



FINNISH ELECTRICITY MARKET DEVELOPMENT AND IMPLEMENTATION PLAN

This memorandum describes the Finnish Implementation Plan as part of the capacity mechanism notification and approval in accordance with Article 20 of Regulation 943/2019.

Update 29.1.2021: This memorandum has been updated to take into account the Commission's opinion on the Finnish implementation plan (C(2020) 7274 final, 28.10.2020).

General wholesale market conditions

Finland is a very energy intensive society. There are three main reasons for this: 1) Finland has the coldest climate in the EU, 2) large energy intensive industry sector producing export goods and 3) long distances within the country and to the relevant markets for the export goods. This places extra emphasis on energy security, including security of supply in electricity.

Many of the cities produce heat for the customers with efficient combined heat and power (CHP) plants. In addition, industrial users produce the needed heat and electricity in CHP plants. However, electricity plays an important role for both the households and industrial processes. About one third of space heating is based on electricity, either directly or with heat pumps. In addition, district heating is dependent on steady supply of electricity as the pumping of the heat medium (water) requires electricity.

Finland is fully dependent on the functioning of the internal market of electricity in EU to deliver sufficient security of supply. Based on Eurostat, the share of electricity imports of the total electricity consumption is one of the highest in Finland: Finland imports around one third of the needed electrical power during peak hours in the wintertime and around 20-25 % of the annual consumption. This is a good sign that the electricity market functions in a very efficient way.

Despite the fact that Finland has a rather balanced generation mix (see figure 1 below), we are going through rapid changes in the electricity system. Most of the condensing power plants have already decommissioned, and the plants have been dismantled. Also, the CHP production, which covers around 25 % of the generation, is under pressure due to lack of profitability. Most of the CHP-plants have been built in the 70's

and 80's and are now coming in the age of renewal. Due to the current electricity market prices, most of the CHP plants will be replaced with biomass-fired heat-only boilers or large-scale heat pumps, thus reducing generating capacity or even increasing consumption during the times of system stress. New generation capacity coming to the electricity system includes mostly wind power and nuclear power which are not well suited for dispatching for the system needs. In addition, there have been several delays on Olkiluoto 3 nuclear power plant (1600 MW), which is a key project for security of supply in Finland. Originally, the plant was supposed to come online in 2009. During the consultation period of this implementation plan TVO published a further delay of the plant and now the latest estimate for the commission is February 2022¹. Due to this, Finland has been one of the leading countries in developing flexibility in the electricity markets and taking new market concepts into operation.

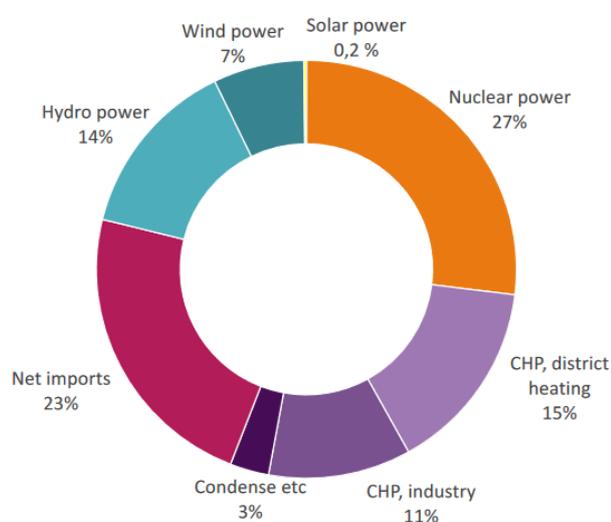


Figure 1. Electricity generation and imports in Finland in 2019 (consumption 86 TWh).

Figure 2 shows estimated available generation capacity for winter 2019-2020 based on Energy Authority's estimate². Energy Authority estimated the available generation capacity in the markets to be 11 200 MW during peak demand and peak consumption to be 15 300 MW, leaving 4100 MW to be covered with imports. Total import capacity is ca. 5100 MW of which 1500 MW comes from a third country (Russia) meaning that under normal conditions the import capacity available within the internal energy market during peak hour is 3700 MW. This already mean that if no power were available from a third country, Finland would face a power deficit without a strategic reserve. In addition to the generation capacity in the markets, there is a strategic reserve of 729 MW, thus leaving deficit of 3370 MW domestically. From July 2020 onwards the strategic reserve is 611 MW leaving domestic deficit of 3 490 MW.

¹ Announcement of TVO of the latest postponement of commission date to February 2022: <https://www.tvo.fi/en/index/news/pressreleasesstockexchangereleases/2020/ol3epregularproductionofelectricitystartsinfbruary2022.html>

² Electricity security of supply in 2019, report by Energy Authority 28.11.2019. Available in Finnish. <https://energiavirasto.fi/documents/11120570/12722768/Raportti-s%C3%A4hk%C3%B6n-toimitusvarmuus-2019.pdf/9d7138aa-8893-97e3-338d-a3559edb0c9c/Raportti-s%C3%A4hk%C3%B6n-toimitusvarmuus-2019.pdf>

Figure 2 also illustrates the importance of the CHP to the resource adequacy and the fact that there is hardly any condensing power plants left in the electricity system. It should also be noted that there are no fast reacting gas turbines left in the wholesale market either and the last remaining condensing power plants run with solid fuels meaning slow ramp up times.

