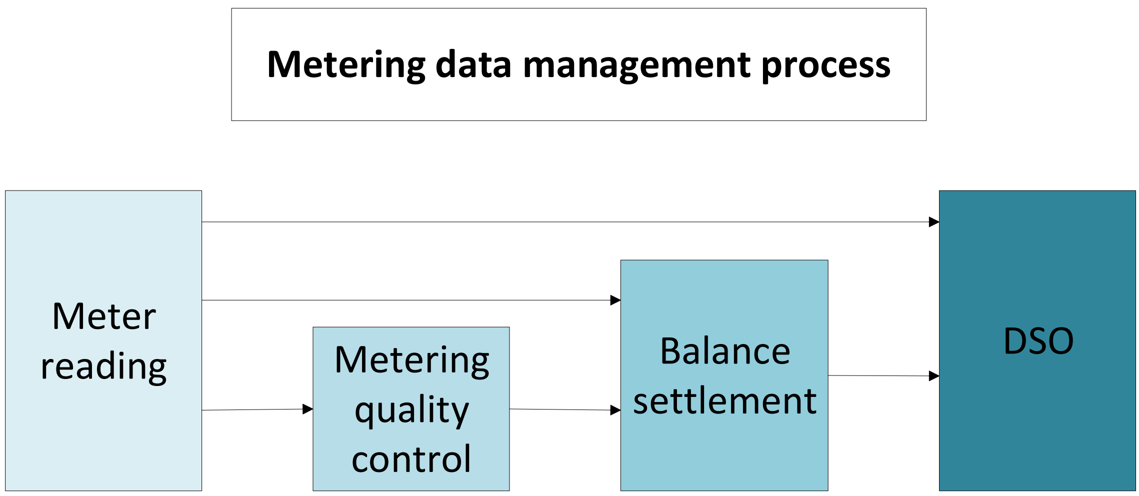

Figure 15. Empower's metering data management processes.

As the metering data management is a very familiar and profitable concept for Empower, investigating possibilities to expand this service to other Nordic countries could be functional. In the beginning, it would not be necessary to pursue a customer who would adopt a large metering-related service package, but to try to sell a smaller service to a smaller customer. This way, foothold in other markets can be gained with a moderate number of employees working in the project. Some of the prerequisites for the expansion already exist, such as the ability to conduct meter reading of the most commonly used meters across the Nordics like Aidon and Kamstrup.

6.6.1 Implementation

AMM services, metering quality control services and balance settlement services can be offered together or separately to DSO customers. Each area further consists of various processes, so it is important to agree with the customer on what processes are included in the service. Prior to actual offers to DSOs, prerequisites of the services need to be acquired. The prerequisites that need to be addressed are e.g. market specifications, system readiness and functional information exchange between parties.

In the implementation of metering data management services, Empower's own systems are integrated with the customer's systems. Empower's systems that are utilised in AMM services are EnerimSMP and EnerimEDM. The process for meter readings is that the readings are transmitted from meter reading systems first to EnerimSMP and then to EnerimEDM. In parallel to meter reading process, metering quality control service conducts validation for the readings so that the readings can be used in the balance settlements. If the balance settlements are handled by the DSO itself or by a data hub, Empower transmits the validated metering values forward. Empower can also provide metering data management services in the customer's system, which speeds up the service implementation. As the services revolve around the same metering data, they form a compact and efficient package to be utilised by the DSO.

The meter reading service requires maintenance and field visits to fix or change non-functioning meters. For AMM services outside Finland, this service could be reasonable to omit from the contract with the DSO, or to acquire from a local actor if it is included in the contract.

6.7 Data hub services

The introduction of a data hub to the electricity market entails a profound change to the market processes of REs and DSOs. For example, grid balance settlements, a service which Empower has produced for DSO customers in Finland for a long period of time, will be eventually performed in the Finnish data hub. Nonetheless, DSOs will continue to be responsible for many processes in the data hub era, hence a revision of Empower's current services would be useful to secure the continuation of customerships in the future.

