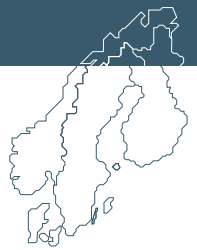
SOLUTIONS REPORT 2020

ENERGINET FINGRID Statnett SVENSKA KRAFTNÄT



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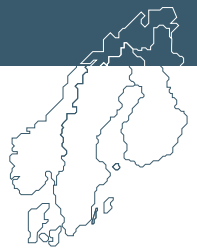


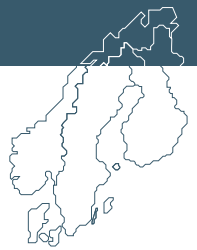
EXECUTIVE SUMMARY

The energy system is undergoing a substantial and rapid transformation on a historical scale. These changes are driven by new policies and political goals, but also by changes in the requirements of markets and market participants due to technological advances and low prices for renewable resources. The expected changes in the Nordic power system identified in the 2016 report "Challenges and opportunities for the Nordic Power System" and further described in the report "The way forward – Solutions for a changing Nordic power system" from 2018 have progressed at a much faster pace than predicted. The goal is still to create a cost-effective, secure and green power system, and the solutions necessary to reach that goal remain consistent with previous assessments.

The identified challenges are as relevant today as they were four years ago. Since then, the Nordic TSOs and their stakeholders have worked hard to implement the identified solutions through cooperation, digitalisation and innovation. The establishment of a Nordic Regional Security Coordinator (RSC) office in Copenhagen and development of a new flow-based capacity calculation method are examples of these efforts.

Rapid changes require innovative and agile ways of working. As work progresses, new challenges, dependencies and requirements arise, that require reprioritising of tasks. The Nordic Balancing Model (NBM) project is a good example of how to move forward in this very uncertain environment. The NBM project went through an extensive stakeholder process and identified numerous dependencies that need to be resolved prior to completion of the project. As a result, the NBM project revisited the project plans and published a revised roadmap in November 2019.

The Nordic TSOs ensure a well-functioning wholesale market for the changing power system. Developing a flow-based capacity calculation method, studying the capacity



EXECUTIVE SUMMARY

calculations of bidding zone configurations and gradually taking new Nordic RSC services into operation will all contribute to high market capacity and secure operations.

Fluctuating generation and changes to interconnector flows cause imbalances in the power system. The Nordic TSOs are working to increase available flexibility in the electricity markets to mitigate this, running several projects in cooperation with DSOs, aggregators and other market participants in order to acquire knowledge and find new solutions.

As the characteristics of the Nordic power system change, balancing supply and demand becomes increasingly more challenging. The Nordic Balancing Model provides new balancing tools, such as higher time resolution in balancing markets and new reserves markets. This will allow for high integration of renewables and make it possible to exchange reserves on the European market platforms under development. Harmonisation of Frequency Containment Reserves (FCR) markets for balancing and the development of a new market for Fast Frequency Reserves (FFR) for low inertia situations will also facilitate the integration of an increased share of fluctuating power generation.

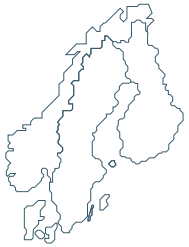
In order to ensure an adequate transmission grid that will meet the needs of future energy system generators and consumers, Nordic TSOs continue to improve transmission system planning methods in order to identify future transmission needs at the Nordic level. The four Nordic TSOs will realise investments of approximately 15 billion euros in 2016-2028, based on the expected need for asset replacements, network reinforcements due to load growth and the connection of renewable resources with increasing demand due to electrification.

An increasing challenge for the Nordic power system is the ability to meet the peak load. The Nordic power balance is gradually becoming weaker. For the winter 2019/20 the Nordic TSOs assessed a total Nordic import need of 4,900 MW to cover a 10-year winter peak, which could be compared with an import need of 3,000 MW in the year before. Norway being the only country with an estimated surplus in the peak hour. While there are significant transmission capacity that could be used for import to the Nordics, this is also dependent on the availability of resources in the exporting countries.

In February 2020, the Nordic TSOs published a document exploring market-based solutions for the future short-term markets beyond the year 2025 presenting priorities reflecting the changes to be considered in the allocation model, transmission management, market timeframes and market platforms.

The stakeholders of the Nordic TSOs are active contributors to working out solutions for the new energy system. It is essential that the Nordic TSOs and their stakeholders continue to work together to create innovative and robust solutions for the future. To foster this cooperation, the Nordic TSOs have designed several processes that ensure increased stakeholder communication.

1 INTRODUCTION



The Nordic power system is currently undergoing the most substantial changes since the liberalisation of our power markets more than 20 years ago. The changes are driven by climate policy and more cost-effective solutions, and it results in a changing electricity generation mix with less predictable generation and an increase in small-scale, fluctuating and distributed resources. In addition, demand patterns are changing due to electrification, urbanisation and new industrial sectors. To address the challenges caused by this transition, the Nordic TSOs initiated a 'Challenge and Solution' process in 2016.

1.1 The Challenge and Solution process

In 2016, the Nordic TSOs published the report "Challenges and opportunities for the Nordic Power System", which identified challenges within five areas: system flexibility, transmission and generation adequacy, frequency quality and inertia. In 2018, the report "The way forward - Solutions report" was published by the Nordic TSOs, and this describes key solutions to meeting the challenges in the Nordic power system in the period until 2025. As described in the report on the way forward, Nordic TSOs are working together on four types of solutions: market development, balancing the power system, grid planning and ICT solutions. Furthermore, the report stated that it will be updated every two years and that stakeholder events will be arranged to discuss the progress. This updated Solutions Report provides updated assessments of the challenges and updates on the identified solutions being implemented.

1.1 Continued progress

Since the last Solutions report published in 2018, the Nordic TSOs and their stakeholders have successfully made headway with several important solutions identified in the previous report. While the TSOs and stakeholders have met some unforeseen challenges in the implementation of certain measures, work progress and updated completion plans have been detailed. There are several examples of significant progress in the implementation of identified solutions. The Nordic Regional Security Coordinator (RSC) office has been established and already provides early releases of several core services identified in the previous report. Work related to the Nordic Balancing Model (NBM), which will renew the Nordic balancing process, continues. Working closely with members of the stakeholder reference group, the Nordic TSOs have drafted a roadmap that reflects on the complexity of shifting from one-hour imbalance settlements to 15-minute imbalance settlements, implementing a single price settlement model and establishing several other balancing tools for the future. Seeking dialogue with all stakeholders on viable market-based solutions for future short-term markets, the Nordic TSOs published a discussion paper in February 2020 which presents objectives and priorities to be explored for short-term markets beyond 2025.

The Nordic TSOs and their stakeholders have also intensified efforts on coping with low inertia situations since the system has changed more rapidly than predicted. It has been determined that the most cost-effective way to handle low inertia situations is to establish an additional reserve type, Fast Frequency Reserve (FFR). The Nordic TSOs now publish real-time inertia values for the Nordic power system to allow market participants to evaluate the need and future market for FFR. Finally, the Nordic Grid Development plan 2019 was published in August 2019. This describes the main drivers of the changing Nordic power system and includes preliminary analyses of five transmission corridors.

1.2 Report organisation

This report provides updates on the solutions identified in the 2018 report. The previous report was organised by the four types of solutions: market development, balancing the

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INTRODUCTION

power system, grid planning and ICT solutions. In general, the present report organises identified solutions by the markets they serve. The report starts by examining the solutions that were identified for the wholesale market in chapter 2. The chapter describes how the Nordic TSOs work to utilise the power system as efficiently as possible, for example using capacity calculation and market coupling. Next, solutions needed in the retail market to unleash distributed flexibility are considered in chapter 3, among others. Chapter 4 provides insight into future ancillary services, where the new Nordic Balancing Model represents an important tool. In chapter 5, we explain how systematic network planning underpins our efforts to ensure that we have a grid that can handle the future requirements of the energy system. Finally, the report describes how digitalisation affects all sectors and the development of solutions in chapter 6, while chapter 7 details stakeholder involvement in all aspects of solution development.

