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Rules and regulation for demand response and micro-production

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Brief summary

The role of demand response and micro-production (prosumers) in the Nordic power markets is expected to increase. This report summarise a mapping of the current national regulation relevant for these issues. The required functionalities of smart meters in Norway, Finland and Denmark facilitate both demand response and micro-production, whereas smart meters installed in Sweden lack functionalities to enable such empowerment of the consumer. Grid tariffs are not regulated in detail in the Nordics, and do not provide guidelines or restrictions on price signals to promote demand response. There is generally no regulated discrimination between demand and generation in market participation (spot, reserve and capacity), with a few exemptions favouring the demand side. Market participation is generally restricted to balancing responsible parties; besides this few restrictions on service providers apply.

Micro-production is generally favoured in the Nordics, mainly by reduced grid tariffs, exemption for taxes and levies (only net consumption is paid for) and simplified grid access. The market access is to some extent limited as the supplier is the contact point for selling surplus electricity and the price for electricity sold is subject to agreement between the parties.

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THEMA Consulting Group is a Norwegian consulting firm focused on Nordic and European energy issues, and specializing in market analysis, market design and business strategy.

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SUMMARY AND CONCLUSIONS

Demand response and micro-production have in common that they both entail more customer participation in the market. Both can therefore cater to the objectives of customer friendliness, increased competition and potentially more efficient markets.

The roll-out of smart meters will be concluded in all Nordic countries (except Iceland) by 2020 and will improve customers' ability to engage in demand response and to invest in small scale electricity production. Hence, the role of demand response and micro-production in the Nordic power markets has become increasingly more important. Our objective is to provide understanding of the current national regulation on demand response and micro-production in the Nordic region.

Regulation on demand response

Demand response to spot prices

The spot prices will normally correspond to the level of generation and consumption. The spot price will be high in periods of peak demand. Demand response to spot prices is only possible when electricity consumers are sensitive to price fluctuations.

Real-time (or close to real time) access to consumption data from smart meters at the consumers premises, to the consumer itself or to any third parties approved by the consumer, facilitates demand response as a reaction to spot prices. Hence, for the demand response to be on hourly basis, hourly measuring is a prerequisite. In Sweden and Finland, the roll-out of smart meters is currently completed, whereas in Norway and Denmark, it is scheduled for 2019 and 2020 respectively. In Iceland there is no plan for roll-out of smart meters. Norway, Denmark and Finland have very similar rules in place on functionality aspects and implementation of smart meters. Metering occurs at least every hour and the data is reported daily to the DSO. Sweden was early in the roll out of smart meters; hence the meters installed have less functionality compared to meters in Norway, Finland and Denmark. However, Swedish Energy Markets Inspectorate is about to suggest new requirements for smart meter that are similar to required functionalities in the other Nordic countries. Also in Sweden the general rule is hourly metering collected on a daily basis. But all consumers (with a fuse less than 63A) are metered and reported once a month unless they themselves have requested hourly metering.

Variations in spot prices, even in combination with hourly metering, do not yield short-term demand response if the contract with the supplier is fixed price without any incentives for flexibility. Supplier contracts may promote demand response in many different ways. Restrictions or obligations on the contract types offered by the supplier will therefore also be relevant for demand response. Currently, there are no obligations and constraints on price structures in supplier contracts in any of the Nordic countries. Hence, there is no obligation for suppliers to provide contracts based on hourly prices to their customers.

Similar in the Nordic area is the lack of any direct regulation on third party access and hence no rules that influence third parties' contribution to demand response. In Norway, Finland and Denmark, a standard communication output to provide real time, local access to measure data is mandatory. This may pave the way for third parties offering automated services on electricity usage. Installation of displays at the consumers' premises as part of smart metering is not mandatory in any of the Nordic countries. However, the required communication output paves the way for easy instalment of displays in Norway, Finland and Denmark.

Demand response to price signals in the grid tariffs

Consumers may also be offered incentives to allow loads to be interrupted whenever requested by the DSO (or TSO) to handle capacity shortage or other operational issues in the grid.

In all countries, the national law states that grid tariffs offered by DSOs to their customers must be transparent, fair and non-discriminatory. The Norwegian, Finnish and Danish regulation also states

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that tariffs should promote efficiency. These overall terms may in some way restrict the use of tariffs to promote demand response. However, these are general terms and do not provide direct guidance or regulation on tariff structure or differentiation.

Norway sets itself apart from other countries by having formal rules that govern tariff structure in some detail. In all other Nordic countries, tariff structure is not regulated. This means that there are *a priori* no obligations, but no restrictions either, on tariff practices.

The Finnish meters installed are required to handle remote load control. The Finnish DSOs are therefore in a position to offer special tariffs if small consumers´ loads are to be interrupted.

Participation in spot or reserve markets in the Nordic power system requires balancing responsibility. Having balancing responsibility is also a requirement to take part in balancing markets in the Nordics. This obligation may restrict some third parties from taking part in the markets, for instance aggregators without balancing responsibility acting on behalf of small consumers without balancing responsibility on their own.

Demand side participation in reserve markets for balancing

The Nordic TSOs collaborate to a large extent in system balancing services, but there are still some differences between the countries. Iceland does not take part in any for the cooperation on system services as the Icelandic power system is not physically connected to the other Nordic power systems.

There is no discrimination between generation and demand in the regulation or product definitions in the reserve markets in any of the Nordic countries. However, the volumes, response time, duration and other characteristics defined by TSO to participate in balancing markets may serve as a barrier for demand response in these markets.

Demand side participation in capacity markets

As for reserve balancing markets, there are no restrictions on demand side participation in capacity mechanisms. On the other hand, some obligations exist. In Norway, the TSO might oblige demand to participate, and in Sweden the TSO is obliged to partly cover the need for reserves from the demand side. The rules for the Finnish reserve are harmonised with the Swedish one, except the obligation for the TSO to include the demand side. Currently neither Iceland nor Denmark has a capacity mechanism, but Denmark is planning to establish a strategic reserve by 2016.

Regulation of micro-production

All countries separate micro-producers from other electricity generators based on production (size). Denmark, Finland and Norway (suggested regulation) also include the use of electricity primarily for own consumption as a parameter for defining micro-production. A similar rule is stated in Swedish regulation, requiring the level of consumption to be larger than the generation fed to the grid. The exact threshold for what is considered to be micro-production varies between countries, but the highest level is in Finland where the maximum power delivered to the grid is 2 MVA. For Norway, Finland and Denmark no extra/ new meter device will be necessary after the general implementation of smart meters, as they are required to measure both generation (fed to the grid) and consumption (of electricity from the grid). As separate metering of generation and consumption is not a general requirement for installed smart meters in Sweden, new meters may need to be installed for micro-producers.

Iceland, Sweden and Norway have no specific regulation setting rules for grid connection of micro-producers. Finland and Denmark have detailed connection requirements for micro-producers laid down regulation or guidelines. Financial advantages through lower grid charges than for other producers are given to micro-producers that connect to the grid in Norway (in suggested regulation), Sweden, Denmark and Finland.

In Sweden the supplier is obliged to provide market access to micro-producers. None of the other Nordic countries regulates a micro-producer’s access to the market through obligations to purchase

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or a price guarantee. In all Nordic countries, market access has to be organized through a supplier except in Iceland where there are no specific regulations for micro-producers. However, in the current regulation of micro-production in Norway, the DSO is obliged to buy the surplus generation.

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1 DEFINITIONS AND BACKGROUND

For several years, the Nordic Energy Regulators (NordREG) have been promoting well-functioning and harmonised Nordic electricity markets (both wholesale and retail). The objectives for NordREG's work have been:

- increased customer friendliness of the market,
- increased competition,
- promotion of DSO neutrality,
- a Nordic electricity market that is efficient and attractive for new stakeholders to enter.

Demand response and micro-production have in common that they stimulate consumer participation in the market. Both can therefore cater to the objectives of consumer friendliness, increased competition and potentially more efficient markets. However, increased consumer participation in the power market can also result in challenges, both of a technical and systemic nature.

The roll-out of smart meters and other elements of a smart grid which now currently is, or will be, completed in all Nordic countries overcomes an important technical challenge for consumers' ability to engage in demand response and also to invest in small scale electricity production and thereby become prosumers. Hence, the role of demand response and micro-production in the Nordic power markets has become a very topical question, which this report can be a first step to answering.

Our objective is to provide understanding of the current national regulation on demand response and micro-production in the Nordic region. The national regulators can use this understanding when evaluating the need for harmonisation and development of legal/institutional framework and conditions in this area based on differences and similarities between the respective Nordic countries. This report is limited to a mapping of the regulatory framework, and do not elaborate on the role of demand response or micro-production in the Nordic power system or review barriers for increased empowerment of the consumers.