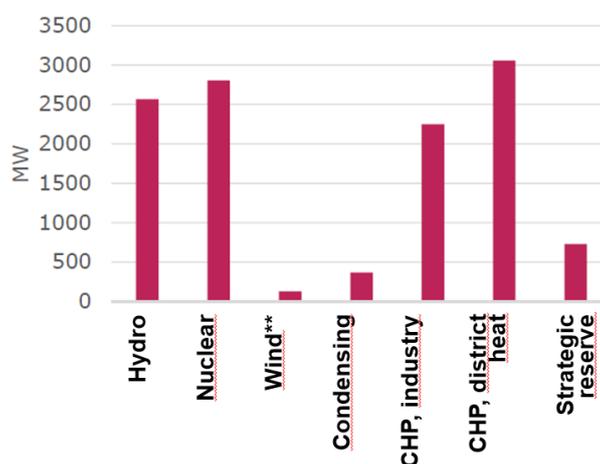


Figure 2. Available generation capacity winter season 2019-2020. Estimated peak demand 15 300 MW. ** Wind power availability 6%. Source: Energy Authority

Since the consultation period of this report Energy Authority has published new report on the resource adequacy in winter 2020-2021³. The situation is very similar to winter 2019-2020: the peak consumption is estimated to be 15 100 MW while available domestic generation capacity is estimated to be 10 800. This leaves 3 670 MW to be covered from the markets, including trade with third countries.

Even though Finland has strong interconnections to the neighbouring countries (total 5 100 MW compared to peak load of 15 300 MW), most of the interconnector capacity (3 600 MW) is based on direct current (DC) technology. In this respect, Finland resembles an island. Alternating current (AC) connections to Sweden connects Finland to the Nordic synchronous system and are crucial for the operation of the Finnish electricity system. Where DC interconnections can transmit energy, AC interconnections provide instantaneous system services which are needed in synchronous operation. Finland and Sweden have agreed to expand the AC connection with new 800 MW overhead line by 2025⁴.

It is important to highlight that 1 500 MW of the import capacity comes from third countries, namely Russia. The commercial transmission capacity from Russia to Finland is 1300 MW and 320 MW from Finland to Russia. There are two modes of power trade between Russia and Finland: bilateral trade and so called direct trade. Fingrid and the Russian parties confirm the bilateral trade volumes for the next commercial day (D) on the morning of the previous day (D-1). The confirmed trade vol-

³ Electricity security of supply in 2020, report by Energy Authority 3.12.2020. Available in Finnish. <https://energiavirasto.fi/documents/11120570/13026619/S%C3%A4hk%C3%B6n-toimitusvarmuus+vuonna+2020.pdf/74cfa703-eca8-2ab9-9094-50e5a3d04e30/S%C3%A4hk%C3%B6n-toimitusvarmuus+vuonna+2020.pdf?t=1606993678420>

⁴ A third 400 kV AC interconnection to Sweden. Fingrid in English <https://www.fingrid.fi/en/grid/construction/cross-border-connections/third-interconnection-finland--sweden/>

umes have to be bid into the day-ahead and intraday markets of the Nordic Power Exchange. The volumes of the direct trade are determined by the given bids on the day-ahead market and intraday market of the Nordic Power Exchange and the corresponding Russian power markets. More information on trade on the FI-RU interconnector can be found on Fingrid's web page⁵. Finland has no intention to increase dependency on third countries regarding security of supply of electricity.

Because of high share of electrical heating, peak load hours coincides with cold spells. In the wintertime, it is common that outside temperature goes down to -40 °C. This causes immediate threat to human health and structural damage to buildings and piping if there are interruptions in the electricity supply. It is unacceptable to any society that no measures would be taken to mitigate risks this magnitude. Politicians need assurance that there is a sufficient safety net if markets fail to deliver the needed security of supply. Finland relies on the market mechanism to provide security of supply and has taken the least intrusive approach when introducing the Peak Load Reserve originally in 2007.

Description of day-ahead and intraday price formation

In Finland there are no formal or informal price limits in day ahead and intraday markets other than the technical limits currently applied within European single day-ahead and intraday coupling as set out in Article 41(1) and 54(1) of Regulation 2015/1222 (CACM). There are also no formal or informal rules or requirements that limit generators' ability to freely price their offers in the wholesale markets, other than set in the requirements in Regulation 1227/2011 (REMIT), 2017/2196 (ER) and in case of a national emergency based on national Emergency Powers Act 2011/1552. There are also no rules or provisions that would require the TSO to release generation reserves based on market prices.