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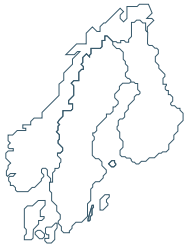
ENSURING HIGH MARKET CAPACITY AND RELIABLE OPERATIONS



In order to have a well-functioning wholesale electricity market, market design must continue to evolve in step with the power system to ensure cost-effective operation. New solutions must be adapted to physical properties in order to safeguard the balance of generation, consumption and transmission at all times. Effective wholesale markets require adequate bidding zones which ensure high capacity in markets and transparent methods for solving congestion issues in a socio-economically optimal way. The Nordic TSOs will strengthen the Nordic market by establishing a regional centre to boost Nordic cooperation and coordination.

2.1 Flow-based market coupling in the Nordic region

Transmission capacities express the maximum limit on the amount of power that can be traded between bidding zones while still respecting operational security. The Nordic TSOs' objective is to allocate as much transmission capacity as possible to the markets, while considering the grid's physical limitations, including outages and potential faults.

The Nordic TSOs collaborate on developing and implementing flow-based market coupling. The flow-based method allows TSOs to provide maximum capacity to the market as the market algorithm will find the optimal economic flow based on bids by all market participants. This is possible because a detailed grid model is included in the market clearing algorithm.

With the current market coupling, only market-based trade between bidding zones is considered by the market algorithm. Real, physical flows are left to the TSOs to manage. Congestion is solved on a border-to-border basis, and the TSOs prioritise and allocate capacity to handle the effect of transit flows and internal congestion. As transit flows are increasingly harder to predict, capacity calculation in meshed grids has become a complex task.

In July 2018, the Nordic NRAs approved the proposal for a new capacity calculation methodology based on flow-based market coupling for the day-ahead and intraday time frames in the Nordic region. To start, flow-based market coupling for the day-ahead market will be implemented. To ensure reliable implementation, the Regional Security Centre (RSC) will run internal market simulations, followed by a year of parallel operation.

2.2 Securing high transmission capacity to the market

The Nordic TSOs have a long tradition of sharing analyses on grid congestion and, if needed, reinforcing the grid or splitting into bidding zones to handle internal issues. This is also the aim of the 70% rule in the Clean Energy Package (CEP). CEP requires that 70% of transmission capacity, observing operational security limits, is made available for cross-border trade. This is already the case at many borders in the Nordic region, but the practical implementation still involves certain challenges.

The main concern is choosing a measure that TSOs can report on, that is both practically measurable and correctly indicates the physical reality. New requirements may potentially lead to suboptimal processes and increased redispatch costs, posing the risk that the solution is not beneficial from a benefit point of view. Therefore, Nordic TSOs are collaborating to find a good solution.

2.3 Bidding zones to handle congestions

In order to maximise economic efficiency and cross-zonal trading opportunities while maintaining the security of supply, the Nordic TSOs have carried out and coordinated a recent pre-study on alternative bidding zones. This study emphasises the likelihood of limited congestion between Sweden's two southern bidding zones in the years to come due to nuclear power plant decommissioning, new interconnectors and planned invest-

2 ENSURING HIGH MARKET CAPACITY AND RELIABLE OPERATIONS

ments in the transmission grid. In contrast, congestion in the Stockholm metropolitan area is expected to continue until planned investments in the mid-2030s are completed. In addition, in the subsequent stakeholder dialogue of the pre-study it was suggested to also analyse a potential merge of the two northern bidding zones. Hence further analysis will be done to investigate a potential merge of the two southern bidding zones, a potential merge of the two northern bidding zones and to establish a new bidding zone around the Stockholm Metropolitan Area.

The pre-study also suggests investigating splitting Norway's northernmost bidding zone in two to handle increasing internal congestion and improve utilisation of capacity in this area. For Denmark and Finland, no bidding zone adjustments are suggested. The proposed new bidding zones are illustrated in Figure 2.

During 2020, these suggested new bidding zones will be further analysed before a proposal is sent for consultation in a public consultation, and eventually for approval by the NRAs.

Figure 1: Current configuration.

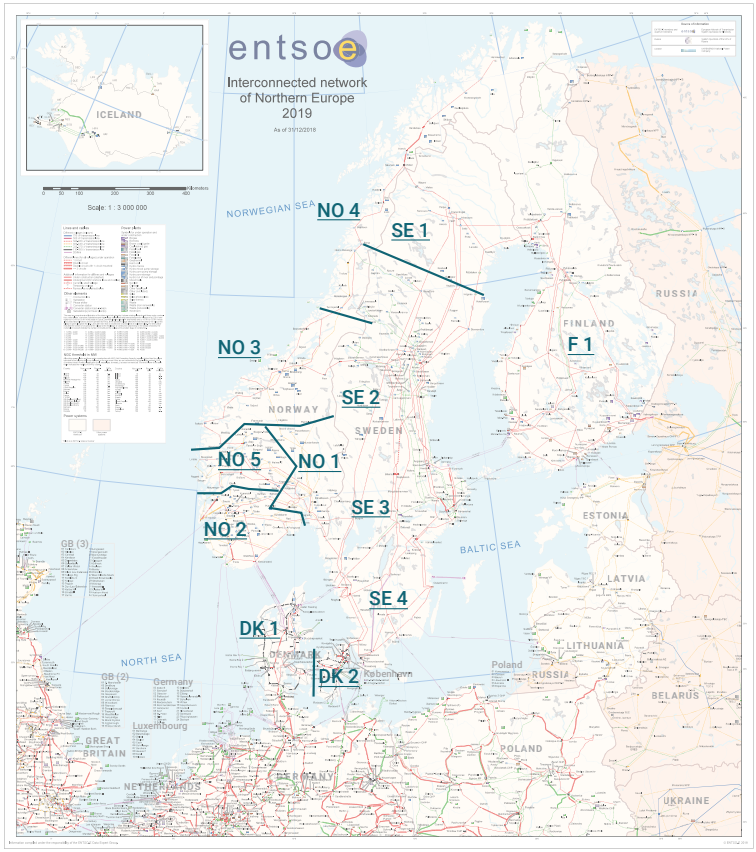
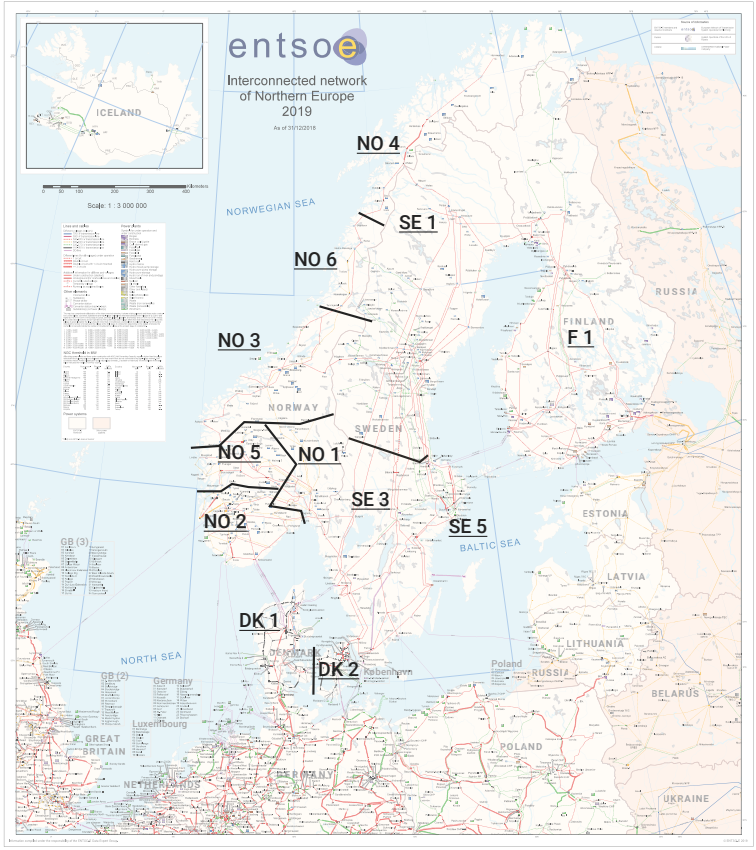
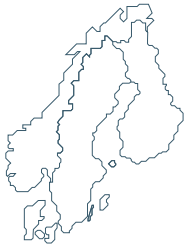


Figure 2: Alternative configurations to be analysed for Sweden and Norway.