1.1 Commonly used terms

Based on our review of available documents, it is our experience that different terms are used for describing the same underlying concepts in different contexts. Hence, we will use the following terms in this report:

- *TSO* – Transmission System operator, the system operator that is responsible for the operation of the high and very high voltage electricity grid. The voltage level can differ per country.
- *DSO* – Distribution System Operator, the system operator that is responsible for the operation of the low, medium and high voltage electricity grid. The voltage level can differ per country.
- *Smart metering* – device to automatically and accurately measure electricity. The meter is connected to the DSO by a two-way communication channel.
- *Supplier* – an electricity supplier that buys electricity in the wholesale market and sells electricity to end customers.
- *Local access* – refers to the access of consumers (or prosumers) to metered data directly via the smart meters interface (based on international communication standards) as opposed to receiving meter data only from the DSO (invoice or web solutions).
- *Real-time* - real-time pricing or communication refer to the possibility to give consumers information about the consumption of electricity at any given time from hour to hour (or within a shorter timeframe).

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1.2 Demand response

1.2.1 Definition and of demand response

The Council of European Energy Regulators (CEER) (2011) gives the following definition of demand response: Changes in electricity usage by end use customers/micro generators from their current consumption/injection patterns in response to changes:

- In the price of electricity over time.
- To incentive payments designed to adjust electricity usage at times of high wholesale market prices or when system reliability is jeopardized.

For illustrative purposes we divide demand response into three different types, all of which are mapped out in this report's chart of current regulatory practices:

- *Demand response to price signals in the wholesale power market*. Such demand response presupposes smart meters that measure electricity consumption hourly as well as the proper type of contractual arrangement with a supplier.
- *Demand response to price signals in grid tariffs*. This type of demand response is generated through customers' response on grid tariffs such as capacity pricing, time of use pricing or interruptible connections in exchange for a lower tariff.
- Demand response through *participation in the TSO reserve markets for balancing or in capacity mechanisms.*

The needs and actions of DSOs, suppliers, third parties and consumers influence the total price of electricity and how this price is set. Various actors in the electricity system can contribute to one or several of the types of demand response described above. The willingness and ability of actors to offer demand response depends on regulatory conditions, which may vary over time and across countries.

1.2.2 The role of demand response in the electricity system?

Demand response can potentially play an important role in the electricity system as it may increase cost efficiency in the Nordic power markets in several ways:

- *Improved price formation:* If the demand side is inelastic, power price formation will depend on the generation side alone. With increasing generation from intermittent technologies, the risk of very high prices in peak load periods increases. More price sensitive electricity consumption will mitigate this risk, as well as the potential market power of electricity generators in peak periods.
- *Reduced investments in the regional or local grid:* If consumption growth drives investments in the regional or local grid, peak load reductions may reduce grid investments.
- *Provision of system services:* The purpose of system services is to maintain the balance of electricity generation and consumption in real-time, and to maintain quality of supply and security of supply in all areas of the power system. The generation side is the main provider of the flexibility needed for system services today, but even some large consumers are active in these markets. The geographical location of flexibility is often crucial for system services, and in some areas the demand side may be the only provider of system services.

1.3 Micro-production

1.3.1 Definition and types of micro-production

Micro-production is small-scale generation of electricity and/or heat by individuals, small businesses and communities of which the main purpose is to meet the generators' own needs as it serves as an alternative or supplement to traditional centralized grid-connected power. The surplus of electricity

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(or heat) production is fed into the grid, with or without a possibility to sell the surplus in the market. Micro-production technologies include small-scale wind turbines, water turbines, photovoltaic installations and micro CHP installations.

Exactly what type of electricity generation is considered to be micro-production can vary between various regulations and supporting documents and thus be different between countries and between sources of energy. The common denominator is that the segmentation is related to size, either in installed capacity or in power delivered to the grid. There can also be a requirement of environmental friendliness in the production to be defined as a micro-producer.

1.3.2 The role of micro-production in the electricity system

Micro-production plays a small, but increasing role in the Nordic power market. The growth in micro-production has first and foremost been the result of favourable regulations and support schemes.

In Iceland and Norway, the volume produced by micro-production is still neglectable in the power system. In Norway, solar panels are mostly installed in off-grid cabins and in pilots on zero emissions buildings. In Denmark, solar power has gained importance as a micro-technology. Currently 550 MW of photovoltaic capacity has been installed[1]. The growth has been strong over the last few years due to generous support systems. Denmark also has some micro-CHP units. Sweden had 45 MW of solar power installed in 2013[2]. Micro-generation is however expected to grow significantly due to proposed large tax reductions for micro-generation from renewables. In

The development of micro-production in the Nordic region will likely primarily depend on the government's facilitating investments through favourable regulations and support systems. With a number of initiatives being underway, the growth rate in micro-production is likely to increase in the years to come.

1.4 Surveying the regulatory framework

The regulatory framework mapped out in this report can be divided into five categories of both legal and non-legal documents, see Table 1 that provides a description of the categories listed in the order of their legal precedence.[3] The reader should be aware that different labels can be used for the same documents in the different countries because of special national practices and customary translation, e.g. some countries use the word 'act' for formal legislative legislation whilst others use 'law' or even 'bill'.

Table 1 lists the authorities and market players that are relevant or play a major role in the development of regulation on demand response and micro-production whose internal knowledge and publications we have relied heavily on for the purpose of this report.

For the purpose of this report, we only survey *national* regulation and *national* authorities and market players. We have assumed that all relevant EU regulation has already been implemented/ transposed into national law, and have therefore not looked at EU law. The commissioners of this report have confirmed that this is an accurate assumption.

[1] "Photovoltaic barometer": http://www.energies-renouvelables.org/observ-er/stat_baro/observ/baro-jdp11_en.pdf

[2] "Photovoltaic barometer": http://www.energies-renouvelables.org/observ-er/stat_baro/observ/baro-jdp11_en.pdf

[3] Norway and Iceland are not EU Member States and therefore not subject directly to EU Legal obligations, but via the EEA Treaty. Hence, for them national rules for international treaties apply. In EU Member States, EU legislation (treaties and applicable legislation) is considered to be above national legislation (supremacy) as is laid down in EU Case Law (In *Costa v ENEL* [1964] ECR 585 the European Court of Justice; in case of conflict between the national and EU law, EU law prevails).

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Table 1: Sources surveyed

Category of law	*Labels / names*	*Description*
EU Law	• Directive • Regulation • Decision	Legislation enacted at EU level that has (in-) direct effect on the law of Member States. This does not include strategic documents, studies, guidelines or any other document of descriptive nature.
Primary national law (Formal legislation)	• Acts • Laws • Statute • Bill[4]	Legislation that is enacted via a formal procedure: approval / inclusion of / by executive and legislative powers.
Secondary national law (Bylaws or delegated legislation)	• Regulation • Decisions • Grid Codes • Public license	Legislation that is enacted / adopted by a body other than the legislator (often a governmental authority) pursuant to a mandate / delegation deriving from a formal law. It is not required that the author of the legislation is a governmental authority, it is the adoption that is the key element. Secondary legislation cannot create new obligations, but defines at detail level what the primary law mandates.
Soft law	• Sector-specific agreements • Recommendations • Declarations • Codes of conduct	Documents or quasi-legal instruments which do not have any legally binding force. They often contain aspirational goals and can become 'legally' or socially binding to a sector or those who sign up for it.
Other documents without any legal character	• Rest	Any document that can be informative but has no legally or socially binding character.

Table 2: Relevant institutions for national regulation of the electricity market

	Iceland	**Norway**	**Sweden**	**Finland**	**Denmark**
Ministry responsible for Energy Markets	Ministry of Industry, Energy and Tourism	Ministry of Petroleum and Energy	Ministry of the Environment and Energy	Ministry of Employment and the Economy	Ministry of Climate, Energy and Building
National Regulatory Authority (NRA)	National Energy Authority of Iceland	Norwegian Water and Energy Directorate	Swedish Energy Markets Inspectorate	Energy Authority	Danish Energy Regulatory Authority
Transmission System Operator	Landsnet	Statnett	Svenska Kraftnät	Fingrid Oyj	Energinett.dk
Industry organisation	Samorka – Icelandic Energy and Utilities	Energi Norge, KS bedrift, Defo	Svensk energi, Oberoande Elhandlare	Finsk energiindustri/ Energiateollisus	Dansk Energi

[4] A 'bill' is a proposal for (an amendment to) a formal law, e.g. the United States. It is therefore not (yet) an act. In some countries, acts are translated as bills. The report will explain the document's legal character if experienced confusing.