The purpose of Emergency Powers Act 2011/1552 is to give authorities certain extra powers in case of national emergencies. There are five categories for national emergencies: 1) an armed conflict or recovery from an armed conflict, 2) a serious threat of armed conflict where additional powers are needed for authorities, 3) serious event or threat of such event that can impair critical functions of the society, 4) especially severe disaster or recovery from such and 5) pandemic. First, the government has to declare the state of emergency based on the above categorisation, and only after that extra powers can be granted to authorities. Each extra powers have to be granted individually and only for a limited period.

Energy-related extra powers are defined in 36§ -43§ and can be only given during emergencies in categories 1 to 3. These powers relate to rationing of heat, fuels and electricity for the customers and how much the price of these commodities can be increased.

The legislation has been in place since 1991 and before that in sectoral legislation. During this time national emergency has only been declared once, during Covid-19 in March 2020. The state of emergency was declared based on category 3 and 5. The extra powers given were given

⁵ Cross-border Connections between Russia and Finland. Fingrid in English
<https://www.fingrid.fi/en/electricity-market/rajajohto-informaatio/400-kv-cross-border-connections-between-russia-and-finland/>

based on category 5 and related to securing the functioning of the healthcare sector by e.g. exempting healthcare sector from certain provisions on employment legislation (overtime, vacations, requirement to work etc) and care of non-critical patients. The government declared in 15.6.2020 that the current situation in the country no longer constituted a state of emergency and gave degrees to repeal the use of powers⁶.

The basis for the Emergency Powers Act from EU law point of view is national security. In accordance to Article 4 of the Treaty of the European Union (SEU) it belongs to the exclusive legal competence of the Member State. The Treaty of the Function of the European Union (TFEU) is also taken into account in the design and the Finnish legislation respects the principles set for national restrictions in the EU legislation (TEUF Articles 36, 45(3), 62 and 65(1)b) and jurisprudence of the European Court of Justice for mandatory requirements. These derogations are applicable under normal circumstances for restrictions on internal market principles.

Article 36 TFEU allows restriction on free movement of goods justified on grounds of e.g. public policy or public security or the protection of industrial and commercial property. Such prohibitions or restrictions shall not, however, constitute a means of arbitrary discrimination or a disguised restriction on trade between Member States. According to the ECT jurisprudence, the restrictions have to be non-economic. The Emergency Powers Act also respects this principle.

Regulation 2019/941 on risk-preparedness in the electricity sector is based on Article 194(2) TFEU giving the EU legislation the possibility to adopt measures to ensure security of energy supply in the Union. The provision is based on the Treaty of the Function of the European Union and is applied according to the internal market principles. The Finnish Emergency Powers Act rules for electricity on the other hand are applicable only when the conditions of Article 4 SEU i.e. threat to nation security occurs. It is primarily for the Member State to decide when the conditions are met. As the requirement is not easily fulfilled it can be considered that Risk-Preparedness regulation is the measure to safeguard security of supply in the EU and the national legislation is put in place to safeguard national security.

Current capacity mechanism scheme (power reserve)

Finland employs a strategic reserve, the peak load reserve. The mechanism is based on Peak Load Reserve Act 117/2011. The peak load reserve capacity is used to ensure that the balance between supply and demand can be achieved if the day-ahead market or balancing market fails to reach a balance during winter period. However, the peak load reserve capacity is not allowed to participate and bid on the commercial market and it is activated only after the market does not reach balance.

During the winter period, from December to end of February, power plants participating in the peak load reserve system are in 12 hours' readiness to start electricity production. Rest of the time, power plants are in one-month readiness. When in production, power plants selected to the peak load reserve are required to be able to increase power out-

⁶ https://vnk.fi/-/valmiuslain-mukaisten-toimivaltuuksien-kaytosta-luovutaan-poikkeusolot-paattivat-tiistaina-16-kesakuuta?languageId=en_US

put with 10 MW within 10 minutes after request and be ready for 200 hours continuous power production with full capacity during the winter period. Demand side response (DSR) facilities are included in the peak load reserve during winter period from December to February. During this period, DSR facilities shall be able to decrease load with 10 MW within 10 minutes after request.

The Energy Authority is responsible for evaluating and deciding the required size of the peak load reserves and arranging the tendering process to procure the peak load capacity. Evaluation of the need for capacity is based on probabilistic methodologies (both Monte Carlo simulation and COPT-methodology) with which LOLE and ENS are estimated. For example ENTSO-E uses Monte Carlo simulations in their methodologies. The actual amount of capacity procured is based on the established need and the amount and price of the actual capacity tenders.

During the period (from 1st of July 2017 until 30th of June 2020) the peak-load reserve capacity consisted of four power plants (707 MW) and two demand-side response (DSR) facilities (22 MW). For the current period from 1st of July 2020 until 30th June 2022 the reserve capacity consists of three power plants (total 611 MW). DSR facilities were not competitive in this tendering round.

Fingrid is responsible for making agreements with the selected power plants and DSR facilities and pays the compensations to the power plants which are financed by the fees collected from the Finnish electricity end-users. Energy Authority approves the operational agreements. The holders of the selected reserve capacity will receive fixed compensation for providing the reserve capacity. If the reserve capacity needs to be activated, only actual costs of the activation are remunerated to the capacity holders.