ENSURING HIGH MARKET CAPACITY AND RELIABLE OPERATIONS

2.4 Regional security coordinator to enhance cooperation

Increasing and more fluctuating power flows across Europe underline the importance of coordinating daily power system operation. The response of European TSOs is to up coordination and operational collaboration in all time frames of operational planning and daily operation. The newly established Nordic Regional Security Coordinator (RSC) office is a cornerstone in this Nordic TSO cooperation.

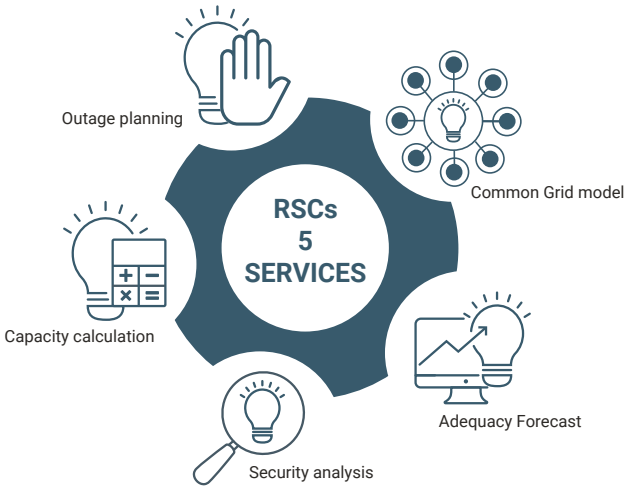


Figure 3: Regional security coordinator to enhance cooperation.

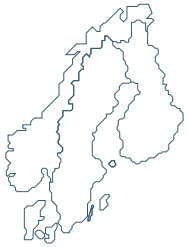
The Nordic RSC office provides operational planning services to the Nordic TSOs. Since the last Nordic Solutions report, the first releases of all services, except the common grid model, have gone live. These releases are, however, preliminary and will be built up gradually. The main focus of the Nordic RSC in 2020 is implementation of the common grid model and the flow-based capacity calculation.

Nordic TSO cooperation and coordination will expand even further, as the RSC role evolves into that of a Regional Coordination Centre (RCC). The RCC will support the Nordic TSOs on tasks such as reserve capacity sizing and post-operational analyses and reporting.

2.5 Setting up multiple market operators

The Nordic TSOs set up an equal playing field between power exchanges, now called Nominated Electricity Market Operators (NEMOs). Previously, NordPool was the only power exchange in the Nordic region. Expected to start in 2020, market participants will be able to choose their trading service provider and submit bids in the power market through any designated NEMO operating in Nordics, currently NordPool, EPEX SPOT and Nasdaq. The Nordic TSOs are working to prepare for more NEMOs on the interconnectors leading in and out of the Nordic region as well.

Nordic TSOs have developed a platform which collects unavailability data for publication on ENTSO-E's transparency platform, as an alternative to Nord Pool's unavailability market messages (UMMs), to ensure non-discrimination between market operators. The Nordic Unavailability Platform (NUCS) is jointly financed by the Nordic TSOs and provides this information for free.



CREATING DISTRIBUTED FLEXIBILITY THROUGH CLOSE COOPERATION WITH MARKET PARTICIPANTS

The Nordic TSOs strive to increase available flexibility in electricity markets to help mitigate the imbalances caused by fluctuating generation and interconnectors. Therefore, a new structure for the future power system's security and market processes is emerging. The new structure underpins the release of the potential of demand response and distributed flexibility. In practice, the new structure aims to create a sound basis for an increased number of participants, more data processing and data exchange within market processes.

3.1 Releasing the potential of demand response and distributed flexibility

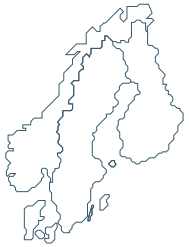
With an increased share of fluctuating power generation and the phase-out of thermal power plants, more and new flexibility is needed for system balancing. Technologies for energy management have developed and matured significantly in recent years, and demand response services have become more attractive, both to service providers and to customers. In order to attract new flexibility providers to the ancillary services markets, the Nordic TSOs need to continue updating market rules to lower entry barriers. Increased market competition will increase market liquidity as well as incentivise efficiency amongst market participants.

According to stakeholders, the main barrier for participating with small-scale flexibility is the current minimum bid size. Today, distributed resources must be aggregated in order to comply with market rules. Lowering the minimum bid size enables new technologies and service providers to enter the markets. Therefore, in 2019, the Nordic TSOs agreed on a common framework for pilot projects testing bid sizes down to 1 MW in the mFRR market. The current minimum bid size is either 5 MW or 10 MW. Piloting provides both market participants and the Nordic TSOs with experience and insights before reduced bid sizes are fully implemented. This also facilitates a smooth transition to and integration with the European balancing energy markets which should be implemented by 2022 and will have minimum bid sizes of 1 MW.

Energy storages. From a TSO and DSO perspective, it is crucial that the power system offers flexible resources that are defined and available as ancillary services when operating the power system. Traditionally, mainly large power plants have supplied flexibility services with only a very limited contribution from the demand side and other technologies like energy storages. However, flexibility can be supplied from many different sources, like demand response or energy storages. Therefore, Nordic TSOs are involved in several pilot projects on energy storages and their future role in the power system /markets.

Energy storage pilot projects. Energy storages can already deliver ancillary services. An ongoing pilot project in Sweden tests and evaluates possible future ancillary services from LER (Limited Energy Resources). During the two-year pilot, 20-60 MW FCR-D will be procured from LER-resources. In Finland, the Järvenpää power plant has put one of the biggest batteries in the Nordic countries into operation. The lithium battery is installed in conjunction with a biomass-fired biopower plant in Järvenpää. The battery's nominal output is 2 megawatts (MW) and the energy capacity 1 megawatt-hour (MWh). The battery consists of approximately 6,600 lithium-ion cells, and it offers quick second and minute level grid flexibility in frequency regulation.

Independent aggregators. An independent aggregator is a market participant who combines multiple customers' loads, storages and/or generation units from other market



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participants' balances and sells it to established markets. The rights, responsibilities and regulation of independent aggregators are in the process of being defined.

Nordic TSOs are currently testing different solutions and sharing experience about independent aggregator models with each other and national regulators. The goal is to implement harmonised solutions which enable independent aggregators to participate in markets but settle energy in a way that ensures that BRPs do not gain or lose undue imbalance energy.

The reserve capacity markets, FCR and FFR, were the first to allow independent aggregators to join. In Finland, the FCR-D market was opened to independent participants as early as 2016, resulting in significant price reductions with an approximate reduction of 40% in 2017 compared to the year before. Since then, other pilots and market rule changes have been carried out to find suitable solutions and remove market entry barriers across the Nordic region.

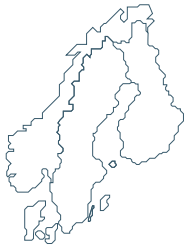
In energy-based reserve markets, mFRR and aFRR, the market model for independent aggregators involves a more complex market process as energy deliveries are traditionally settled in the national settlement process and based on the open supply chain. Fingrid has been piloting independent aggregators in mFRR markets since 2017. However, little learning was gained from the pilots during the first years and they are still running.

BSP and BRP settlement. In addition to introducing aligned independent aggregator models in reserve markets, the Nordic TSOs are working to find a method to split the current balance- responsible party role into a balancing service provider (BSP) and a balance responsible party (BRP). The plan is for BSP billing to be delegated to eSett to increase efficiency and provide an interface and harmonised billing process across the Nordic region for BSPs. Norway follows a different timeline because EBGL is still not implemented in Norwegian legislation.

3.2 TSO/DSO task delegation

As more renewable generation and distributed flexibility is connected to distribution grids, the operation of these will see large changes. Power flows will fluctuate bidirectionally, potentially causing congestion and voltage challenges in mid-voltage and low-voltage grids in addition to the impact on transmission grids. To cope with operational challenges, DSOs are taking more active roles in managing distribution systems across Europe, including the Nordic region. The Nordic TSOs welcome the strengthened DSO role.