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2 DEMAND REPONSE TO SPOT ELECTRICITY PRICES

This part of the report discusses demand response to price signals (spot prices) in the wholesale power market. The spot prices will normally correspond to the power balance with high prices in periods with a tight balance and vice versa. Demand response to spot electricity prices is only possible when electricity consumers are sensitive to price fluctuations. It is worth noting that small consumers are only faced with day-ahead prices (Elspot) in the market. Larger consumers with balancing responsibility will also have the opportunity to respond to intra-day spot prices (Elbas).

Local access to consumption data from smart meters in real time, by the consumer itself or by any third party approved by the consumer, facilitates demand response as a reaction to spot prices. Adjustments of consumption must be done within the same timeframe as consumption is measured for the consumer to gain from demand response. Hence, for the demand response to be on an hourly basis, hourly measuring is a prerequisite. Our focus is therefore to map out relevant rules and regulation relevant for smart metering, summarized in Table 3. In Norway, Finland and Denmark, a standard communication output to provide real time, local access to measure data is mandatory. This may pave the way for third parties offering automated services on electricity usage. Installation of displays at the consumers' premises as part of smart metering is not mandatory in any of the Nordic countries.

Similar in the Nordic area is the lack of any direct regulation on third party access and hence no rules that influence third parties' contribution to demand response. Variations in spot prices, even in combination with hourly metering, do not yield short-term demand response if the contract with the supplier is fixed price without any incentives for flexibility. Supplier contracts may promote demand response in many different ways. Currently, there are no obligations and constraints on price structures in supplier contracts in any of the Nordic countries.

The text box below explains of how third parties may act as facilitators for demand response.

Third parties as facilitators of demand response

Third parties that facilitate demand response include energy service providers, technology providers and aggregators:

- *Energy service providers* may offer a wide range of services included advice on optimising energy usage, provide energy efficiency, market monitoring and information services or the service provider may have a mandate to optimize the portfolio on behalf of the client. A service provider may also provide a service driven by comfort levels (e.g. maintaining 20 degrees indoor temperature) as opposed to "selling electricity".
- *Technology providers* may automate both data handling (i.e. consumption measures, weather/ weather forecast and price signals) and signals to provide demand response, especially for small consumers.
- *Aggregators* handle loads from several customers in order to meet minimum volume requirements for selling demand response in balancing markets. This includes the physical nomination of loads (and generation) in spot- and intraday markets. Balancing responsibility is generally obligatory in these markets.

Note: The main aim of both energy services and technologies (in todays' market) is to provide energy efficiency gains. Nevertheless, such services and technologies may help pave the way

2.1 Smart metering

2.1.1 Similarities and differences in the Nordic area

Table 3 below shows the roll-out status for smart meters in the Nordic countries and the regulation of some functional features. Most countries (except for Iceland), have in recent years adopted

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regulations for mandatory smart-metering. Norway and Denmark are somewhat behind the rest of the Nordic countries regarding schedule. In Sweden and Finland, the roll-out is currently completed, whereas in Norway and Denmark, full roll-out is scheduled for 2019 and 2020 respectively.

Looking at functional and implementation aspects of smart-meters, Norway, Denmark and Finland have very similar rules in place. Measurement occurs at least every hour and the data is daily reported to the DSO. Furthermore, a standard communication output to provide local access to measured (or meter) data is mandatory in these three countries. Installation of a display at the consumers' premises as part of smart metering is not mandatory in any of the Nordic countries. However, the required communication output paves the way for easy instalment of displays in Norway, Finland and Denmark. Only in Norway and Finland is remote control of consumer load mandatory (if a meter is installed).

Sweden was early in the roll-out of smart meters; hence the meters installed are somewhat limited in terms of their functional capabilities. Also in Sweden the general rule is hourly meter readings collected daily. But all consumers (with a fuse size of less than 63 A) are measured and reported on a monthly basis unless they themselves have requested hourly metering (at no extra cost). The Swedish Energy Markets Inspectorate is about to suggest new requirements for smart meter that are similar to required functionalities in the other Nordic countries. If the suggested change is implemented, new regulations may be in place during 2016.

For a regulatory overview of data handling of meter data in the Nordics, please see THEMA Report 2015-02: "Mapping of TSO and DSO roles and responsibilities related to information exchange".

Table 3: Comparison table of relevant smart metering regulation

	Iceland	**Norway**	**Sweden**	**Finland**	**Denmark**
Roll-out status	No regulation or plan	2019	Completed	Completed	2020
Regulated technical measuring resolution of meters	No regulation	15 minutes	No deviation from actual	15 minutes	15 minutes
Regulated actual measuring resolution	No regulation	Hourly	>63 A or on request: hourly, Other: monthly	Hourly	East DK: 15 minutes West DK: Hourly
Data collection frequency	No regulation	Daily	>63 A: Daily Other: Monthly	Daily	Daily
Local access to data	No regulation	Mandatory	No regulation	Mandatory	Mandatory
Technical possibility to reduce loads	No regulation	Required	No regulation	Required	No regulation

2.1.2 Iceland

The roll-out of smart meters in Iceland is not yet decided, but the country, as an EEA member, will have to adapt to EU regulations on smart meters and install such meters if the economic cost/benefit analysis proves positive. Currently, there is no regulation that imposes the use of smart meters. Nor are there any specifications for functionality on smart meters in place. One DSO installs smart meters at all connection points to ensure security of supply, and some larger customers have smart meters installed.

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2.1.3 Norway

Smart meters are regulated by chapter 4 of the regulation on measurement, calculation and coordinated action of power distribution and billing of grid services[5]. According to this regulation, DSOs are obliged to have installed smart meters at all[6] sites from the 1st of January 2019[7]. The same regulation also requires a possibility of data measurement every 15 minutes, actual data measurement occurring every hour, daily data frequency collection as well as the provision of a standard communication output to provide local, instant access to consumption data to the consumer.

The installed meters must also be able to remotely disconnect or reduce the load at the consumer's site. In addition, the Smart Meter communication network must be able to transmit power prices (from the supplier), tariffs and steering signals to the consumer.

2.1.4 Sweden

Smart metering in Sweden is regulated by the Electricity Act as well as the Regulation on measuring, calculating and reporting distributed electricity (1999/716)[8] with later amendments by the Swedish Energy Markets Inspectorate. By law, DSOs are in Sweden responsible for instalment and readings of equipment that measure household electricity consumption. The roll-out of smart meters in Sweden was completed already in 2009.

Hourly metering and daily reporting is the main rule according to the Swedish regulation. Sites with consumption below 63A are exempted from this regulation. For these sites consumption is measured and reported on a monthly basis. However, electricity consumption below 63A can also be subject to hourly measurement if the customer so desires. Instalments of hourly metering equipment are in this case by law free of charge for the consumer if the consumer has an electricity contract based on hourly spot prices. There is currently a requirement set by the TSO on the DSOs technical ability to remotely reduce consumption at large consumption sites (> 5 MW)[9].

There is currently no regulation on meter devices regarding local access to measure data or the possibility to remotely disconnect or reduce loads. However, the Swedish Energy Markets Inspectorate is about to suggest new requirements for smart meter when replacing existing meters that are similar to required functionalities in the other Nordic countries. According to Swedish Energy Markets Inspectorate there should indeed be functional requirements and that the meter should:

1. be equipped with an open, standardized interface that delivers real time information on power, aggregated consumption, voltage and, if relevant, production. The consumer is given access to this information.
2. for all phases meter voltage, current, energy and active and reactive power in both directions.
3. allow remote reading of all metered data.
4. register consumption with a frequency of 60 minutes. It should also be possible to change the registration frequency to 15 minutes.

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[5] Forskrift om måling, avregning og samordnet opptreden ved kraftomsetning og fakturering av nettjenester: https://lovdata.no/dokument/SF/forskrift/1999-03-11-301#KAPITTEL_4

[6] With some exceptions: sites with low and unpredictable electricity consumption and sites where a considerable inconvenience of the instalment for the customer can be documented

[7] Reference: http://www.nve.no/PageFiles/808/Forskrift%2011.%20mars%201999%20nr.%20301.%20Kapittel%204%20Avansert%20m%C3%A5le%20og%20-styresystem.pdf

[8] Förordning om mätning, beräkning og rapportering av overförd el: http://www.riksdagen.se/sv/Dokument-Lagar/Lagar/Svenskforfattningssamling/Forordning-1999716-om-matni_sfs-1999-716/

[9] SvKSF 2012:01: Föreskrifter om ändring i Affärsverket svenska kraftnätsföreskrifter och allmänna råd (SvKFS 2001:1) om utrustning för förbrukningsfrånkoppling

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5. register and save information on any interruption longer than 3 minutes on one or several phases, including start and end time of the interruption.
6. detect zero faults and automatically send alarm when this occurs.
7. allow remote upgrading of software and settings.
8. allow remote connection and disconnection of electricity supply.