The activation of the power plants will happen at the maximum price of the day-ahead market, at present EUR 3,000 per MWh. DSR facilities will be activated from the balancing market platform at the price of EUR 3,000 per MWh (or at actual costs provided by capacity holder in tendering process if it is higher than EUR 3,000 per MWh).

The Finnish and Swedish TSOs have agreed to coordinate the activation of their peak load reserve resources. The TSOs will activate strategic reserve resources in relation to the total reserve capacity in the countries, if the situation in the electricity system allows this. In the current scheme, activation is done in the day-ahead timeframe if supply and demand do not match. If the mismatch occurs only in one country, this would mean in normal conditions that the import capacity would be in full use and the reserve would have to be activated in the country of deficit. If there are simultaneous deficits, if there are other constraints in the electricity system (e.g. faults which limit internal transmission capacity) or the deficit occurs after the day-ahead market and there is transmission capacity available the reserve could be activated also in another country.

Finland is currently revising the strategic reserve legislation to be in line with the requirements in Regulation 943/2019.

Balancing markets

The Nordic countries established a common regulation power market in 2002 to handle balancing needs. Within the market, imbalances are handled and settled according to common rules defined in the System Operation Agreement between the Nordic TSOs. Balancing is managed within the Nordic control areas as one system consisting of all four Nordic TSOs. The balance management is based on frequency requirements and agreed in the System Operation Agreement. Even though the balancing model is shared within the Nordics, there are some national differences in details.

Figure 4 presents the balance management in the Nordic electricity market model. Besides actions of a specific operating hour in the regulation power market, Elbas-market can be used for intra-day trading and revisions of nominations after the day-ahead market (Elspot) has closed.

| Physical market Power transactions | | Specific operating hour | Balance settlement |
|---------------------------------------|--------------|------------------------------------|----------------------------------|
| ELSPOT | ELBAS | Regulation power market | Balance energy |
| 12 - 36 h | 1 - 32 h | Balance management | max 3 months |
| Bilateral transactions | | | Power balances of the parties |

Fixed transactions must be agreed and reported before the specific operating hour

Figure 3. Balance management in the Nordic electricity market model (Source: Fingrid Oyj).

In the Nordic regulation power market, all bids are collected into the joint Nordic merit order list and in the order of the list the production increases and decreases are carried out where firstly, it is most advantageous and secondly in the price order of the bids, however, taking into account congestions between control areas. This leads to effective utilisation of the Nordic balancing resources.

The balance between production and consumption within a specific operating hour is created through the regulation market by the upward and downward regulation of production and consumption to handle physical imbalances taking into account the effects on congestions.

The price of the regulation power during the specified operating hour (the imbalance settlement period in Finland is 60 minutes) is determined based on ordered up- or down-regulations. This implies that the price of the regulating power is known only after the end of the specific operating hour. It has been agreed, that the price of up-regulation is the most expensive up-regulation bid ordered by the TSO during the specific operating hour. All those who have participated in the up-regulation during the specific operating hour receive the same compensation per MWh. Respectively the price of down-regulation is the cheapest down-regulation bid ordered by the TSO during the specific operating hour. All those who have participated in the down-regulation during the specific operating hour receive the same compensation per MWh.

The TSO provides information on forecasts and values for the reserves before, during and after the operating hour and also regulation prices after the operating hour. Most of this information is given only to the market participants and to Nord Pool. Publicly available information can be found on Fingrid's website www.fingrid.fi and Nord Pool's website www.nordpoolgroup.com.

The Finnish, Norwegian and Swedish TSOs decided in 2012 to implement a harmonised Nordic Balance Settlement model on the TSO level. The implementation includes harmonisation and integration of the national grid and bidding area level balance settlement. A common operational unit, eSett Oy responsible for imbalance settlement and invoicing of the Balance Responsible Parties in Finland, Sweden and Norway. It is jointly owned by the Finnish, Norwegian and Swedish TSOs while the Danish TSO is joining soon⁷. The project's goals have been firstly to provide similar operating conditions to all balance responsible parties despite the area and country, secondly to offer balance settlement in similar principles to all market participants through one unit and thirdly to create common rules and standards for data exchange in cooperation with other actors in the electricity market. The go-live for the common Nordic Balance Settlement was on May 1, 2017.

European Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing requires that by 18 December 2020 all TSOs shall apply the imbalance settlement period of 15 minutes in all scheduling areas while ensuring that all boundaries of market time unit shall coincide with boundaries of the imbalance settlement period. The regulation allows that the national regulatory authority may, at the request of the TSO or at its own initiative, grant the relevant TSOs a derogation from this obligation until 1 January 2025. In October 2018, the Energy Authority published after an analysis and a consultation with neighbouring Estonian and Nordic NRAs a statement in which the Energy Authority did not find reasons for such derogation in Finland. In December 2018, all Nordic NRAs published a similar joint statement. However, in March 2019 the Nordic TSOs announced that TSOs have identified a risk of delay in the implementation of the 15 min imbalance settlement period in the Nordics . In May 2020 the TSOs announced that they will jointly apply for a derogation until 22 May 2023. The TSOs sent requests for derogation to NRAs in June⁸ and the Nordic NRAs are now evaluating the request.