The Nordic TSOs believe that closer TSO-DSO cooperation is beneficial in relation to making the retail customer an active player in the power markets. As distributed flexibility increasingly participates in TSO reserve markets, the need for TSOs and DSOs to coordinate their actions increases as a means to avoid operation that may be reciprocally harmful. The Nordic TSOs have established a working group for knowledge sharing related primarily to local flexibility markets in the Nordic countries. On a national basis several pilot projects with the DSOs are ongoing. Nordic TSOs also share information with each other to align coordination principles across the Nordic region.



CREATING DISTRIBUTED FLEXIBILITY THROUGH CLOSE COOPERATION WITH MARKET PARTICIPANTS

Examples of TSO/DSO collaboration. The purpose of the R&D EU-project CoordiNet is to establish different collaboration schemes between TSOs, DSOs and consumers to contribute to the development of a smart, secure and more resilient energy system. Special emphasis lays on the analysis and definition of flexibility in the grid at every voltage level, ranging from the TSO and DSO domain to consumer participation. CoordiNet aims to demonstrate how DSOs and TSOs, by acting in a coordinated manner, can provide favorable cooperation conditions for all participants while removing barriers to participation for customers and small market participants connected to distribution networks (https://coordinet-project.eu/projects/project).

Statnett has run three pilot projects to gain experience with new kinds of interfaces and the delegation of tasks between system operation (TSO) and decentralised system operators (DSO). These involve1) monitoring bottlenecks in regional grids and recommending mitigating actions, 2) regional voltage regulation and coordination between transition and regional grids and 3) analysing and recommending operation in regional grids which is currently carried out by system operation, for example coordination of planned outages.

As distributed flexibility can be provided to TSOs, DSOs and other market participants, it is important to enable direct access to all markets. Several pilots and new platforms are being developed in Europe and in the Nordic region to facilitate multilateral flexibility trading. This requires proper definitions of the roles and responsibilities of participants, as well as a clear line between regulated and competitive domains. Data exchange and market processes should be compatible with the settlement processes.

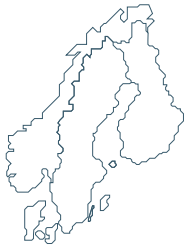
3.3 Smart meters

Smart meters are a fundamental prerequisite to increasing consumers' opportunities to participate in electricity markets. With the introduction of smart meters and hourly settlement, retailers and other participants are encouraged to develop more innovative offerings, giving consumers the choice to benefit from optimising their consumption patterns. In addition to hourly energy data, smart meters can also serve as a source of real-time metering for home automation systems. Smart meters facilitate customers' participation in TSO and – in future DSO – ancillary services markets which might have stricter data requirements.

All Nordic countries have now rolled out smart meters. As a result, dynamically priced energy contracts are becoming increasingly popular in the Nordic region. New grid tariff structures can be designed to incentivise grid-friendly behaviour, which helps to avoid undue investments. The new smart-meter enabled incentives and services are more important because of the increasing share of electric vehicles and other electric devices. Smart, distributed assets will give customers more significant roles in electricity markets and have great potential when it comes to providing flexibility services.

3.4 Datahubs

As an essential step in facilitating data access, national datahubs are either under development or already in operation in the Nordic countries. These datahubs will provide easy, secure and equal access to consumer data and will facilitate a transparent and neutral retail market where consumers can make efficient and informed decisions, and where suppliers and third parties can develop innovative services.



CREATING DISTRIBUTED FLEXIBILITY THROUGH CLOSE COOPERATION WITH MARKET PARTICIPANTS

The Nordic TSOs are working in close cooperation with electricity retailers and distribution system operators to accomplish this central part of retail market facilitation. The national datahubs are already in operation in Denmark and Norway. Finland aims to have its datahub go live in February 2022. In Sweden the national legislation is not yet in place, and it is expected that the datahub will go-live no earlier than the end of 2022.

Looking further ahead, linking Nordic datahubs could ease the exchange of data across national borders and facilitate an integrated Nordic retail market. Integration of datahubs could begin with the harmonisation of data models and the establishment of common interfaces for market participants to enable easy access to data across the Nordic region. In fact, Energinet and Fingrid have signed a Letter of Intent together with six other electricity grid operators to establish an alliance of enhanced energy data access for all Europeans. The alliance aims to agree on standards on how to obtain meter data and send secure market messages. The Nordic TSOs and Nordic regulators also discuss the potential of a harmonised Nordic retail market model.

Even more harmonised retail markets would increase competition across the Nordic region, which would benefit customers. The challenge in establishing more heavily integrated retail markets lays in the existing differences in retail market roles, responsibilities and processes across the Nordic region[1] . Retail market models are one of the topics that will be discussed in the ongoing Nordic Electricity Market Forum process.

[1]See for example the Finnish smart grid working group's report on retail market models

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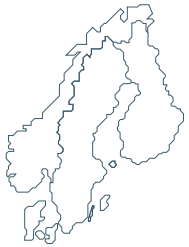
BALANCING TOWARDS NEW, MORE EFFICIENT SYSTEM OPERATIONS



Wholesale electricity markets are designed in such a way that supply of electricity will meet the demand before the delivery. The Nordic TSOs must stabilise and balance the system and keep frequency and grid constraints within secure limits to ensure the security of supply at all times in real time. As the characteristics of the Nordic power system change, Nordic TSOs are taking steps to enable new solutions for reinventing monitoring and control of the power system and its market functions.

With more distributed flexibility resources, an increased number of active participants in the marketplaces and a need for automated processes in both the power system and in the marketplaces, security processes and business processes will be extremely highly integrated in the future power system. One example of this is the ongoing NBM programme which also aims to provide improved price signals.

The desired partial solution includes an increased number of active distributed participants in the marketplaces that sell, for example, their flexibility as ancillary services. This means that these participants need access to data to allow for well-informed decisions that will be crucial to their business processes. From a DSO and TSO perspective, data about participants resources are important for both security and business processes. There are many other drivers that imply that data, data exchange and processing data in different time frames will increase to an unprecedented level in future processes for operation of the power system and its markets. Smart meters are one example of an enabler for this trend. Other examples of enablers are pilots in TSO/DSO development projects like CoordiNet.

As a result of years of collaboration between Nordic TSOs and stakeholders, another solution underway addresses system frequency stability in low inertia situations. The new ancillary service, Fast Frequency Reserve (FFR), will be implemented in the Nordic power system by summer 2020. FFR will be market-based and is a cost-effective measure to managing inertia problems in the Nordic power system.

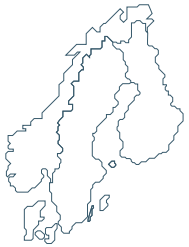
The TSOs are satisfied with the outcome of the frequency stability projects that have led to both FFR and new technical requirements for FCR. It was a steep learning curve, working with these solutions. But with high ambition levels and a stepwise approach, targets were met. NBM has a similar high ambition level that represent the TSOs' vision of balancing the Nordic system in the best way possible. Nordic TSOs have an ambition for the region that aligns with regulation, and Nordic TSOs are preparing to join and influence European balancing markets in accordance with European regulation.

4.1 Nordic Balancing Model project

The Nordic Balancing Model (NBM) programme renews Nordic balancing process. It will facilitate increased volumes of variable renewable energy, European market integration and improved balancing market efficiency while maintaining operational security in the most cost-effective manner.

In November 2019, an updated roadmap for the NBM programme was published after extensive stakeholder involvement. This roadmap includes the implementation of aFRR and mFRR capacity markets, a single price model, mFRR energy activation markets and 15-minute time resolution. Plans for the implementation of European energy activation market platforms (MARI and PICASSO) are described to some extent.

The Nordic TSOs have boosted stakeholder involvement by establishing an NBM stakeholder reference group, publishing materials on project progress and milestones and



BALANCING TOWARDS NEW, MORE EFFICIENT SYSTEM OPERATIONS

arranging subject matter webinars[2] . In close cooperation with stakeholders, Nordic TSOs have drafted a roadmap that considers the complexities of the project.

Imbalance settlement. An imbalance settlement model and imbalance pricing provide incentives for market participants to balance their trading positions. The Nordic TSOs are implementing a new single price settlement model, and Nordic stakeholders have supported the new model and requested early implementation. The Nordic TSOs propose to implement the single price model for imbalances in Q2 2021.