The recommendations will be submitted fro the Swedish Energy Markets Inspectorate to the government late May 2015. The government is thereafter expected to send the suggested cange on public consultation for two to three months, most likely during the autumn. New requirements for smart meters may be implemented during 2016.

2.1.5 Finland

According to Finnish Energy Industries (2010), the decree on metering obliged system operators to bring 80 per cent of all metering sites within the scope of hourly metering by the end of 2013. For all sites above 3*63A, the deadline was set to the end of 2010. As a result, the roll-out of smart meters is completed.

The Electricity Market Act (588/2013) with amendments regulates smart metering in Finland as well as a decree on metering of electricity supply (66-2009). The installed meters are required to be able to register meter data every 15 minutes, but the actual measuring resolution time is set to hourly. Meter data is transferred to the network operator on a daily basis.

The metering decree obliges local access to metering data on the consumers demand. In addition, it states that metering devices must be able to receive and transmit load control commands to the consumer. The purpose of the decree paragraph is to promote introduction of demand flexibility controls and management of power shortages[10].Third parties have access to the communication channel through a power of attorney[11].

2.1.6 Denmark

The Danish electricity supply act charges DSOs' with the obligation to measure input to and output from the electricity grid. A recent amendment[12] requires smart meters to be installed at all sites by the end of 2020. According to the same act, the meters shall be able to register measurements at least every 15 minutes. The frequency of data transfer to the DSO is defined in a special regulation from the TSO[13]. Energinet.dk requires different resolution in measured data in the East and West of Denmark. The demanded measuring resolution is 15 minutes in the eastern part and hourly in the west.

The amendment also enables local access to meter data via a standard communication output to provide local, instant access to consumption data to the consumer. There is no regulation on possibilities to remotely disconnect or reduce the load at the consumer site.

2.2 The role of third parties

2.2.1 Similarities and differences in the Nordic area

Table 4 and the discussion below give an overview of the regulation regarding the possibility for agents to behave as third parties. The similarity in the Nordic area is the lack of any direct regulation governing third parties and hence no rules that influence third parties' contribution to demand

[10] Finnish Energy Industries (2010): Principles of hourly metering
[11] According to statute 66/2008 (valtioneuvoston asetus sähköntoimitusten selvityksestä ja mittauksesta) chapter 6 paragraph 8.
[12] Bekendtgørelse om fjernaflæste elmålere og måling af elektricitet i slutforbruget.
[13] http://energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/El/Regulation%20D2%20Technical%20requirements%20for%20electricity%20metering.pdf

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response. However, third parties may be given access to meter data in all countries by power of attorney by the consumer Suppliers will be provided measure data for their customers from the DSO in all countries (THEMA, 2015).

In Denmark, the DSO is the obliged party for energy efficiency (in fulfilling the energy efficiency directive), but at the same time DSOs are restricted from delivering energy efficiency services themselves. But also in Denmark no regulations restrain DSOs or other agents to take part in demand response.

There are no obligations or constraints on price structures in supplier contracts in any of the Nordic countries. Hence, there is no obligation for suppliers to provide hourly prices to their customers.

Participation in spot or reserve markets in the Nordic power system requires balancing responsibility. Having balancing responsibility is also a requirement to take part in balancing markets in the Nordics. This obligation may restrict some third parties from taking part in the markets, for instance aggregators without balancing responsibility acting on behalf of small consumers without balancing responsibility on their own. Suppliers normally hold the balancing responsibility for small consumers, and may therefore have a competitive advantage over other energy service providers of demand response. However, helping consumers respond to spot prices does not require balancing responsibility. It is worth noting that imbalancing costs discriminate between generation and demand where costs of imbalances generally are lower for demand than for generation.

Table 4: Comparison table on regulation of third parties providing demand response

	Iceland	**Norway**	**Sweden**	**Finland**	**Denmark**
Restrictions on who may provide energy services	None	None	None	None	Energy savings must occur through other parties than DSO
Restrictions on what services may be provided	None	Balancing responsibility required for participation in market places	Balancing responsibility required for participation in market places	Balancing responsibility required for participation in market places	Balancing responsibility required for participation in market places
Restrictions on energy services	None	None	None	None	DSO is the obliged party on energy efficiency
Restrictions on 3rd parties access to measure data	None	By power of attorney	By power of attorney	By power of attorney	By power of attorney
Regulation on pricing in electricity contracts	None	None	None	None	None

2.2.2 Iceland

There is no special regulation on Iceland governing the role of third parties in the energy sector.

2.2.3 Norway

There is no regulation on pricing structure of supplier contracts or if and how third parties may help consumers react to spot pricing.

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As stated, the Smart Meter communication network must be able to transmit power prices (from the supplier), tariffs and steering signals to the consumer. On steering signals, there is no regulation on who may send steering signals and how this should work in practice.

2.2.4 Sweden

There is no regulation on pricing structure of supplier contracts or if and how third parties may help consumers react to spot pricing.

A bill related to the electricity act[14], states that the Swedish NRA is obliged to make a publicly available list containing the technical demands and other terms and conditions for demand response services. This regulation must be seen in connection with the implementation of the Energy Efficiency Directive, and ensures that parties that would like to offer energy services have the knowledge necessary to do so.

Furthermore, a recently adopted regulation states that by request from the electricity customer, third parties have access to measure data from each site[15].

2.2.5 Finland

There is no regulation on pricing structure of supplier contracts or if and how third parties may help consumers react to spot pricing.

2.2.6 Denmark

There is no regulation on pricing structure of supplier contracts or if and how third parties may help consumers react to spot pricing.

The law defines activities to induce energy savings as a Public Service Obligation of DSOs and the costs in connection with this work are covered in the net tariffs. Furthermore, DSOs are obliged to ensure that consumers are informed of the possibilities for energy savings. According to a decree[16] from last year, energy savings can only occur through other parties than DSOs.

[14] SFS 2014:354: Förordning om ändring i elförordningen. https://lagen.nu/2013:208
[15] SFS 2014:350: Förordning om ändring i förordningen (1999:716) om mätning, beräkning och rapportering av överförd el.
[16] § 21 in «Lov om ændring af lov om elforsyning, lov om naturgasforsyning og lov om energinet.dk».

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3 DEMAND RESPONSE TO GRID TARIFFS

This part of the report discusses demand response to price signals in grid tariffs. The grid tariffs may be based on:

- Energy only: volumetric based on energy usage (fee per kWh transferred to the consumer)
- Capacity: based on the power (W) output delivered from the grid. Variations may be subscribed power, actual maximum power output (measured for a defined period of time) or based on the fuse size (A).
- Time of use: the tariffs (based on volume/ energy or power) are differentiated in time, based on season, time of day or by the hour.
- Dynamic: the tariffs increase only when the capacity of the grid is scarce.

Consumers may also be offered incentives to allow loads to be interrupted whenever requested by the DSO to handle capacity shortage or other operational issues in the grid.

Table 5 and the following paragraphs give an overview of the regulation of tariffs in each Nordic country that determine whether consumers are given price incentives in grid tariffs to adjust their consumption in any way.

In all countries, the national law states that grid tariffs offered by DSOs to their customers must be transparent, fair and non-discriminatory. The Norwegian, Finnish and Danish regulation also states that tariffs should promote efficiency. These overall terms may in some way restrict the use of tariffs to promote demand response. However, these are general terms and do not provide direct guidance or regulation on tariff structure or differentiation.

Norway sets itself apart from other countries by having formal rules that govern tariff structure in some detail. In all other Nordic countries, tariff structure is not regulated. This means that there are *a priori* no obligations, but no restrictions either, on tariff practices.

The Finnish meters installed are required to handle remote load control. The Finnish DSOs are therefore in a position to offer special tariffs if small consumers´ loads are to be interrupted.