The significant change that comes with the introduction of a data hub provides also the opportunity to integrate several smaller services under one larger concept. An energy data management service is a combination of services that could be provided to DSO customers in the data hub era. This would include both current services which will remain relevant in the future, but also such processes that require the capability of operation through the data hub.

Empower could provide datahub services to both REs and DSOs since they are required to operate with a data hub. As their responsibilities for data hub related processes are different, the RE service and the DSO service are distinct from one another. Furthermore, the service for each customer can be adjusted to suit the customer’s needs, i.e. to include only certain parts of the service package. The DSO service consists of areas like updating grid tariffs, metering point data and metering values to the data hub interface. The RE service on the other hand consists of receiving metering values and metering point data from the data hub, and updating customer and contract information to the interface.

6.7.1 Implementation

The main part of the service is to communicate with the data hub interface on behalf of a market actor. Messages to the data hub are sent by Empower, and messages intended to the customer arrive first to Empower’s system. The system used in the communication with all Nordic data hubs is EnerimIXS, which converts the messages to the desired formats. The customers communicate with Empower about what the business processes that need to be updated in data hub. Conversely, Empower forwards the messages sent by data hub to the customer in an agreed format. Figure 16 presents Empower’s position in this service. As Empower is the party that operates with the data hub, Empower can also instruct customers about the data hub specifications and limitations to perform processes more effortlessly. For example, when a RE requests to update certain data to data hub, such as customer master data, data hub might require that the message contains such mandatory information that is not included in the RE’s request. Consequently, Empower instructs the customer about the requirements and the next time the process runs more smoothly.

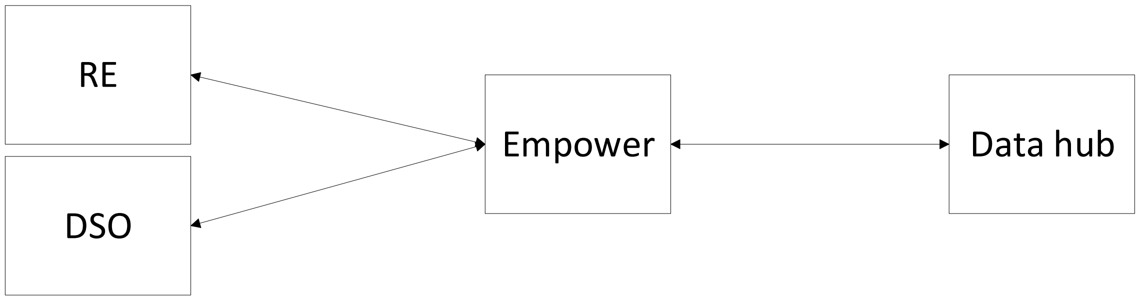

Figure 16. Empower's position in data hub services.

In order to act on behalf of a customer towards the data hub, Empower needs to be nominated as the actor responsible for messaging. Moreover, communication with a data hub requires a certificate to ensure the identity, thus a certificate needs to be procured for each customer. This could be done as a part of the service implementation process.

A RE’s data hub processes concern primarily customer processes. Empower could manage the necessary business processes, like keeping the data hub updated about A RE’s current contracts with end users and their master data, or receiving metering values and invoicing data. If a RE is not interested in operating with a data hub but wants to concentrate on other business matter instead, Empower could take on the data hub super user role. This role entails the management of all RE-related data in the data hub. The data hub service for DSOs is similar in structure, but the difference comes from different business processes that Empower performs on behalf of a DSO.

The introduction of a data hub entails system integration activities for market parties. As Finland and Sweden are yet to introduce data hubs into the electricity market, market parties have a lot of work to do before go-live. In Finland the integration activities are proceeding steadily, while in Sweden the project is at an earlier phase than Finland. As the retail market operation in each market requires data hub compatibility, Empower should definitely develop this to achieve necessary prerequisites. Data hub integration activities may not be attractive for smaller REs or DSOs due to the large workload. Therefore, Empower could assist these parties with the integrations, which could in turn create further services, like the aforementioned data hub services.