In March 2018, all Nordic TSOs signed a Cooperation Agreement on an initiative of the Nordic Balancing Model (NBM) to update and adapt the balancing market design, develop methods and operational processes as well as related IT systems in order to ensure an efficient and secure balancing scheme compliant with the European network codes. The NBM initiative will be based on the introduction of modernized Area Control Error (mACE) in the Nordic LFC Block where instantaneous power imbalance will be set to zero for each sub region (bidding zone) separately instead of present system where imbalance will be set for whole Nordic synchronous area. The figure below describes the roadmap for these changes. According to the TSOs' plans, the 1st generation of NBM will contain:

⁷ E-Sett: Denmark Go-Live commissioning plan, <https://www.esett.com/denmark-go-live/>

⁸ Nordic TSOs: 15 minutes balancing period from 22 May 2023
<http://nordicbalancingmodel.net/nordic-tsos-15-minutes-balancing-period-from-22-may-2023/>

- Nordic aFRR capacity market
- Nordic mFRR capacity market
- Single price model
- 15 minutes time resolution
- mFRR balancing process automation (including changes to the mFRR energy activation market)
- Data & transparency

The 2nd generation of NBM will contain:

- European mFRR Standard product
- aFRR energy activation market with European standard product
- Full mACE model implementation

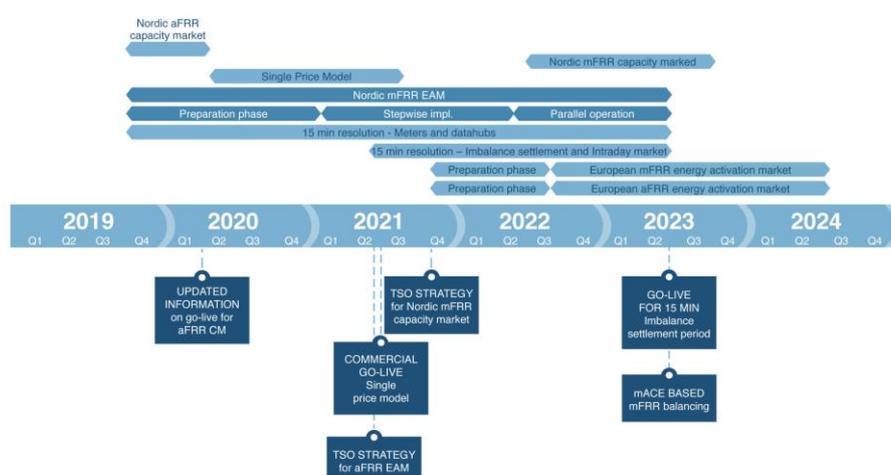


Figure 4. Nordic Balance Settlement roadmap⁹

Imbalance settlement

Finland has had for long a balancing responsibility for all market participants. Act 588/2013 and degree 66/2009 set up the legal basis for imbalance settlement in Finland. Finland is also the first country in Europe to have carried out a full roll-out of smart meters to all customers included household customers (currently 99,8 % coverage of customers, 100 % measured in energy) and mandated the use of hourly data for settlement purposes.

Imbalance settlement rules are developed by the TSO and approved by the NRA. These rules can be found on Fingrid's web page¹⁰ and summarised below.

The rules are the same for all parties, but in the Nordic countries there is currently a separate balance for production and consumption. For production, a two-price system is used and for consumption a one-price system.

In the two-price system, separate prices are calculated for the purchase and sales of imbalance power.

⁹ <http://nordicbalancingmodel.net/nbm-building-blocks/>

¹⁰ Fingrid, balancing services: <https://www.fingrid.fi/en/electricity-market/balance-service/>

Sales price of imbalance power: The price of imbalance power in the production balance sold by Fingrid to the balance responsible party is the up-regulating price of the hour. If no up-regulation has been carried out or if the hour has been defined as a down-regulating hour, the Finnish day ahead price is used as the sales price of imbalance power in the production balance.

Purchase price of imbalance power: The price of imbalance power in the production balance purchased by Fingrid from the balance responsible party is the down-regulating price of the hour. If no down-regulation has been carried out or if the hour has been defined as an up-regulating hour, the Finnish day ahead price is used as the purchase price of imbalance power in the production balance.

In the one-price system, the purchase and sales prices of imbalance power are identical.

During an up-regulating hour, the price of imbalance power is the up-regulating price, and during a down-regulating hour, the price of imbalance power is the down-regulating price. If no regulations have been carried out during an hour, the price of imbalance power is the Finnish day ahead price.

In addition to the imbalance energy costs, there are weekly and volumetric fees for balancing services. The transmission system operator's reserve costs account for the highest cost item in the balance service. There, reserves refer to those reserves which the TSO needs to maintain frequency and system security of the nation-wide transmission grid.