Table 5: Comparison table of relevant tariff structure regulation

	Iceland	Norway	Sweden	Finland	Denmark
Small customers	No regulation	Some obligations and restrictions, but no detailed regulation	No regulation	No regulation	No regulation
Large consumers	No regulation	Some obligations and restrictions, but no detailed regulation	No regulation	No regulation	No regulation
Low tariff for interruptible loads	Possible for large consumers, but no obligation	Yes, subjected to restraints on how and when	No regulation	No regulation	No regulation

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3.1 Tariff structure

3.1.1 Iceland

There are two types of charges possible: A capacity charge and an energy charge. On Iceland there is no regulation specifically targeting DSO tariff setting. As long as the energy authority approves the tariffs, DSOs are free to offer their customers all types of tariffs. According to the regulatory authority, it only opposes proposed tariff structures by DSOs if it is considered to exceed the DSO's income frame is not in accordance to the Electricity Act and it´s derived regulation.

3.1.2 Norway

The regulation[17] on reporting, income and tariffs in connection with grid activity lists the overall principles for Norwegian grid tariffs. The most general principle is that DSOs are obliged to offer non-discriminatory and predefined terms and conditions in contracts. However, tariffs can be discriminatory if based on objective parameters.

Consumers (with hourly measurement) may be given a tariff based on two or three different components: a fixed fee, energy and capacity. As a rule, the fixed component covers specific costs related to each customer and a share of the fixed costs of the grid. The energy component is at least supposed to cover costs from marginal losses in the system, but may also cover a share of other costs. The capacity element is based on the customer's use of power over a predefined period. Time-differentiated energy-based tariffs must be offered to customers that by law are obliged to measure their consumption several times a year. The Norwegian Water Resources and Energy Directorate has announced that the regulation on grid tariffs to small consumers may be changed when smart meters are in place. A conceptual hearing on new grid tariffs is currently taking place until August 2015. If the Norwegian Water and Energy Directorate want to change current regulation of tariffs, there will be a new hearing on suggested changes during 2016.

3.1.3 Sweden

The general rule on grid tariffs in the Swedish electricity law[18] is that tariffs should be objective, non-discriminatory and *set in a way that is consistent with efficient use of the electricity grid as well as efficient production and use of electricity.* The electricity law states that the Government may implement new acts to describe grid tariffs in more detail. There are, however, no specific obligations or restrictions on tariff structure in Swedish regulation. The Swedish Energy Markets Inspectorate (2012) notes that there are no constraints *a priori* on capacity pricing or time-differentiated tariffs.

3.1.4 Finland

The Electricity Market Act (588/2013) regulates tariff structures in Finland. The general principle for tariff setting is that tariffs and other contractual terms in contracts should be objective and non-discriminatory. Furthermore, DSOs are obliged to publish the terms of their contracts to the public and justify their calculation method to the regulator. There is no further guidance for tariff structure in the regulation.

Requirements for the DSOs reporting of measured data to the consumer are however based on the typical tariff structure in Finland. The measured data must be reported according to the consumers metering service. Service options are hourly, based on day/ night (where night-time is defined as between 22.00 and 07.00) or by season where winter is defined from the 1st of November to the 31st of March[19]. Also data may be reported unstructured by time.

Worth noting when discussing demand response, is that the Finnish Energy Law clearly states that the DSO must not hinder demand flexibility in any way unless there are special reasons to do so.

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[17] Forskrift om økonomisk og teknisk rapportering, inntektsramme for nettvirksomheten og tariffer, §14.
[18] Ellag (1997:857) with subsequent amendments.
[19] förordning 66/ 2009: http://www.finlex.fi/sv/laki/alkup/2009/20090066

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The same paragraph (24 b) states that both costs and benefits of demand response may be reflected in the grid tariffs.

3.1.5 Denmark

The Danish electricity supply act[20] does not contain specific rules on how DSOs should set the consumer grid tariffs; however, it does state that the methods DSOs use for the calculation of these tariffs must be approved by Energitilsynet. Furthermore, the general principle in the law is that DSOs may discriminate between customers for reasons of efficient use of the grid and security of supply. However, there is no regulation in place that specifically addresses reduced tariffs for interruptible connections.

Industry organisations can develop standardised guidelines for tariffs and other conditions in grid tariffs. Dansk Energi published an updated guideline to tariff calculation models in 2010. According to Dansk Energi, these guidelines are their recommendations, which each DSO can choose whether to use as a base for their contracts with customers[21]. They are not specific on tariff structure and therefore open to many possibilities, including time-differentiated tariffs. However, the DSO must be able to justify their choice of tariff structure.

3.2 Tariff incentives for interruptible loads

This part of the report focuses specifically on the financial incentives and/or tariffs for interruptible loads.

3.2.1 Iceland

As long as the energy authority approves the tariffs, DSOs are free to offer their customers all types of tariffs including compensation for interruptible loads and grid access restricted to off-peak hours. According to Landsnet's homepage[22]: "A discount may be given on the tariff for transmission that leads to more efficient use of the grid, such as for curtailable electricity". This applies to, e.g. delivery and transmission at voltages higher than 66 kV.

3.2.2 Norway

Norwegian DSOs can compensate their customers with lower grid connection fees if the connection may be interrupted at request from the DSO. The precondition is that this is necessary due to grid constraints, and not used as a means to give advantages to some customers. The smart meters that are to be installed in Norway will be able to cut off or reduce the consumer's total load. The meters are not required to reduce specific loads, and are therefore not a good tool to enable interruption of loads for small consumers.

3.2.3 Sweden

There is no explicit mentioning in the law of a possibility to discriminate between electricity users based on their agreement to take part in demand response (interruptible connection). This means that in principle, all DSO may apply such tariffs by their own choice. A report from the Swedish Energy Markets Inspectorate (2012) however discusses the possibility of extending the use of low tariffs for interruptible loads in Sweden. They point out that it is possible today for Swedish electricity consumers to adjust their consumption over time; however more demand response would be available if the law guaranteed the consumers some form of compensation for their flexibility. The report from the Swedish Energy Markets Inspectorate emphasizes that tariff practices among DSOs are rather disparate.

[20] Lov om elforsyning.
[21] Vejlednig til tarifberegningsmodell 12-03-2012.
[22] http://landsnet.is/english/transmissionandmarket/transmissiontariff/

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3.2.4 Finland

There are no obligations or restrictions for DSOs to offer special tariffs for interruptible loads. On the other hand, the smart meters installed are able to receive and transmit load control commands to specific loads at the consumers' site. The DSO therefore has the ability to remotely interrupt loads should they decide to offer special tariffs to interruptible loads.

3.2.5 Denmark

As stated, Danish DSOs have few restrictions and obligations when it comes to tariffs and tariff structures. This includes special tariffs for interruptible loads.

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4 DEMAND RESPONSE IN THE PROVISION OF SYSTEM SERVICES

Planning and operating a power system can be challenging since production and demand must be exactly equal at all times, bottlenecks must be immediately addressed and capacity constraints in the network respected. The TSOs are given the overall responsibility to operate the Nordic power system. A certain level of flexibility from generation and the demand side is necessary in order to address critical situations when they arise. The different mechanisms enable TSOs to balance the power system real-time and to promote long-term security of supply.

4.1 The reserve markets

The schedules for the real-time operations of consumers and generators are based on power purchased and sold in the wholesale market (Elspot and Elbas). TSOs purchase reserves in the balancing market in order to ensure system security (frequency) and manage imbalances and bottlenecks, incidents and disturbances. Such services are contracted in advance and activated during the operating hour.

4.1.1 Similarities and differences in the Nordic area

The Nordic TSOs collaborate to a large extent about system balancing services, but there are still some differences between the countries:

- *Primary reserves*: The procurement of primary reserves is a national responsibility; however, the Nordic System Operating Agreement governs requirements for volume, trade and technical aspects[23]. Procurement of primary reserves in Eastern Denmark is performed in collaboration with the Swedish TSO. Western Denmark is part of the synchronous grid of Continental Europe, and must supply primary reserves corresponding to its share in the synchronous area. Iceland also has a primary control reserve.
- *Secondary reserves:* Separate markets exist in Finland and in Western Denmark. The Norwegian and Swedish TSOs currently conduct a pilot project for a market on secondary reserves (FRR-A).
- *Tertiary reserves* are implemented through a common market for Norway, Sweden, Denmark and Finland, named Frequency Restoration Reserves Manual (FRR-M)[24]. Also Iceland has implemented a market for tertiary reserves.

Iceland does not take part in the cooperation on system services, as the Icelandic power system is not physically connected to the Nordic power system.

There is no discrimination between generation and demand in the regulation or product definitions in the reserve markets in any of the Nordic countries. However, the volumes, response time, duration and other characteristics defined by the TSOs to participate in the reserve markets may serve as a barrier for demand response in these markets. Table 7 describes typical features for the Nordic reserve markets.

Table 6: Typical features in the Nordic reserve markets.