6.8 Meter asset management service

Meter asset management is a data analytics service for DSO customers. The idea is to keep closely track of the customer's metering instrument base by collecting data and analysing it, thus helping e.g. to anticipate potential faults for the meters which are approaching the end of their lifetime. The foundations of this service are comprehensive history data of metering base and technical knowledge of the meter itself. Meter asset management is mainly a supplementary service for Empower's current DSO customers who already have a significant metering data management service in use.

The idea of this service is to provide a more advanced overview of a DSO's metering base. In Finland, DSOs have responsibilities to report the condition of their grid regarding the model of allowed income (Energiavirasto 2018). By enhancing the monitoring of grid instrument the reporting towards the Finnish NRAs becomes more efficient, reducing costs in this regard. Empower could provide a platform where the relevant meter data would be available; meters and their location, what has happened to a meter in the past, for how long can a meter considered to be reliable etc. This monitoring could also reduce the visits to the field by anticipating potential faults. Moreover, the inherent faults of the meters could be better tracked and dealt with.

6.8.1 Implementation

The main system that would be used in this service is EnerimSMP. EnerimSMP is used primarily to store data of metering instruments and organise work orders. In this service, EnerimSMP is used to compile reports of the metering instruments from the stored data and make these reports available to the DSO. The reports could be further analysed to determine when it would be optimal to replace certain meters. The report would contain information about guarantee periods, acquisition prices and dates, fault history, expected meter lifetime etc.

Implementing the meter asset management service to existing DSO customers significantly reduces the time needed to collect the necessary data to start producing reports. This way, the main point of development would be to update EnerimSMP to produce practical reports. Once this functionality is in place, the next stage is to sell the service to an appropriate DSO customer. To further facilitate the service for the customer, reports could be analysed in collaboration with Empower to deliver proficient points of view and thus bring more value to the customer.

6.9 Consulting service

Market changes not only produce a necessity to execute changes in a market party's operation. The transition simultaneously offers an opportunity to rethink one's business, but this might turn out to be challenging. With high quality market knowledge a party like Empower could produce a service to help market parties navigate this transition, and optimise their business approach.

Consulting service could be a quick way to enter foreign markets, since it does not require similar system infrastructure as many of Empower's other services. For example in Sweden, several market changes are taking place simultaneously, and this may cause slight confusion for own strategy going forward. As Empower has been involved in projects that consider future market models and the market environment, such as the INTERRFACE or Dominoes projects, this expertise could be utilised as a separate consulting service to market actors, such as industrial customers or REs. Consulting could be also done regarding data hub preparations, market selection, the effects of a more customer centric market and how to take advantage of increasing amounts of data. For Danish customers, consulting can be done regarding the eSett go-live in Q2/2021, especially because Empower went through the go-live process when eSett was first introduced.

6.9.1 Implementation of consulting service

The first step towards the implementation of consulting service is to form a team, i.e. a group of experts who possess a wide and timely knowledge of the Nordic electricity market. This team could consist of people that work with different market domains, like retail market, wholesale market, market design and information exchange. This way, the group has multi-level expertise to encounter the different questions and challenges emerging from the discussions with the customers.

When the team is formed, decisions need to be made concerning which market actors consulting service will mainly be offered to, and what market domains the service will concentrate on. Potential customers could include smaller industrial customers or REs who may struggle to keep up with the market changes with smaller human resources. Also market actors who wish to expand their operation to Finland are a prospective group. The scope of the consulting would be tailored depending on the customer's needs, but the central contents of the service would likely include the future shape of the market and guidance in related strategical choices.

Contacting potential customers is the next stage in the implementation of the service. After a team has been formed and a basic strategy has been developed, the next phase is to try to find potential customers through existing contacts, branch events or promoting the service at interactions with potential market actors. Once an appropriate customer is discovered, it is important to engage them in more profound discussion about what kind of help they would appreciate. The customer's needs then determine what kind of approach could be applied. Once the position and objectives of the customer are known within the team, the actual consulting can be performed as meetings, either online or live depending on the situation.

7 DISCUSSION

In this chapter, different aspects regarding the service ideas and their implementation described in chapter 6 are examined. The aspects cover benefits, challenges, country applicability and moment of implementation.