15-minute imbalance settlement period. Moving from 1-hour imbalance settlement and market resolution to 15-minute resolution will enable market participants to balance their positions in a more granular time frame and hence reduce structural imbalances in an efficient, market-driven manner. The 15-minute day-ahead market must go live by 1 January 2025, according to the Clean Energy Package. Actual go-live for 15-minute imbalance settlement and 15-minute intraday market is proposed for Q2 2023, and the final go-live date will be confirmed by the NRAs in late 2020 or early 2021.

Modernised ACE. The new Nordic balancing concept involves a transition from controlling the frequency of the power system at a Nordic level to a concept based on Area Control Error (ACE) similar to that of Continental Europe. The concept is to control balancing in individual bidding zones and is a prerequisite for joining the coming European balancing market platforms.

Compared to standard ACE-based operations, the new Nordic concept will apply across border imbalance netting and balancing reserves. We call it modernised ACE. While ensuring clear roles and responsibilities among balancing participants, the main benefits from the new balancing concept include better opportunities to harmonise with and participate in the coming European balancing markets3. Furthermore, the new balancing concept will improve frequency quality and altogether contribute to an improved security of supply.

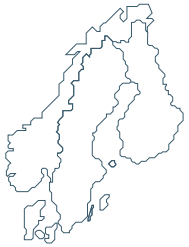
Capacity and energy markets for aFRR and mFRR. Balancing capacity markets are needed to ensure availability of adequate real-time balancing resources in all situations. Sufficient aFRR capability in the Nordic region is needed to ensure a safe transition to the updated Nordic balancing model, including 15-minute resolution.

The Nordic TSOs are currently preparing to establish a Nordic cross-border aFRR capacity market, aiming to get supply to meet growing demand in all bidding zones. The Nordic TSOs plan to start the operation of the market during 2020, however the go-live date is dependent on the ongoing regulatory process. Currently, the Nordic NRAs have referred the proposals to ACER for decision.

Implementation of the modernized ACE concept is complete with the introduction of the new energy activation market for aFRR. Each LFC area will have their own aFRR controller that regulates power balance in that area. When the European PICASSO platform is operational, the Nordic region will be part of a European aFRR activation market.

One of the major milestones in the NBM Roadmap is the introduction of a new method for mFRR activation. In ACE operation, each TSO will be responsible for activating mFRR for their own LFC areas (bidding zones). When the European MARI platform becomes operational, the Nordic countries will be part of a European mFRR activation market.

[2] More information can be found on the project website



BALANCING TOWARDS NEW, MORE EFFICIENT SYSTEM OPERATIONS

Changes to automation in the Nordic mFRR energy activation market are necessary before the transition to 15-minute resolution. The Nordic TSOs have published two memos (link) to describe the current process and what to expect from the development of a Nordic mFRR energy activation market. The implementation is planned in three phases and based on a consultation with stakeholders.

4.2 Frequency services

New FCR technical requirements. The Frequency Containment Reserve (FCR) design project aims to create a harmonised Nordic technical specification of the frequency containment reserve for normal operation (FCR-N) and frequency containment reserve for disturbances (FCR–D) in the Nordic system and to create a clear prequalification process for these reserves. The Nordic TSOs currently perform a common feasibility study with the aim to optimise the Nordic socio-economic benefits. Nationally, Nordic TSOs are reviewing possibilities of and obstacles to implementing the new FCR requirements.

The goal of the new requirements is to improve system frequency quality by reducing the amount of slow (60 s) oscillations in the Nordic system by specifying the requirements for reserve performance in a more detailed manner. Harmonised requirements and processes will also help market participants operate across the Nordic region. At the same time, harmonisation will ensure that reserves purchased are right, regardless of which country they are delivered from.

A high-level implementation roadmap has been drafted and decisions are expected at both Nordic and national levels in 2020. Implementation will be a national process that ensures the transition of the remaining FCR capacity, leading up to 100% procured FCR according to the new specification. Implementation requires that reserve balance service providers adjust their power plant settings to fulfil these new requirements. Later on, Nordic TSOs will lay down requirements for FCR-D downwards regulation, which will be needed to prevent overfrequency situations in the future. The tentative time plan expects completion in Q4 2021.

Inertia and FFR. Inertia is a power system's ability to withstand frequency changes due to resistance provided by the kinetic energy of the rotating masses connected to the power system. During times of low inertia, a large sudden power imbalance, for example due to a sudden disconnection of a large generation unit, can cause a large, instantaneous frequency deviation and endanger the security of supply. In the previous Solutions report, it was estimated that the Nordic TSOs would need new solutions by 2025 in order to cope with low inertia situations. However, the system has changed more rapidly than expected, and actions were required as early as the summer of 2019.

Based on analyses, the most cost-effective way to cope with low inertia situations is to establish a new reserve product, Fast Frequency Reserve (FFR). FFR solves low inertia problems in the foreseeable future. It is an important and big step, but work to develop and improve FFR will continue in coming years.

The Nordic TSOs drafted the technical requirements and a consultation was held in 2019[3]. Nordic TSOs began to publish inertia values for the Nordic power system to enable market participants to evaluate the need for and future market of FFR[4] . Currently, national FFR markets are being developed since it is not feasible to create a common Nordic market due to the urgent need for a solution. FFR markets will be commissioned in summer 2020. Nordic TSOs aim to harmonize the FFR markets in the years ahead.

[3] Technical Requirements for Fast Frequency Reserve Provision in the Nordic Synchronous Area

[4] Inertia of the Nordic power system

5

CREATING THE FOUNDATION FOR THE FUTURE ENERGY SYSTEM

The Nordic TSOs are preparing the grid for a future energy system that will become increasingly more complex and integrated. Extensive project investments of 15 billion are planned for the period 2016-2028 in the four countries based on expected requirements for asset replacements, network reinforcements due to load growth and connection of renewable resources with increasing demand due to electrification. The Nordic TSOs continuously cooperate on joint Nordic grid development, using common grid plans and bilateral studies of transmission investments. In addition, system adequacy continues to be a major focus area for Nordic TSO planning as the energy system evolves.

5.1 Long-term transmission system planning

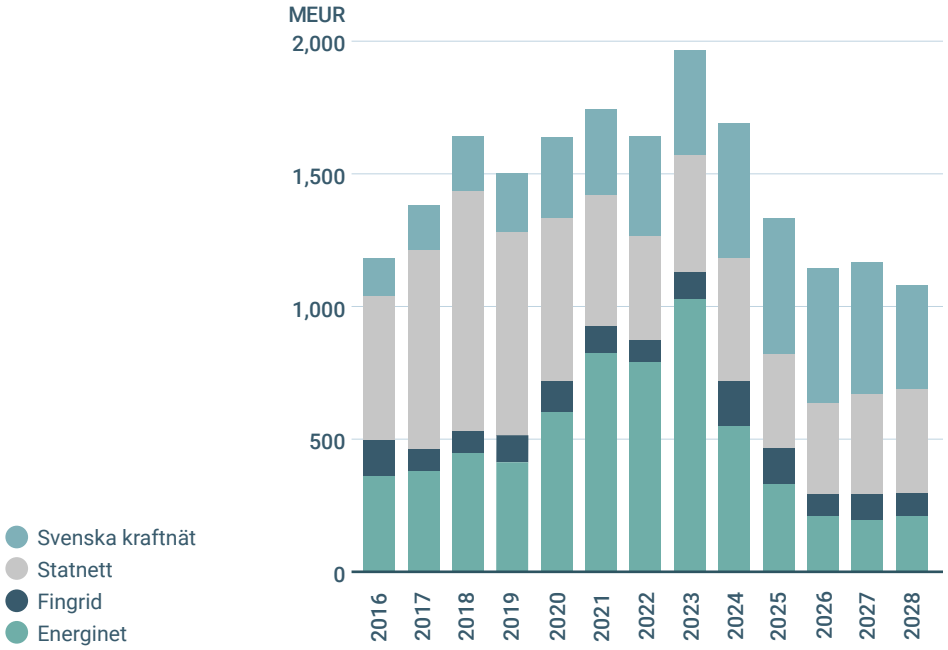
The four TSOs publish a common Nordic Grid Development Plan (NGDP) every other year. The NGDP describes the main drivers of the changing Nordic power system, and planned and ongoing grid development to meet future needs. The 2019 study[5] included a preliminary analysis of five transmission corridors of particular interest between the countries, called bilateral studies.