	Primary reserves (FCR-N/FCR-D)	**Secondary reserves (FRR-A/LFC)**	**Tertiary reserves (FRR-M)**
DS participation	No discrimination	No discrimination	No discrimination
Marked design	Capacity auction, symmetric for upward and downward ramping.	Capacity auction, separate or symmetric for upward and downward ramping.	Volume auction, separate for upward and downward ramping. Hourly resolution

[23] https://www.entsoe.eu/Documents/Publications/SOC/Nordic/System_Operation_Agreement_2014.pdf.
[24] See for example http://www.statnett.no/Drift-og-marked/Markedsinformasjon/

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	Hourly, weekly and/or yearly resolution		
Activation	Automatic activation based on frequency	Remote activation by TSO	Manual activation by provider
Response time	< 1 minute	2-15 minutes	< 15 minutes
Minimum volume	0.1-1 MW	0.3-5 MW	10 MWh/h (lower in critical situations)
Duration	< 15 minutes	Depends on circumstances	15 minutes – 1 hour per bid (duration depends on circumstances)

4.1.2 Iceland

Iceland has a tertiary balancing market with hourly resolution. There is no regulation restricting demand side to participate in balancing markets, but hydro power plants are currently the major player delivering these services since they offer the lowest bids. Iceland also has a primary control reserve.

4.1.3 Norway

The Energy Act[25] in Chapter 6 defines the system responsibility of the Norwegian TSO. The TSO's activities are regulated more specifically by the regulation of system responsibility in the power system[26]. The latter sets the conditions for the procurement of system services. The TSO is required to secure the momentary balance in the power system at any point of time, and the regulation does not discriminate between measures from generation and consumption. Moreover, the TSO shall behave objectively and non-discriminatory, but has the right to disconnect loads in the case of a power shortage, according to the regulation.

The Norwegian and Swedish TSOs currently conduct a pilot project on secondary reserves, named "Hasle-piloten". The pilot project includes a market for secondary reserves, called Frequency Restoration Reserves Automatic (FRR-A)[27]. A provider of secondary reserves must be prequalified and meet a set of technical specifications.

The Norwegian markets for primary and tertiary reserves are parts of the Nordic markets for these services. In addition to the Nordic market for tertiary reserves (FRR-M), Norwegian generators and consumers may commit to offer tertiary reserves into FRR-M through the "Regulerkraft-opsjonsmarked" (RKOM)[28]. RKOM is used for ramping up generation or ramping down consumption during winter. RKOM is divided into two segments, a "high quality" segment and a "limited" segment. The "high quality" segment cannot have any constraints on duration or recovery time whereas the "limit" segment can specify constraints on duration and a recovery time up to eight hours. The price in the two quality segments is the same, unless any bid with limited quality has been skipped in order to meet the demand. In the latter case, the price of high quality reserves will be higher than the limited quality reserves. Moreover, the compensation for offers with limited quality will be reduced based on the limitations in duration and rest time.

[25] LOV-1990-06-29-50: Lov om produksjon, omforming, overføring, omsetning, fordeling og bruk av energi m.m.

[26] Forskrift om systemansvaret i kraftsystemet.

[27] http://www.statnett.no/Global/Dokumenter/Kraftsystemet/FRRAVilk%C3%A5r%20Offisielle%20oktober2014.pdf

[28] VILKÅR for tilbud, aksept/prissetting og håndtering av bud i regulerkraftopsjonsmarkedet (RKOM) http://www.statnett.no/PageFiles/2491/Vilk%C3%A5r%20for%20Regulerkraftopsjonsmarkedet%20(RKOM)%20fom%2010.11.2014.pdf

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4.1.4 Sweden

The Electricity Act (1997:857) Chapter 8 regulates the Swedish TSO. The system responsibility is regulated more specifically in "Förordning (1994:1806) om systemansvaret för el". The TSO has the right to disconnect loads if a fair market compensation for changing generation is not sufficient to exercise the system responsibility[29]. The TSO shall establish targets for operational security that are objective, transparent and non-discriminatory. There are no restrictions on demand side participation in the balancing markets.

The Swedish markets for primary and tertiary reserves are parts of the Nordic markets for these services. In addition, the Swedish TSO collaborates with the Norwegian TSO in the pilot project for secondary reserves (see paragraph above).

4.1.5 Denmark

System operation by the Danish TSO is primarily regulated by Danish Electricity Supply Act[30] and the "law of Energinet.dk"[31]. The former gives Energinet.dk the responsibility for security of supply, whereas the latter more specifically regulates the role of the TSO. Energinet.dk may specify terms for access to its services that are objective and non-discriminating. There are no restrictions on demand side participation in the balancing markets.

The balancing reserve markets in Denmark are described in Energinet.dk's ancillary service strategy[32]. The Danish market for tertiary reserves is a part of the Nordic market. Procurement of primary reserves in Denmark is different for the Eastern and Western parts, because the two parts belong to different synchronous areas. Eastern Denmark procures primary reserves in collaboration with the Swedish TSO. Primary reserves in Western Denmark are procured through a daily market, and are activated when the frequency deviates from 50 Hz in the region 49.8 Hz to 50.2 Hz.

There is a secondary reserve in Western Denmark, referred to as Load Frequency Control (LFC). The market for LFC is symmetrical, i.e., a bid must be available for upwards and downwards ramping. The maximum response time is 15 minutes. Secondary reserves are procured on a monthly basis. Currently, there is no secondary reserve market in Eastern Denmark.

4.1.6 Finland

The Electricity Market Act (588/2013) with amendments regulates the Finnish TSO[33]. The TSO is responsible for the technical operability and reliability of the Finnish electricity system, and may impose conditions on the use of power plants and loads connected to the transmission system in order to meet its responsibilities. The terms for trade of balancing electricity must be equitable and non-discriminatory to all market participants. Still, the terms shall account for the conditions needed for reliability and efficiency of the system. There are no restrictions on demand side participation in the balancing markets.

The Finnish markets for primary and tertiary reserves are parts of the integrated Nordic markets[34]. Primary reserves are procured on a yearly basis (in fall) and in a daily market with hourly resolution. The Finnish TSO has a market for secondary reserves (FRR-A). This market has hourly resolution, and is separate for upward and downward capacities. The provider receives a capacity payment, in addition to an energy payment if the reserve is activated. The minimum volume is 5 MW, and full activation must occur within two minutes.

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[29] The Electricity Act (1997:857) Chapter 8, Section 2
[30] https://www.retsinformation.dk/forms/r0710.aspx?id=159158#Kap5
[31] Bekendtgørelse af lov om Energinet.dk.
[32] http://energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/El/77566-11%20v1%20Energinet%20dk%27s%20ancillary%20services%20strategy.pdf
[33] Version used here: 9.8.2013/588.
[34] The balancing reserve markets in Finland are described on Fingrids websites http://www.fingrid.fi/en/powersystem/reserves/Pages/default.aspx.

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4.2 Demand response in capacity mechanisms

TSOs may want to contract manual and/or automatic reserves in a long-term perspective (capacity markets), providing the TSOs with more certainty for their operations and the market players with long-term incentives to provide a specified kind of flexibility. TSOs may also purchase long-term energy reserves (guaranteed volumes in Elspot) from consumers and generators to ensure security of supply in possible future constrained situations (e.g. strategic reserves and energy options to power intensive industry). Long-term contracting promotes investments in flexibility by both providing long-term price signals and opportunities to limit risk.

4.2.1 Similarities and differences in the Nordic area

Table 7 contains an overview of national regulation relevant for capacity mechanisms. As for reserve balancing markets, there are no restrictions on demand side participation in capacity mechanisms. On the other hand, some obligations exist. In Norway, the TSO might oblige participants to provide demand, and in Sweden the TSO is obliged to partly cover the need for reserves from the demand side. The rules for the Finnish reserve is harmonized with the Swedish one (but the markets are separate), except the obligation for the TSO to include the demand side. Currently neither Iceland nor Denmark has a capacity mechanism, but Denmark is planning to establish a strategic reserve by 2016.

Table 7: Demand response in capacity mechanisms

	Iceland	Norway	Sweden	Finland	Denmark
Type of mechanism	No regulation	Contracts on cutting consumption in critical situations (ENOP)	Strategic reserve	Strategic reserve	Currently no regulation, but a strategic reserve is planned from 2016
Demand side participation	No regulation	Restricted to demand side. TSO may oblige participation.	Demand is required to cover 25 %	No restrictions or obligations	Is planned to include both demand and generation.

4.2.2 Iceland

There is no capacity mechanism in Iceland (as we have defined it), but low (TSO) tariffs for disconnectable loads may be used in situations of capacity shortage (see 3.2.1).