The costs of the various types of reserves are allocated, using the matching principle, both to balance service and to other TSO services – primarily grid service – so that the costs of frequency-controlled normal operation reserve belong to the balance service, and the disturbance reserves (frequency-controlled disturbance reserve and fast disturbance reserve) belong both to the balance service and other services. The principle of dividing the costs of disturbance reserves is the same for both reserves.

The Nordic TSOs launched Fast Frequency Reserve in May 2020 to control inertia in the electricity system. In order for the TSOs to launch the reserves as soon as possible the markets are national. The goal for the TSOs is to later work towards a common Nordic FFR market.¹¹ The costs of Fast Frequency Reserve is collected from the grid service fees.

¹¹ENTSO-E: Fast Frequency Reserve–Solution to the Nordic inertia challenge, 13.12.2019
<https://www.fingrid.fi/globalassets/dokumentit/fi/sahkomarkkinat/reservit/fast-frequency-reserve-solution-to-the-nordic-inertia-challenge.pdf>

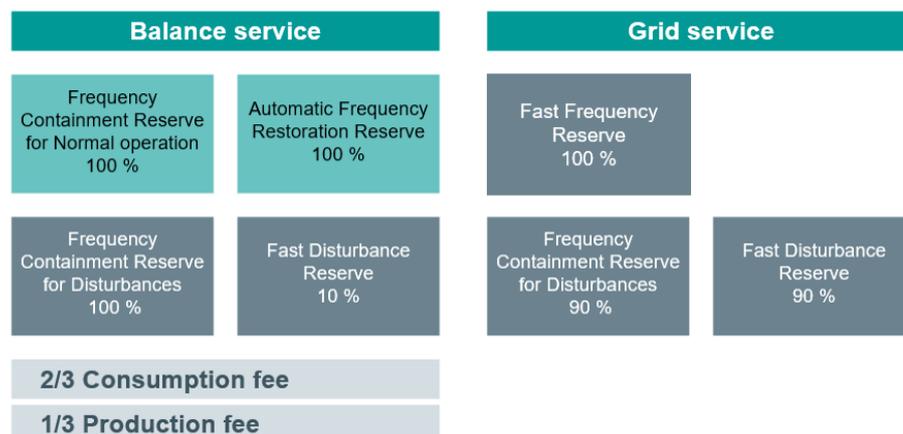


Figure 5. The division of costs between balance service and grid service.

In situations where a TSO has to disconnect consumers involuntarily the imbalance settlement price is determined by the same rules as described above. However, the TSO has to first use all market-based measures before disconnecting consumers which gives an indication that the price will be high.

Scarcity pricing in balancing

Nordic balancing market has highly integrated balancing model and common market due the long history of close co-operation and voluntary harmonisation, which goes beyond the current legal requirements. Nordic TSOs are in a process of establishment of the new Nordic balancing model (NBM) reflecting the requirements set in European legislation, which includes transition to the ACE-based balancing in 2024 and the application of the imbalance settlement period (ISP) of 15 minutes in 2023 and common Nordic aFRR capacity markets in 2022.

Figure 6 below illustrates the changes and steps of the Nordic TSOs in preparation to the target model for imbalance settlement in the Nordics. First change is the introduction of the Single Price and Single Position in 11/2021, to fulfil requirements of ISH due to ACER decision in 2020 to have a common Nordic model. In order to minimize changes to the market participants, imbalance pricing and settlement will be kept as today for a limited interim period. Next step in the implementation timeline is to introduce Nordic aFRR capacity market and Automated Nordic mFFR energy market. In 2023 the Nordics will move to the 15 Minutes Imbalance Settlement Period, where imbalance pricing needs to be changed to take into account the new time resolution and new balancing products. These changes facilitate the implementation of ACE based model and introduction of European MARI and Picasso platforms.

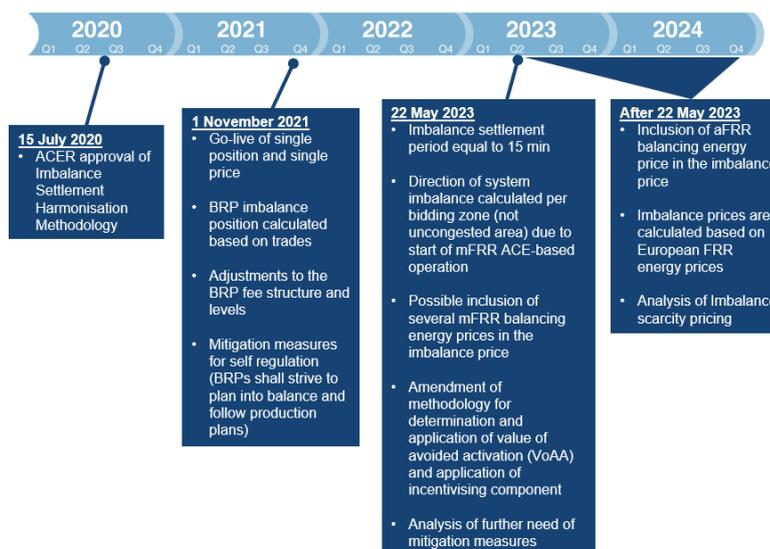


Figure 6. Overview of up-coming changes in the Nordic level until 2024 to imbalance settlement (non-exhaustive)