One concept that is a factor in almost every service is information exchange. Information exchange in some form is related to each market process, and therefore it is an essential cornerstone of each service. The development of messaging related capabilities is carried out previously or concurrently to the service development since it is imperative for the provision of services. Furthermore, the capabilities are often elaborate to build since the number of market processes and environments is high, which renders the development time-consuming. For example, each data hub environment entails a whole separate messaging interface to interact with, which create a lot of work.

7.1 Invoicing services

There are several aspects regarding the development of invoicing services which require consideration. First, Empower’s system needs to be capable to handle invoice formats which it receives from DSOs or data hubs. There are various national invoice formats in use, like Finvoice, Swefaktura and EHF invoice, and data hub messages in a specified form which contain raw data for Empower to handle. Disturbances in handling the formats could cause delay to the RE’s payments towards DSOs, and in the worst case lead to unnecessary disconnection of end users. If the delay of financial transactions from RE to DSOs extends, the end user might be disconnected even though his payments would not be lacking.

One topic worth considering is the credit risks that emerge when RE performs the combined billing. Since the customer’s RE is responsible for invoicing the DSO’s tariffs, the RE bears the financial risk in case of payment defaults from customers. However if the RE goes bankrupt, in that case the DSO bears the financial risk. (Nordic Council of Ministers)

7.2 Reserve market services

The discussed reserve market services are not completely new services in itself, as they are more like modifications of the service produced in Finland. Thus, the development and service start-ups follow a similar pattern as previously for Finnish services. The market specific adjustments do not pose a complicated technical challenge, but nevertheless a lot of working hours are required for the whole development due to several markets. As for timespan, the services could be deployed in other countries rather soon, definitely within one year. The timespan is mostly dependent on the matter of allocating development hours to the project.

Presence in all the Nordic reserve markets is advantageous for especially for a few reasons. Firstly, the reserve markets services are rather simple to perform in daily operation after the start-up has been done. The services can be performed without too big of an increase in daily workload. Secondly, the Nordic balancing model aims for market harmonisation, which supports the efforts to expand services across the Nordics. Thirdly, the position to enter the flexibility markets is most likely much more seamless if presence is maintained in national reserve markets first.

15 minute imbalance settlement period emphasises the importance of self-balancing. Thus, it could be possible that the imbalance of BRPs will generally be decrease through the implementation of 15 minute ISP and as a consequence also the reserve activations could decrease. This is by no means certain but rather a point of view to keep in mind. Market behaviour is generally hard to predict and this is no exception.

7.3 Local energy community services

Although the provision of flexibility would be a valid idea for the local energy communities, it would in short-term be towards the TSOs instead of DSOs. The national TSOs have traditionally been the parties which procure the resources for grid balance control, and will have an even larger resource pool to procure from in the future with the development of flexibility and reserve markets. Therefore, DSOs have not yet been constrained to procure balancing energy. In long-term, the situation might be different since for example the market model proposed in the INTERRFACE project has TSOs and DSOs cooperating in the procurement of balancing energy.

7.3.1 Compensation calculation and netting of small-scale production

The compensation of energy within citizen energy communities is included in the EU's directive on the common rules for the electricity market (2019/944/EU). The directive states that regulatory framework for the cooperation between DSOs and citizen energy communities shall be provided by each member state by the end of 2020. The electricity transfers within a citizen energy community will be facilitated through this cooperation. For example, the upcoming regulation will allow transferring the produced renewable electricity to all the community members to reduce the purchased electricity from the grid. (Auvinen et al. 2020; European Commission 2019b)

Introducing new legislation obliges DSOs to enable new features, such as offering the compensation calculation for the prosumers. If a DSO already cooperates with a service provider on meter reading and metering data validation, it is reasonable to consider that the service provider would assist with the new features as well. In this way, the DSO does not have to concentrate on the system upgrade, and the service provider obtains an addition into its portfolio. Furthermore, the algorithm is easy to duplicate to different DSOs, so the service provider could offer this functionality to other DSOs with little extra work.

As the directive comes from the EU level, it requires implementation in Finland, Sweden and Denmark. The opportunities for this service will therefore exist in each country. However, it is likely easier to find potential DSO customers if some other service is already being produced to the DSO. In Sweden and Denmark Empower IM has no such customers, which partly hinders finding potential customers.