NGDP 2019 shows that ongoing and near-future investments in the Nordic grid are at a historic high. The main drivers behind this development are integration of renewables, further integration towards other synchronous areas, the need for a sufficient level of security of supply, and the need for reinvestments in an ageing Nordic grid.

Solutions for efficient future grid development. Future grid development in NGDP 2019 is based on three principles: A common Nordic scenario, a common Nordic methodology for cost-benefit analyses and, based on these, bilateral analyses of corridors identified to be significant for the Nordic system.

The five corridors between the areas SE-NO, SE-FI, SE-DK, NO-DK and NO-FI were identified in NGDP 2017 as the most significant and were therefore further evaluated in NGDP 2019. The five bilateral studies indicated a long-term need and the socio-economic benefit of both maintaining and expanding interconnector capacity within the Nordic system.

Figure 4: Total Investments by the Nordic TSOs.

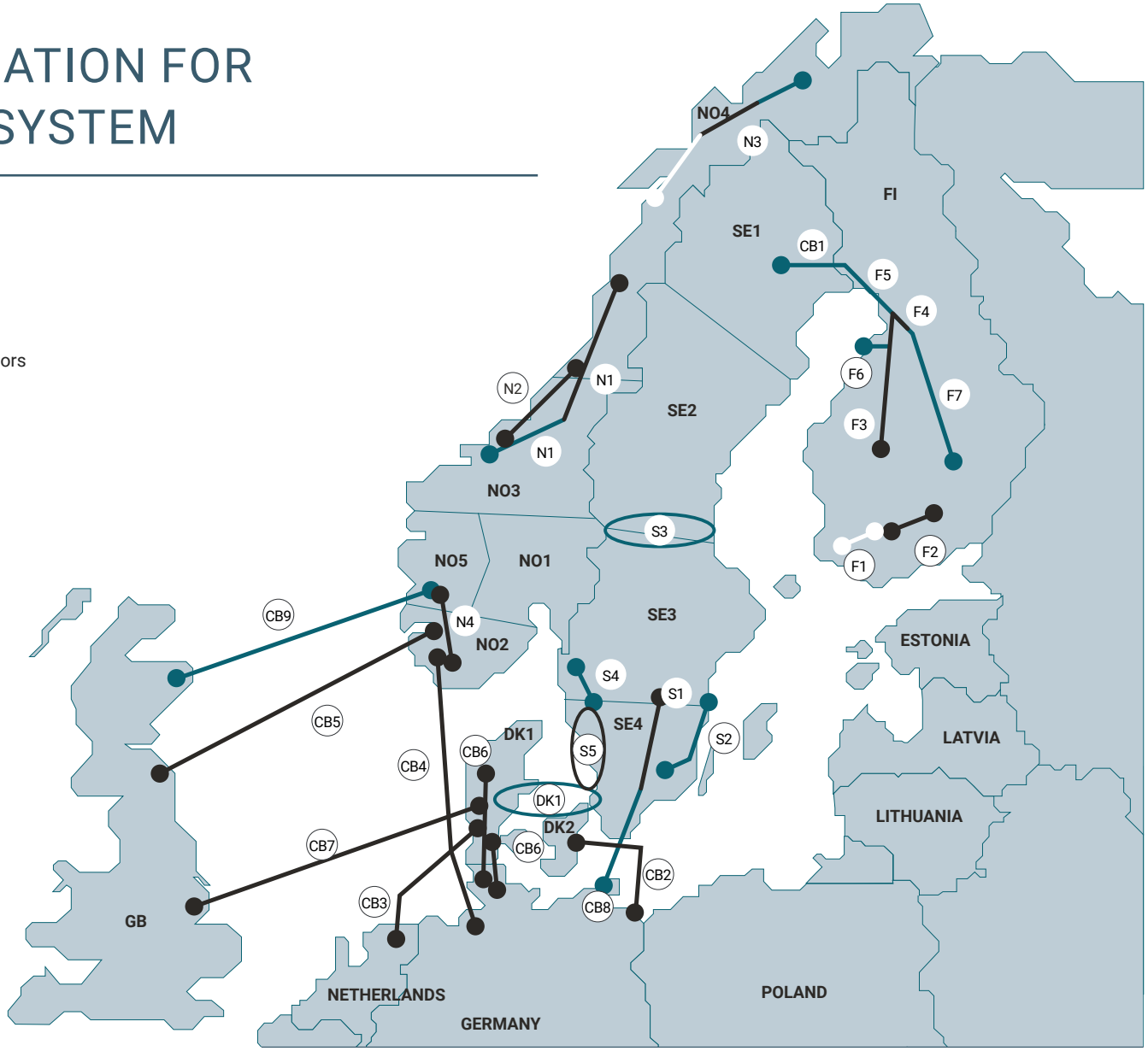


[5] Nordic-Grid-Development-Plan-2019

CREATING THE FOUNDATION FOR THE FUTURE ENERGY SYSTEM

Figure 5: Overview of existing and planned interconnectors described in the NGDP 2019.

- Taken into operation
- Under construction/Decided Planned/
- Under consideration



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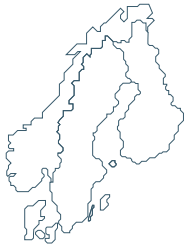
CREATING THE FOUNDATION FOR THE FUTURE ENERGY SYSTEM



Several challenges continue to impact development of the transmission grid. Wind and solar power have become competitive, and the industry is now investing in these without subsidies. This has resulted in an even faster development of wind and solar power capacity than seen in the past. This fast development makes it difficult for the Nordic TSOs to predict how many projects will be realised and when. Nordic TSOs are responding by working together to understand what drives this trend and explore best practices related to planning the grid under these circumstances. The Nordic TSOs will continue to develop a more top-down approach to help make grid investments decisions.

Another focus area for the Nordic TSOs related to planning is understanding the impact of sector integration. Sector integration (heating, electrical vehicles (EVs), power-2-X etc.) is an important part of the transition to a sustainable energy system, as it can create some of the needed flexibility. The Nordic TSOs have started a dialogue related to the operational aspects of sector coupling, such as where flexible units are likely to be placed and the possible make-up of the consumption profile.

In order to succeed with the renewable transition, the Nordic TSOs are also increasing collaboration, not only with other market participants, but also with society in general. Various aspects of future renewable resources, power lines and other infrastructure affect communities in many ways. Future planning therefore requires new reflection, optimisation of the existing grid and closer dialogue with various stakeholders, including the public, on the sustainable transition to increase awareness of the consequences.

5.2 System adequacy

System adequacy is essentially a question of whether supply is sufficient to meet demand at all times. While the historical track record is strong in the Nordic power system, the ongoing transition affects the balance due to changes in both power supply and demand. System adequacy consists of grid adequacy and generation adequacy. Grid adequacy ensures that the grid is available and sufficient to deliver energy and capacity to meet demands. Generation adequacy measures if there is sufficient generation supply to meet the demand at the time when it is needed.

The Nordic TSOs believe that three principles should be adopted to manage potential generation adequacy challenges. First, resource adequacy challenges are most efficiently dealt with by facilitating well-functioning, energy-only power markets, where prices reflect the value of electricity at all times. Second, to allow for a cost-effective use of intermittent renewable energy sources and trade of energy between surplus and deficit areas, the Nordic TSOs must aim for adequate transmission capacity within and between the Nordic countries, as well as to neighbouring regions. Third, time-restricted strategic reserves are preferable to market-wide capacity mechanisms. Capacity mechanisms should only be used as a last resort if the energy-only market does not deliver a satisfactory supply-demand balance.

An increasing challenge for the Nordic power system is the ability to meet peak load as new renewable energy resources are added and thermal capacity is decommissioned. For the winter 2019/20 the Nordic TSOs assessed a total Nordic import need of 4,900 MW to cover a 10-year winter peak, which could be compared with an import need of 3,000 MW in the year before. The study showed Norway being the only country with an estimated surplus in the peak hour. Addressing adequacy and the import possibilities will be important focus for individual TSOs and for the entire Nordic region going forward.