Nordic TSOs are in progress to detail the changes seen for the 15-Min ISP and ACE-based balancing model and introduction of shortage price. We believe that a common Nordic solution for shortage pricing should be implemented, as common market rules creates better environment for the market participants to operate in all Nordic countries. To identify possibility to implement solution solely in Finland, in case needed, Fingrid will start during 2021 with internal analysis of shortage pricing and follow-up with stakeholder consultation. Thereafter Fingrid continues the work in year 2022 together with Svenska Kraftnät with the aim of having aligned implementation plan and timetable to reflect also the possibility to continue the current strategic reserves co-operation between Finland and Sweden.

Value of lost load

At the moment there is no single official estimate for the value of lost load (VoLL) in Finland. This is of course natural as the value depends on the customers' preferences. There are several studies that estimates VoLL. In their latest assessment for the need of peak load reserve¹², Energy Authority used values between 3 000 €/MWh to 20 000 €/MWh for VoLL to estimate the optimal size of the reserve. In an earlier study¹³ for the need for peak load reserves for 2015-2020 VoLL of 6 000 €/MWh was used for household consumers and 28 000 €/MWh for industrial consumers.

One of the most recent publicly available surveys on VoLL is a master's thesis done for Energy Authority¹⁴. The survey estimates VoLL (willing-

¹²Study on the need for peak load reserves 2020-2022, Energy Authority, 1.7.2019. In Finnish. <https://energiavirasto.fi/documents/11120570/12722768/Selvitys-tehoreservin-tarpeesta-2020-2022/ae334c0e-2c57-4f02-a26d-7beaad74dbb5/Selvitys-tehoreservin-tarpeesta-2020-2022.pdf>

¹³Kiviluoma et al. Study on the need for peak load reserves 2015-2020. VTT, 2014. In Finnish <https://www.vttresearch.com/sites/default/files/julkaisut/muut/2014/VTT-R-06032-14.pdf>

¹⁴ Henri Hämäläinen: The value of supply security for electricity consumers in Finland, Master's thesis, Lappeenranta University of Technology, 2018. In English https://lutpub.lut.fi/bitstream/handle/10024/152907/Master%27s%20Thesis_H%c3%a4m%c3%a4l%c3%a4inen_Henri.pdf?sequence=1&isAllowed=y

ness to pay and willingness to accept) for household consumers to be in the range of 3 900-19 300 €/MWh.

Procurement of ancillary services

Fingrid procures different kinds of reserves from reserve markets. Reserves are power plants and consumption resources which either increase or decrease their electric power according to the need of the power system. This chapter gives an overview on the procurement of different reserves. Detailed information on ancillary services (e.g. contracts and rules for each market place) can be found on Fingrid's web page¹⁵.

In the joint Nordic system (Finland, Sweden, Norway and East Denmark), the obligations for maintaining reserves have been agreed in the System Operation Agreement between the Nordic Transmission System Operators (TSOs).

Total of 600 MW of Frequency Containment Reserve for Normal operation (FCR-N) is constantly maintained for the frequency regulation of the normal state. Frequency Containment Reserve for Disturbances (FCR-D) is maintained to the extent that the power system can withstand, for example, disconnection of a large production unit without the steady state frequency deviation exceeding 0.5 Hz. Reserve maintained in the whole system is set weekly to correspond to the greatest individual fault in the system. In a normal situation, a total of 1,450 MW of Frequency Containment Reserve for Disturbances is maintained in the joint Nordic system. The jointly maintained FCR-N and FCR-D are divided annually between the Nordic TSOs in relation to the total annual consumption and production in each country.

It has been agreed that 300–400 MW of Automatic Frequency Restoration Reserve (aFRR) is maintained in predefined morning, evening and night hours in the Nordic countries in 2020. The predefined procurement hours are announced on Fingrid's website.

Furthermore, each TSO maintains Manual Frequency Restoration Reserve (mFRR) to cover the dimensioning fault in its own area.

The TSO of each country procures its share of reserves as it considers best. In order to meet reserve obligations, trade can be done between countries. Part of reserves must be maintained nationally, so that the frequency can also be maintained in situations of island operation. In normal situation, a maximum of 1/3 of the obligations for frequency containment reserves can be purchased from other Nordic countries.