Because the compensation calculation can be realised in a separate management system, there is no need that the meters would have the functionality to sum different phases of the current. Omitting this functionality will keep the costs of new meter installations from raising further.

It is not certain whether netting and compensation calculation will be performed by DSOs or will it be assigned to a data hub. One point of view is that since DSO needs to conduct metering data validation, it would also conduct the calculations prior to sending metered data to a data hub. In this case the opportunity for service enhancements exists. Even if Finnish and Swedish data hubs take over netting and compensation calculation, there might be a time period between the introduction of legislation and the introduction of data hub. In this case, the service enhancements would still be valid for even 1–2 years, which means that the development of functionalities should be considered.

7.4 Flexibility services

Although there are extensive projects which study the flexibility market design and operation, the projects are still mostly at demonstration phase so it will take time until a flexibility market is introduced at large-scale. Consequently, the final market can be expected to differ from the demonstration projects as the projects serve to find out what works well and what does not work. The market design is then adjusted based on the lessons learned from the projects.

Like the market design, the market roles are not explicitly defined so no definite conclusions can be made regarding Empower's position in the market operation. However, an appropriate approach would be to recognise such a position that resembles Empower's role in other markets, such as reserve markets. In the flexibility markets this role might be a flexibility service provider, and Empower should pay close attention on how this position will eventually be specified. The customer base of a flexibility service provider would essentially be end users who choose to offer their resources to the market. Concentrating on market interface aspects allows to omit the technical aspects for the implementation on end user level, which could simplify and speed up the development.

Because the DSOs have not traditionally been involved in the procurement of flexibility, it is reasonable to assume that the DSO flexibility procurement will not become widespread very fast. Instead, the procurement might occur first for specific areas which have been difficult to keep in balance. Thus, the market might not grow fast and the ambitions of Empower's services should be kept moderate.

Flexibility services are relevant to all Nordic countries. The increasing generation from renewable energy sources poses a challenge for the system balance, and flexibility markets could provide one solution to the challenge. Out of the Nordic countries, Norway has the least need for new sources of flexibility as Norway's hydro power generation is simultaneously a great source of flexible generation.

7.5 Aggregator services

NordREG has published some recommendations how the regulatory framework should be modified to suit the introduction of independent aggregation. Recommendations for both immediate and further work for legislative changes have been given to address the problems that have been recognised so far. For instance, the regulations should be fair and efficient to enable independent aggregators to access the markets, e.g. that REs could not introduce costs on their customers if they choose to agree on a contract with an aggregator (NordREG 2020). However, because these are merely recommendations, it is not certain that the legislation will be exactly like NordREG has suggested. Therefore, the recommendations can be used as indicative statements of what the regulation might develop into. The development of the regulation should be monitored in order to stay up-to-date of the current situation.

The real-time control and correct allocation of control commands to end user resources could be problematic. The system that controls the resources should be aware of the real-time situation in order to achieve optimal allocation. Moreover, another challenge might be to get the realisation of technical allocation to correspond the planned capacities. Therefore, concentrating on the market integrations would be more likely an easier approach.

The customer base for the aggregation services might become considerably large if suitable market models are established for end user aggregation. Being involved in aggregation activities provides a rather straightforward way to gain financial benefits, given that resources for participation exist. NordREG has recommended that the potential market for aggregation should be harmonised across Nordics to maximise economies of scale and scope (NordREG 2020). Therefore, if the market will be harmonised, it will open up possibilities for Empower to be active in all countries regarding aggregation.

7.6 Metering data management service

For metering data management service the big upcoming change is that balance settlements will be executed in the data hubs. Therefore, balance settlement service cannot be offered to Danish and Norwegian customers, and to Swedish and Finnish customers only for the time before the implementation of the respective data hubs. What remains relevant are the meter reading and metering quality control services.