5

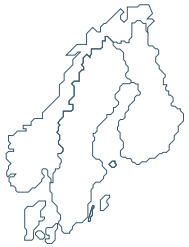
CREATING THE FOUNDATION FOR THE FUTURE ENERGY SYSTEM

In addition to preparing annual national system adequacy studies, the Nordic TSOs continue to take an active part in the development of the yearly Mid-term Adequacy Forecast (MAF) through their roles in ENTSO-E. The Mid-term Adequacy Forecast is a pan-European ten-year assessment of system adequacy. Going forward, the annual MAF analysis will be updated to meet the new requirements of the Clean Energy Package, and in 2021, the European Resource Adequacy Assessment (ERAA) will replace MAF. The Nordic TSOs will continue to participate in the adequacy assessment spearheaded by ENTSO-E and actively work to incorporate the Nordic view in the study's findings on system adequacy.

All Nordic countries experience local adequacy issues in regard to power supply to city areas due to a combination of aging grids, consumption growth and decommissioning of local generation plants. The Nordic TSOs have initiated a dialogue on this issue and plan to cooperate on developing new, innovative solutions. Potential mitigating measures in this respect may be some of the flexibility and storage solutions discussed in chapter 6, that might be closer to being implemented in the energy system than expected earlier.

6

SECURE, DIGITAL AND INNOVATIVE TOOLS



IT investments are essential to handling the transformation in the power system. The need for secure, reliable and real-time solutions and the TSOs' large amounts of data are transforming the TSOs into innovative IT companies. Digitalisation and automation will change planning and operation of the system, ways to cooperate with others and the competence requirements. The first step is to automate parts of the process and provide planning and operational experts with necessary decision support. In the long term, explored in R&D projects, Nordic TSOs expect operators to mainly supervise system operations and only take manual action in exceptional cases.

6.1 Digital security lays the foundation for our solutions

Cyber security is of outmost importance for the Nordic TSOs. The work is risk-based and consists of continuous improvements, close to main operations. The Nordic TSOs' solutions rely on this work.

Cyber security is addressed differently in national regulation, and this is challenging when cooperating across borders. As an example, the Nordic RSC has spent a lot of time identifying common standards, conducting tests of tools and implementing physical security upgrades, all to ensure that every information security requirement is observed. This has delayed work progress and is currently still blocking the Nordic RSC from taking part in pan-European processes.

6.2 Digitalising for efficient and automated solutions

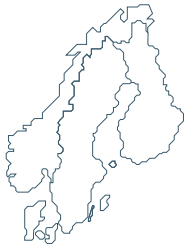
Increased transmission capacity and an increased share of fluctuating generation require efficient and automated solutions. This can only be achieved with new ICT tools and processes. New digital communication and control solutions have great potential to improve the security of supply and market efficiency. New tools and procedures require high quality data, and the Nordic TSOs are working to improve both the quality and accessibility of data.

Developing smarter solutions must be done in cooperation with other industry parties in the Nordic region and Europe. This requires a common language and shared definitions to gather and exchange information.

Digitalising the TSOs' assets is highly valuable. New technology, improved data and novel analytical methods give the TSOs improved control of the power system's real-time condition. These also underpin improved and more risk-based decisions, taking real-time conditions and the historical development of assets into account, combined with predictions of expected development and forecasting of external influences from, for example, the weather. This will result in more cost-effective maintenance and reinvestments.

6.3 Securing data quality and transparency

High-quality data and transparency are crucial to well-functioning, competitive markets. The TSOs' huge amounts of data must be secured and made available to market participants and other stakeholders at the correct level. Data transparency is an important principle for the Nordic TSOs, both to obtain acceptance of the work that the TSOs do, to support automation of other participants' processes and to facilitate more efficient decision-making. Open data and machine-readable interfaces are central to taking electricity market transparency to the next level. All Nordic TSOs offer data services which provide free data access for everyone. For example, all the Nordic TSOs publish their forecasts for generation and consumption. These publications include the same information as the operational centres and the Nordic RSC use for planning.



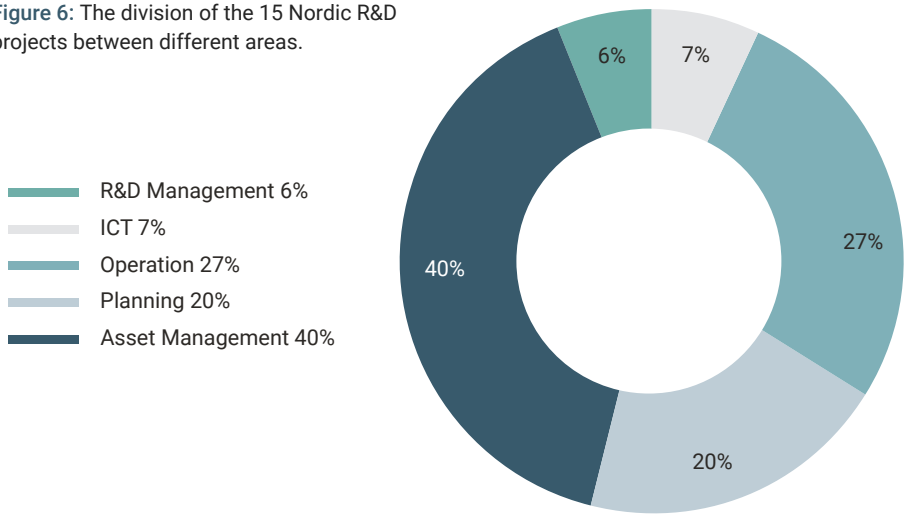
SECURE, DIGITAL AND INNOVATIVE TOOLS

6.4 Cooperation on R&D is to invest in the future

Nordic R&D is closely linked to the overall aim of creating a cost-effective, secure and green power system. Digitalisation and automation are key enablers to reaching the goal.

All Nordic TSOs prioritise R&D and run many projects with national, Nordic and European partners. Nordic Energy Research plans to establish a Nordic funding scheme for common Nordic R&D projects, something which will arrange for more Nordic cooperation on common R&D challenges. Furthermore, the Nordic TSOs have a strong voice in the European R&D working group for TSOs.

Figure 6: The division of the 15 Nordic R&D projects between different areas.



Currently, the Nordic TSOs have 15 common ongoing R&D projects. Figure 6 illustrates the division between different areas. Two major Nordic projects are under development: NEWEPS (Nordic Early Warning and Early Protection System) and Sandie (Nordic Sandbox Research and Development Digital Infrastructure Environment). While the first project aims to develop new monitoring and control solutions for the control centres, the second project aims focuses on the testing and simulation of such solutions.

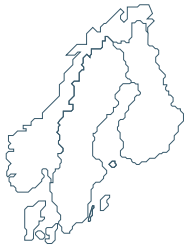
6.5 Examples of Nordic R&D projects

The Nordic TSOs work together on a wide range of R&D projects, and the chapters below shortly describe some of these projects. The projects mentioned have received or are applying for funding from the national research councils.

Measuring the impact of R&D projects

Stakeholders involved in Research, Development & Innovation (RD&I) have a strong need to visualise the profit and impact of research in different phases of RD&I projects, for example in terms of expected economic benefits and potential, expected non-economic impact and/or expected societal benefits. Today, there are no scientific or generally accepted methods of performing such analyses for RD&I performed in the power sector.

The main deliverable from the project will be a methodology, including quantitative and qualitative indicators for assessing RD&I projects and results. The expected benefits will be increased impact, value and rate of return on RD&I investments and projects.



SECURE, DIGITAL AND INNOVATIVE TOOLS

The research is performed by SINTEF in collaboration with Impello Management and NIFU. All the Nordic TSOs are involved in the project, in addition to other Nordic and European partners. The project aims to finish by September 2020.

NEWEPS

The Nordic TSOs would like to develop a common operator information system with shared data to keep the power system secure and stable when power system dynamics change. This is opposed to having several national systems. The system will monitor system stability, security and enable system level control applications. When stability margins are critical, the system will make relevant predictions and issue warnings as close to real time as possible, allowing future operators to propose and rank control measures to maintain system security. The TSOs have called it an early warning and early prevention system, and if successful, it can become a supplement to the TSOs' national information systems.

The NEWEPS project has just been launched and will run for four years. It will build on the competences and knowledge from previous R&D projects and the benefits of using PMUs (phasor measurement unit).