Fingrid's reserve obligations and procurement sources in 2020:

¹⁵ Reserves and balancing power, Fingrid web page https://www.fingrid.fi/en/electricity-market/reserves_and_balancing/#reserve-products

| Reserve product | Obligation | Procurement channel | Maximum contracted capacity |
|--|---|---|-----------------------------|
| Frequency Containment Reserve for Normal Operation (FCR-N) | 120 MW | Yearly market | 87 MW |
| | | Hourly market | 140 MW |
| | | Other Nordic countries | - |
| | | Vyborg DC link | 90 MW |
| | | Estonia, Estlink 1 & 2 | 35 MW |
| Frequency Containment Reserve for Disturbances | about 290 MW | Yearly market | 458 MW |
| | | Hourly market | 635 MW |
| | | Other Nordic countries | - |
| Automatic Frequency Restoration Reserve (aFRR) | 60–80 MW (certain morning and evening hours only) | Hourly market | - |
| | | Sweden | - |
| Manual Frequency Restoration Reserve (mFRR) | 880–1100 MW | Balancing energy and balancing capacity markets | - |
| | | Fingrid's reserve power plants | 953 MW |
| | | Leasing reserve power plants | 301 MW |

Demand response

Demand response is well developed in Finland. Finland has been at the forefront of promoting real-time price signals for all consumers. Industrial users have been active in the markets since the opening of the markets in the 1990's and it is common for industrial users to optimise their supply portfolio based on day-ahead market prices. Larger household consumers (mostly electrical heating) have had for long time-of-use tariffs for distribution which has effectively moved consumption to the night time. However, based on Smart Grid Working Group conclusions, Finland is moving towards market based load control schemes for these customers as well.

As required by national degree 66/2009, smart electricity meters with hourly measurement resolution were effectively installed to all customers already in 2013. All the customers are also settled based on hourly measurements. All customers have the possibility to choose an electricity contract with dynamic pricing based on the day-ahead market prices. Almost all suppliers provide also dynamic contracts to their customers. At the end of 2018, approximately 9% of the retail customers had a dynamic electricity price contract. There are also service providers, both aggregators and independent aggregators, who give small customers the possibility to participate to balancing markets. To our knowledge, Finland has been the first country in Europe where this has been possible for household consumers. As the voluntary roll-out of first generation smart meters started already in early 2000's, Finland is now considering the functional requirements for next generation smart meters. The draft

degree has been in public consultation in May¹⁶ and the new degree will be passed during 2021. Bulk of the current smart meters will come to the end of their lifetime in 2025-2030.

All the customers in each network face the same tariffs. There are no exemptions for different customers for network tariffs but national degree 65/2009 requires that tariffs for feeding electricity to network from a generation unit connected to distribution networks cannot exceed 0,07 cent/kWh.

In October 2018, Smart Grid Working Group set up by the Ministry of Economic Affairs and Employment proposed an extensive operational programme to increase the demand-side response of electricity and the opportunities for customers to participate. The working group's key proposals were:

- Clarifying the roles of actors in the market-based implementation of demand-side response (e.g. principles for the storage of electricity, discontinuation of the load control implemented by distribution networks)
- Improving the operating prerequisites for different energy communities and aggregation models
- Defining the functionalities of next-generation smart meters
- Enabling flexibility in the operation of grid companies
- Enabling joint invoicing for all suppliers

The Ministry of Economic Affairs and Employment is currently implementing these proposals in parallel with the Clean Energy Package implementation. Implementation is well under way in Finland. Many elements of the flexibility requirements, such as fully deregulated retail markets, balancing responsibility, customers' ability to choose dynamic tariffs, 100% roll-out of smart meters, etc., already exist in the Finnish electricity market legislation.

Summary

Finland is an integral part of the Nordic electricity system and well-functioning wholesale markets. Finland relies on its security of supply of electricity on the internal market for electricity as around 25% of the peak consumption has to be covered with imports from neighbouring EU countries as well as from Russia. Market structures are developing in line with the EU legislation. In addition the Nordic TSOs and Fingrid nationally are launching initiatives to further enhance the functioning of the system. Finland is a forerunner in smart grid development and demand response and has installed smart meters for all customers first in Europe. However, due to the coldest climate in Europe, dependency on a third country on security of supply and uncertainty of large individual production development project Finland considers a strategic reserve to capture and alleviate the residual risk of mid-term supply inadequacy in a cost-efficient manner and with minimal interference to the markets.

¹⁶ Draft degree on functionalities for measuring instruments and data systems handling measurement data in electrical networks. In Finnish <https://www.lausuntopalvelu.fi/FI/Proposal/Participation?proposalId=cff91c75-78de-4926-861f-38d1358f039c>

Summary of the measures and expected date:

- Implementation of Electricity Market Directive, 2020
- Nordic aFRR capacity market, 2020
- Single price model for imbalance settlement, 2021
- Analysis and consultation on national solutions for scarcity pricing in balancing in Finland by Fingrid, 2021
- Renewal of power reserve legislation in line with Electricity Market regulation, 2021
- Implementation of Smart Grid Working Group's recommendations, 2021
- Analysis of alignment of implementation plans on scarcity pricing between Finland and Sweden by Fingrid, 2022
- Introduction of 15 minutes imbalance settlement period, 2023
- Nordic mFRR capacity market, 2024
- Third AC interconnector between Finland and Sweden, 2025