As the service package consisting of meter reading and metering quality control services is quite extensive and no previous experiences from markets outside of Finland exist, the objective should be to obtain a smaller customer to ensure sufficient resources for the development. A suitable customer could be e.g. a municipality in Sweden, Norway or Denmark. However, Norway and Denmark have recently finished their extensive meter upgrades to next generation smart meters, meaning that the customer acquisition might prove out to be harder. The challenge is that the actor who has been responsible for the installations of new meters, has an advantageous starting point to produce metering data management services. In Sweden, the collective meter change is taking place as well, but most likely not all of the installations have been agreed on. Therefore, a municipality in Sweden could be the primary target customer to obtain.

The development of metering data management services is fastest to implement if Empower uses the DSO’s own system to produce the service. This would mean that Empower needs to learn how to use the customer’s system if it not yet familiar. On the other hand, it is in Empower’s interests as a system provider to sell own systems, in this case EnerimEDM, to the customers and therefore this should be the primary objective. The integration phase with the DSO’s system would take longer, but it would further validate the position of Empower’s own system in the market.

7.7 Data hub services

Data hub services might be especially relevant for smaller REs who might not want to develop their system to be data hub compatible if the number of metering points is small. This applies for REs who have little operation in Sweden or Finland where the data hubs are not yet introduced. For these customers, the super user role could be possible to include in the service as well. If Empower get the opportunity to help market actors in the data hub preparations, there is a good possibility that collaboration extends also in the data hub era.

Communication with and operating through a data hub is routine-like. After the data hub integration is complete, the processes follow the same rules over and over again, plus the repeatability for different customers is high. The amount of work is not directly proportional to the number of metering points a customer has, therefore larger customers are manageable given that the systems work properly.

It is important for Empower to retain the current customerships also in the data hub era. The revision of current DSO services into an energy data management service is a key part in this. Helping current DSO and RE customers with the integration activities is another way to ensure that customerships are retained, but nevertheless a new type of service package is needed. RE processes also need adjustment going into data hub operation, but the necessary changes are smaller.

Data hub integration is a long and complicated process, which is why market actors are willing to seek collaboration with service providers. In Finland, the go-live date of the Finnish data hub had to be postponed until Q2/2022 due to the lacking preparedness among REs, DSOs and system providers. It is difficult to anticipate how much work an integration for a single market participant could involve, thus the number of actors Empower would help needs to be kept moderate in order to avoid the accumulation of workload.

RE services are relatively easy to offer into all Nordic countries as the service is inherently smaller than the energy data management service due to a lower number of responsibilities for data hub processes. DSO services, i.e. energy data management services, are valid to offer in Finland, but there are no major hindrances for the services to be applied outside of Finland. Data hub services do not require physical presence so it is a viable service to offer outside of Finland. Moreover, data hub operability in all Nordic countries supports the Empower's objective of expansion into other countries. If the operability exists, the development of system capabilities and market knowledge for DSO services is likely not too high.

7.8 Meter asset management service

The biggest challenge regarding meter asset management is to find customers who could utilise it. As the potential customers consist of DSOs who already are Empower's customers, the service is limited to only Finland. The challenge resides in the marketability, i.e. how this service brings additional value to a DSO. If a suitable customer is found, this service does provide a good enhancement especially if the meter analytics contribute to a lower number of field visits.

Meter asset management would not require much development anymore as the idea has been discussed before, and some preparations have already been made. Creating reports in EnerimSMP might still be a topic which needs attention, especially if the reports should be tailored for each DSO customer.

7.9 Consulting service

The advantage of providing consulting service is that it might create new opportunities with the same customer if the consulting is done well. For example, if Empower would assist a market party with data hub integrations, there is a chance to obtain data hub services after the data hub has been deployed. The service is also quick to produce. If there is enough market expertise among the consulting team, the only challenge is finding a suitable customer. Implementing the service for the first customer provides the basis for other similar consulting services. For example, data hub consultations require knowledge of the integration process and practices. This knowledge and consulting material needs to be produced once, and later the same material can be used for similar consulting towards another customer. For Sweden, where Empower does not have too much market operation, consulting service would be a quick and agile way to enter the market and find new customers. Possible customers could include REs or industrial customers in Sweden, Norway or Denmark.