4.2.3 Norway

The Norwegian TSO does not have a conventional strategic reserve for power shortages, but has an “energy options market” for demand reduction (ENOP), which is used to limit demand in situations of capacity shortage (energy). Hence, this is to be seen as a capacity mechanism for the Norwegian power system. The energy reserve consists solely of demand response, because the Norwegian generating system contains mostly hydropower, which has no flexibility in total energy generation. The provider specifies reference consumption, as the maximum-metered consumption over an eight-week period from the last three years. Demand response included in ENOP can also be offered into FRR-M and RKOM, but demand response offered through a reduced grid tariff cannot be included in ENOP.

4.2.4 Sweden

Sweden and Finland has harmonised operational rules for strategic reserves.

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The Swedish TSO has a strategic reserve regulated by “Lag (2003:436) om effektreserv” and “Förordning (2010:2004) om effektreserv”, consists of up to 2000 MW of generation and demand response, and is active in the period November 16 through March 15. The reserve is gradually phased out in the period up to 2025. The reserve should consist of at least 25 percent load response, however, the regulation opens for a lower share of load response if the conditions for load response are not met. Providers of demand response to the reserve might be offered into ElSpot. Providers must commit to offer available demand response into FRR-M.

4.2.5 Finland

Finland has a strategic reserve with rules that are harmonised with the Swedish strategic reserve. However, there is no minimum requirement for the share of demand in the Finnish reserve.

4.2.6 Denmark

Denmark does currently not have a strategic reserve, but is planning to implement this from 2016. The strategic reserve is suggested to open for both generation and demand response.

Energinet.dk is an autonomous public institution whose overall objective is to ensure efficient use and investments of electricity- and gas infrastructure and to ensure open and equal access to these infrastructures. In order to fulfil this objective, the TSO has quite substantial degrees of freedom in extraordinary situations. The law[35] stipulates that when there is a risk of grid collapse, the TSO can oblige producers, traders and consumers to make necessary adjustments, without financial compensation.

[35] Energinet.dk: Ancillary services to be delivered in Denmark- Tender conditions: http://energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/El/8871-11%20v3%20Ancillary%20services%20to%20be%20delivered%20in%20Denmark%20-%20Tender%20conditions.%20Valid%20from%203%20October%202012.pdf

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5 MICRO-PRODUCTION

This section describes regulation in place in the Nordic countries that explicitly target small-scale electricity production. We mostly focus our analysis to regulation of the electricity market, but also a brief overview of subsidies for micro-production is included. We survey the national regulations for rules concerning the following issues (results are summarised in Table 8):

- Segmentation criteria; volume and other
- Metering; is separate metering and meter device for production required?
- Grid access; Connection steps and grid costs
- Market access; payment for surplus generation

As we discussed in section 1.3.1, there is no universal definition of micro-production. The segmentation of generators according to their size differs therefore per country, even in regulations within one country. For Norway we have summarised the suggestion from an ongoing hearing. The results may be subject to some changes, but is suggested decided in June 2015 and to be implemented January 2016.

Table 8: Regulation on micro production

		Iceland	Norway	Sweden	Finland	Denmark
Segmentation	Volume	100 kW	Suggested in ongoing hearing: 100 kW (to the grid)	43,5 kW (to the grid) and fuse < 63 A (tax regulation < 100 A)	2 MVA	Varies according to power source: PV: 50 kW Wind: 25 kW CHP: 11 kW
	Site	No regulation	Suggested in ongoing hearing: Generation mainly for own consumption	Net consumer of electricity over the year	Generation mainly for own consumption	Generation mainly for own consumption and 100 % owned by the consumer
Metering	Metering	No regulation	Separate metering from one device	Generation and consumption must be metered separately for tax deduction	Separate metering	Separate metering from one device
	New meter needed?	No	Not after smart meter is installed	If installed meters cannot separate between generation and consumption	No, installed meters handle both generation and consumption (< 3*63 A)	Not after smart meter is installed
Connection	Steps	DSO responsible for defining technical specification for micro-producers	No defined connection steps	No particular regulation for micro-producers	Technical information to the network operator The system operator grant permission	Technical information to the network operator Registration on the TSOs website

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	Costs	All producers pay the same connection fee, set by the DSO	Suggested in ongoing hearing: Exempt from generation feed-in tariffs. Tariffs and levies are based on net consumption	<43,5 kW/63 A exempt from all tariffs	<2MVA: no investment contribution Consumption > production: normal consumption fees apply Service fee max: 0,07 cents/ kWh	Certain producers are exempt from grid access charges Tariffs and levies are based on net consumption
Access to market	Price	No regulation	Suggested in ongoing hearing: No regulation	No regulation	No regulation	No regulation
	Rules	Supplier is the contact point for selling power	Suggested in ongoing hearing: Supplier is the contact point for selling power	Suggested: the supplier is the contact point for selling power	May sell to market or not. The supplier is the contact point for selling	No regulation

All countries separate micro-producers from other electricity generators based on production (size). Denmark, Finland and Norway (suggested regulation) also include the use of electricity primarily for own consumption as a parameter for defining micro-production. A similar rule is stated in Swedish regulation, requiring the level of consumption to be larger than the generation fed to the grid. The exact threshold for what is considered to be micro-production varies between countries, but the highest level is in Finland where the maximum power delivered to the grid is 2 MVA. For Norway, Finland and Denmark no extra/ new meter device will be necessary after the general implementation of smart meters, as they are required to measure both generation (fed to the grid) and consumption (of electricity from the grid). As separate metering of generation and consumption is not a requirement for installed smart meters in Sweden, new meters may need to be installed for micro-producers. As stated, the requirements for smart meters in Sweden may be changed in 2016, which may include separate metering of generation and consumption.

Iceland, Sweden and Norway have no specific regulation setting rules for grid connection of micro-producers. Finland and Denmark have detailed connection requirements for micro-producers laid down regulation or guidelines. Financial advantages through lower grid charges than for other producers are given to micro-producers that connect to the grid in Norway (in suggested regulation), Sweden, Denmark and Finland.

In Sweden the supplier is obliged to provide market access to micro-producers. None of the other Nordic countries regulates a micro-producer's access to the market through obligations to purchase or a price guarantee. In all Nordic countries, market access has to be organized through a supplier except in Iceland where there are no specific regulations for micro-producers. However, in the current regulation of micro-production in Norway, the DSO is obliged to buy the surplus generation.

5.1 Segmentation and measurement of micro-production

5.1.1 Iceland

Iceland uses the same definition of micro hydropower as Norway, i.e. plants with an installed capacity of less than 100 kW. There is currently no specific regulation for micro-production, but the

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government is considering drafting a new law similar to the suggested Norwegian regulation in order to encourage micro-production.

5.1.2 Norway

The general regulation of generation in Norway does not generally discriminate micro-production from other small scale generation. On a voluntary basis, the DSOs are given the right to exempt micro-production for feed-in tariffs and to by surplus generation from prosumers at prices agreed between the parties (market price is recommended). Micro-producers under this agreement are also exempted to grant a license to operate. This arrangement entered into force in March 2010.

In June 2014 NVE started a hearing on regulation of prosumers, or so-called "plusskunder". Final decisions on will be taken in June 2015 and enter into force by 1st of January 2016. The special features of these producers are that they generate electricity mainly for their own consumption (for instance through solar panels on residential roofs) and that the power fed to the grid does not surpass 100 kW. Henceforth, this is the category we refer to as "micro-production" in Norway.

The suggested regulation states that a single device should be able to measure both the consumption and production of micro-producers[36]. Hence, no new installation of meter is necessary to start micro-production after the general roll-out of smart meters.

5.1.3 Sweden

A micro-producer' installation in Sweden can generate maximum 63A and have a capacity of maximum 43,5 kW injected into the grid under the condition that the installation is, over a period of a year, a net consumer of electricity.

A government commissioned inquiry (Regeringens proposition 2013:151) suggests that both generation and consumption at a micro-production site must be reported in order to receive tax-deductions from the generated power that is delivered to the grid. As separate metering of generation and consumption is not a general requirement for installed smart meters in Sweden, new meters may need to be installed for micro-producers.

5.1.4 Finland

The Finnish Energy law defines micro-production as sites generating less than 2 MVA. Finnish energy industries define a micro-production unit as an electricity generation plant connected to the low-voltage network at the consumption site, with the primary purpose of generating electricity for own use. The plant only feeds into the network occasionally or insignificantly. We have regarded this as the definition of micro-production from prosumers. The size limit is 16 A (highest current that can be fed into the grid by the installation).