The challenge that is inherent to consulting is the abstraction of the service. If there are no clear objectives or areas for which consulting could be done, finding customers could be very challenging. The accumulation of market expertise might also seem irrelevant if there are no clear objectives to concentrate on. Gathering enough manpower for the team might pose another challenge, if the consulting service is not high prioritised.

Consulting service can be also used as a way to explain and teach about the opportunities that the market changes like the introduction of a data hub entail. There might some sort of lack of knowledge about the market changes among market participants. Empower could provide clarifications to the market future and attempt to use it as a way to steer customers towards Empower’s services.

8 SUMMARY AND CONCLUSIONS

The objective of this thesis was to find new service opportunities for a service provider operating in the Nordic electricity retail market. The future market changes in the Nordic electricity retail market and how they affect the market structure and processes were investigated. Market participants need to adjust their processes driven by these changes, and this could create new opportunities for service provision. Empower IM Oy operates in the retail market producing services mainly towards electricity suppliers and distribution system operators. Market changes provide an opportunity for Empower to update its current services and develop new services.

The central future market changes in the Nordic electricity retail market include the introduction of national data hubs in Sweden and Finland, switching from 60 minute imbalance settlement period to 15 minutes, installation of next generation electricity meters, increasing flexibility services and the introduction of renewable energy communities. The changes support the introduction of more renewable electricity generation and the strengthening of end user position in the retail market. The market changes affect all market participants, including REs and DSOs.

Empower's current service provision is concentrated on the Finnish market, though Empower has some customerships in all Nordic countries. The revision of own business processes provides the opportunity to consider expanding service provision further in other Nordic countries. In this thesis, several such services were recognised that could be relevant to consider regarding service development and expansion. The potential new services include services that could be produced towards either REs, DSOs or end users. Regarding potential services, the implementation and related benefits and challenges were discussed.

The future market changes have a significant effect of Empower's provision of services. The effects range from removal of a service entirely (balance settlement service), to slight changes in the way the service will be provided in the future (reserve market service), to completely new business opportunities that directly result from the market changes themselves (data hub service). The market changes apply for all Nordic countries so the effect is similar across the Nordic market. Many of the changes serve to harmonise the

Nordic market even further, which supports Empower's objective to expand its services in all Nordic countries. The market changes occur in the next of 1–5 years which means that there are activities related to the changes constantly going on.

There are several market processes that Empower could acquire or develop in the future. The processes concern different customers as there are processes towards REs, DSOs, industrial customers and end users. Most of the discovered services are possible to produce in all Nordic countries. However, it should be thoroughly analysed which services are prioritised in the development, i.e. which services show most potential. The level of difficulty in the development is often higher when new services are developed for other Nordic countries due to fewer experiences and somewhat inferior specific market knowledge. On the contrary, succeeding in the development and gaining better foothold in other markets opens up significant opportunities to accelerate business growth even further.

In general, smaller services are easier to introduce to markets with little current operation. In order to facilitate the service development, different aspects like system requirements, market regulations and implementation plans are essential to consider. Moreover, analysing the potential benefits and challenges of service development can contribute to better awareness of the services and help build a strategy for the development. In table 3, the recognised areas for service development are presented. In addition, a few relevant service characteristics are presented.

Table 3. Summary of service characteristics.

Service	Customer	Implementation time	Level of difficulty	Country applicability
Invoicing service	RE	Short-term/moderate, 1–2+ years	Medium	All Nordic countries
Reserve market service	Industrial customers	Short-term, ½+ years	Medium	All Nordic countries
Energy community service	Energy community, DSO	Moderate, 1+ years	Low	Finland
Flexibility service	End user	Long-term, 4+ years	High	All Nordic countries
Aggregation service	End user	Long-term, 4+ years	High	All Nordic countries
Metering data management service	DSO	Moderate, 1–2+ years	Medium	All Nordic countries
Data hub service	RE, DSO	Short-term/moderate, 1–2+ years	Medium	All Nordic countries
Meter asset management service	DSO	Short-term, 1+ years	Low	Finland
Consulting service	RE, industrial customer	Short-term, ½+ years	Medium	All Nordic countries

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