According to Finnish Energy Industries (2010) principles of hourly metering, the installed meters must be able to measure power both to and from the grid. This feature is included in all smart meters already installed in Finland. Hence, no new meters need be installed to handle micro-production. However, for micro-production with a fuse larger that 3*63 A, separate meters must be installed.

5.1.5 Denmark

In Denmark, micro-producers are considered to be units that mainly use production for own consumption with a maximum installed capacity of 50 kW for photovoltaic installations, 25 kW for windmills, and 11 kW for CHP plants.[37]

Net measuring of electricity is based on separate metering of generation and consumption on the site. This feature is included in the functionality requirements of smart meters to be installed in

[36] Forskrift om måling, avregning og samordnet opptreden ved kraftomsetning og fakturering av nettjenester (§4).
[37] Bekendtgørelse om nettoafregning for egenproducenter af elektricitet.

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Denmark. Hence, no new meters need be installed to handle micro-production after the roll-out of smart meters.

5.2 A micro-producer's access to the grid

5.2.1 Iceland

There are no special rules governing the procedure by which micro-producers are connected to the grid, but rules are set by the DSO. There is no requirement for a separate meter.

All producers must pay a connection charge, which is set by the DSO. This charge must cover the cost of the connection as well as handling fees. The concession fee is set to minimum 100.000 IKR (approximately 6 500 EUR), but increases with installed capacity. The minimum fee is valid for generation installations with a capacity of up to 50 kW.

5.2.2 Norway

The suggested regulation of micro-producers, and the current exempt states that the producer do not need a balancing agreement with the TSO which is the case of all other electricity generators. There are no specific actions needed to connect a micro-producer to the grid, except fulfilling technical requirements from the network operator on installed generation equipment. The network operator is responsible for connecting micro-production. Normal rules for investments contributions in the grid also apply for micro-generation.

The suggested regulation[38] states that micro-producers should be exempt from part of today's grid charges on electricity sold in the market. The proposed exemption concerns a fixed annual feed-in tariff (called "innmatingstariffen") that all generators currently pay. Micro-producers must still pay an energy tariff that is supposed to reflect the marginal loss inflicted on the grid. The same regulation states that micro-production (generation) may be measured as net production to the grid, meaning that consumption is deducted by the generated production that is locally used. The implication is that the micro-producer does not pay grid tariffs and other charges on the electricity consumed on-site, which is covered by own production of electricity.

5.2.3 Sweden

There are no special rules governing the procedure by which micro-producers connect to the grid. However, Regeringens proposition 2013/14:151 suggests that the micro-producer must notify the DSO to start deliver to the grid, and the DSO must measure and report on the amount of electricity delivered to the grid and ensure that the power to the grid does not surpass 100A. Connection steps may be provided in contracts between the site and the DSO.

Swedish micro-producers have special financial conditions when injecting electricity into the grid. According to the Swedish electricity law, micro-production is exempt from all charges connected with injecting electricity into the grid.

An inquiry[39] commissioned by the Swedish Ministry of Finance recommended in 2013 the continued use of billing based on gross measurement of micro-production as to moving to a billing system were taxes and other charges are calculated based on their net contribution to the grid. The latter was thought to conflict with the system for value added taxes. Instead, to encourage micro-production their report recommended giving tax credits to micro-producers approximately equal to what they would have gained had one moved from a gross to a net measure in the regulation. The Swedish

[38] NVE: Forslag til endring i avregningsforskriften
http://webby.nve.no/publikasjoner/hoeringsdokument/2013/hoeringsdokument2013_02.pdf

[39] Statens offentliga utredningar 2013:46 (2013): *Beskattning av microproducerad el m.m*. Betänkande av Utredningen om nettodebitering av el.

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government has proposed[40] a tax deduction of 60 öre per kWh for micro-producers whose fuse does not exceed 100 A.

5.2.4 Finland

Network recommendation YA9:09[41] defines rules for connecting micro-production to the grid in Finland. Steps to connect electricity production to the grid include:

- Delivering information on the technical properties on the generation equipment to the system operator.
- Providing the system operator with an appropriate commissioning inspection record.
- The system operator provides permission to use the plant.

For micro-production that does not sell surplus generation to the market, a separate contract must be made with the DSO for the generation.

The system operator must connect micro-production that meets the technical requirements in its area at request and for a reasonable charge. The connection fees for generation that output less than 2 MVA can only include direct connection costs and must not include any general network investments costs. If the connection of the generation installation causes protection changes in the network, the customer is also responsible for these costs. As long as the sites' consumption is greater than the generation, the normal connection fees for consumption apply. If a site is a net producer of electricity the terms for micro-production no longer applies, and more "normal" generation tariffs should apply.

As for the financial conditions, according to the Electricity Market Decree[42], a maximum network service fee for production at 0.07 cents/kWh (VAT 0 per cent) may be charged for generation connected to a low- and medium-voltage network, but only if the surplus electricity is sold on the market.

A small-scale provider, whose production plant's nominal output is not more than 50 kVA, is exempt from electricity tax and related liabilities regarding the electricity he has produced, and which is used on-site.

5.2.5 Denmark

Connection steps for micro-producing in Denmark are as follows[43] (energinet.dk):

- The municipality be contacted as they in some areas must approve the installation
- Delivering information on the technical properties on the generation equipment to the local network operator who sends the information to the TSO
- The micro-producer receives forms to register the plan and to apply for net metering from the TSO
- The micro-production plant must be registered on the TSOs website

The installed equipment must also be certified.

Relevant regulation for micro-producers costs of grid connection is that certain electricity micro-producers are exempt from producer tariffs on electricity injection into the grid. Furthermore, electricity from renewable micro-producers is promoted through net-billing which means that all

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[40] Regjeringens proposition 2013:151 Skattereduktion för mikroproduktion av förnybar el.
[41] http://energia.fi/sites/default/files/mikrotuotato_connection_of_micro-generation_to_the_electricity_distribution_network.pdf
[42] Electricity Market Act section 14b.
[43] http://energinet.dk/DA/El/Solceller/oensker-du-solceller/Sider/default.aspx and http://energinet.dk/DA/El/Husstandsvindmoeller/oensker-du-en-husstandsvindmoelle/Sider/default.aspx

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electricity consumption by micro-producers is exempt from public charges, including producer charges[44].

5.3 A micro-producer's access to the market

5.3.1 Iceland

The supplier is the micro-producers point of contact to sell surplus electricity, but there is no obligation for the supplier to buy. There is no regulation of price for the electricity delivered to the grid.

5.3.2 Norway

Micro-producers in Norway are exempt from the trading license that is generally required to trade electricity, but are also restricted to sell surplus electricity exclusively in the market place. To access the market, surplus electricity from micro-production must currently be sold to the DSO, but in suggested regulation to the consumers' electricity supplier. There is no regulation on the compensation micro-producers receive when selling electricity, nor is there any such suggestion in the current hearing of prosumer regulation. The suggested regulation states that if there is no agreement with the supplier, the surplus electricity may be fed to the grid without compensation.

5.3.3 Sweden

Micro-producers are free to sell their surplus to any electricity supplier company. A government commissioned inquiry (Regeringens proposition 2013/14:151) recommended that as a starting point the supplier should also be obliged to receive the electricity generated by the micro-producer. But micro-producers may also sell the surplus electricity to other suppliers. Pricing is not suggested regulated.

5.3.4 Finland

The Finnish Energy Industries have provided guidelines for suppliers on contracting micro-production[45]. The supplier has to notify the DSO (by email) as they start purchasing micro-production. The DSO will thereafter report consumption and generation separately.

The pricing of electricity sold is not specified in the guidelines, but states that each buyer of electricity independently defines the price it offers for small-scale electricity producers. The supplier is also free to bundle purchase and (specific) sales contracts. According to the same document, value added tax is added to the price when buying electricity from a retailer. However, when a micro-producers are selling surplus electricity to a retailer, the sale is taxfree, unless the small-scale provider is liable to pay value added tax.

5.3.5 Denmark

There are no special rules governing micro-producers' market access in Denmark, nor any rules concerning the price of micro-generated electricity. However, micro-producers may apply to the TSO for a special subsidy per kWh delivered to the grid. To apply for this subsidy, the micro-producer must have an agreement with a supplier to buy surplus electricity.

[44] Reference: http://www.res-legal.eu/search-by-country/denmark/summary/c/denmark/s/res-e/sum/95/lpid/96/

[45] Finnish Energy Industries: Guidelines for suppliers on contracting micro-production: http://energia.fi/sites/default/files/guidelines_for_suppliers_on_contracting_micro-generation.pdf.

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