Load modelling

The overall goal of the load modelling project is to improve the accuracy of the Nordic load models used for both long-term and operational power system planning. Especially, the objective is to better model voltage and frequency responses of loads connected to the system. More accurate load models decrease error rates in capacity assessments and can improve power system security. The project was launched in 2015 and will be finalised in 2020.

ICEBOX

Ice on power lines can cause major disruptions. These disruptions lead to excessive repair costs and resulting losses. Safety concerns for employees tasked with the repair of power lines in harsh environmental conditions must also be considered. Ice on power lines is a problem found in most high-latitude countries.

The primary objective of the project is to develop methods for mapping, preventing, monitoring, forecasting, and removing ice on power lines. These are tools that will be used in the day-to-day operation of the Nordic transmission system, but also for planning and design of new overhead power lines in harsh environments.

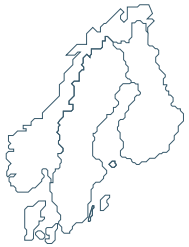
The Nordic TSOs, including Landsnet, run this project together with several research partners. The project will run from 2018 to 2021.

Sandie (Sandbox)

There is a big gap between the experimental proof of concept (TRL 3) to prototype demonstration in an operational environment (TRL 7), and many barriers may have to be overcome. The solutions are not mature enough to be tested in real environments, but without this possibility, we are not able to move forward.

Sandbox "Sandie" will help to bridge this gap and show the possibilities and potential of ideas, in addition to maturing and adapting the ideas and being a collaboration platform. Statnett has just launched a preliminary project to investigate what this sandbox could be like and to propose alternative concepts. The pre-project will finish in Q2 2020, and, based on the results, a decision to move forward with the Sandie project will be made. Several of the Nordic TSO's has shown interest in this initiative, and the goal is that a possible follow-up will be a Nordic project.

7 WORKING TOGETHER FOR THE GREEN TRANSITION



The green transition in the Nordic transmission grid must be a joint effort between TSOs, DSOs, generators, consumers and the authorities. The significant changes required in the electricity system in the Nordic region cannot happen without creating solution jointly through cooperation and innovation. Thus, one of the focus areas of the Nordic TSO's is to involve their stakeholders early and frequently.

The Nordic TSOs cooperate at several levels. Cooperation related to common system solutions address issues such as well-functioning power markets, security of supply and Nordic grid development. Technical cooperation on dedicated solutions address issues such as timing, alignment of processes and implementation of concrete solutions. The variety of topics and stakeholder involvement results in multiple stakeholder participation processes as one overall process is neither feasible, nor suitable. This section provides examples of some of these Nordic and national stakeholder processes that are underway.

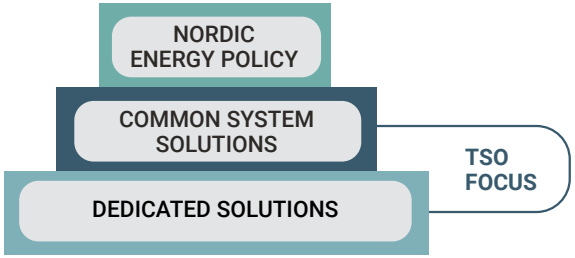


Figure 7:
The Nordic TSO cooperation.

7.1 Solutions workshop

As part of the Solutions process, the four Nordic TSOs held a Stakeholder Workshop in April 2019 to provide an update on the work performed in response to the TSO's 2018 Solutions report. Over 130 stakeholders participated in the workshop. In addition to sharing the status of the solution tasks, the purpose of the workshop was to receive input from stakeholders regarding ongoing work related to the Nordic grid as a result of the Solutions report. Presentations by the TSOs provided updates on the grid development plan, RSC coordination, the NBM and 15-minute time resolution, as well as inertia management.

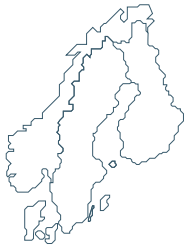
7.2 Stakeholder involvement - NBM

The NBM programme has a strong communication and stakeholder involvement process. The NBM website[6] is the main tool in securing consistent communication from Nordic TSOs to stakeholders on the content and implementation plans for the NBM. The NBM programme has strengthened stakeholder involvement by establishing a Nordic stakeholder reference group that meets on a regular basis. Minutes from stakeholder meetings can be found on the NBM website, including a proposed new timeline for implementing 15-minute ISP, in June/July 2019[7] .

7.3 Stakeholder information - RSC

The Nordic RSC regularly presents status information for Nordic regulators and participates in joint Nordic Stakeholder workshops. During several visits from stakeholders, the current situation of and plans for the further development of the Nordic RSC has been discussed.

[6] Nordic Balancing Model [7] A summary on the stakeholder feedback



WORKING TOGETHER FOR THE GREEN TRANSITION

7.4 Nordic electricity market forum

The Nordic TSOs participate actively in the work of the Nordic Electricity Market Group (EMG) which aims to establish a high-level, cross-national, cross-stakeholder forum to promote Nordic leadership in electricity market development. The Nordic electricity market vision sets an ambitious goal for all stakeholders:

"In 2030, the Nordic region has the world's most competitive, innovative, and consumer-oriented electricity market, that contributes to reaching the ambitious Nordic climate goals."

Nordic Electricity Market Forum (NEMF) 2019 was held on 28 November 2019 in Oslo. Topics included updating participants on the status of ongoing work related to flexibility, market design, CEP and planning, panel discussions and receiving input from participants related to the priorities of work for the year ahead. Participants also voted on the Nordic Priorities for the new EU Commission. Comments on the TSOs at this workshop were very much aligned with the comments at the Solutions workshop in April 2018.

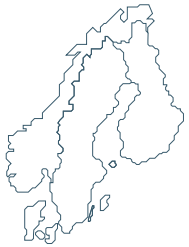
7.5 Future short-term markets

To initiate early dialogue with all stakeholders, the Nordic TSOs held a consultation on a discussion paper that explored possible market-based solutions for the future short-term markets. The summary of stakeholders' responses and the final document from TSOs have been published[8].

Table 1. Objectives and priority topics to be explored in relation to future short-term markets.

OBJECTIVES	TOPICS
Deliver all available transmission capacity for different market time frames	Common transmission capacity management to facilitate co-existence of and participation on several market platforms
Ensure robustness and diminish entry barriers for market participants	Increase transparency: additional information from the Nordic market in the ENTSO-E Transparency Platform and measures to tackle ownership and sensitivity of data going forward
Ensure simple access for market participants	Interaction between individual market platforms, taking available transmission capacity into account
Facilitate easy market access for flexibility resources	Market structure for flexibility markets and coordination with other platforms
Ensure operational security	More detailed locational information of generation and consumption resources for capacity allocation in different time frames
Ensure good liquidity and proper market design	Monitor developments in the day-ahead and intraday markets after implementation of intraday hybrid model and changes in intra-day gate closure time, and follow up with suitable measures if necessary

[8] Short-term markets future developments



WORKING TOGETHER FOR THE GREEN TRANSITION

The involvement of stakeholders in this process is vital for setting the vision for future developments of short-term markets, and the Nordic TSOs have received valuable input for the further development work addressed in the final document .

7.6 Stakeholder comments and priorities

Generally, stakeholders agree that ongoing work involves implementing the right solutions to the challenges faced in the Nordic grid. During the latest Nordic Electricity Market Forum the following key comments were raised from stakeholders towards the Nordic TSOs:

- In all aspects of planning, involve stakeholders early to ensure understanding of assumptions and purpose, to get input on possible standards and market solutions and to coordinate between the parties.
- More flexibility is needed. Regulators need to open the markets and act faster, TSOs should use flexibility rather than traditional tools, and standardising requirement across countries will support the development of flexibility tools.
- Improve DSO and TSO coordination about infrastructure as the green transition is happening very fast and we jointly have to address the complex issues.
- To enable efficient power markets across the Nordic countries, grid planning should not only be done at a national level but should also consider interconnectors from a top-down viewpoint. Stakeholders also stated that bidding zones should not be used until a more Nordic approach has been considered.
- Joint measures and analyses are needed to ensure resource adequacy.

ATTACHMENT A: ABBREVIATIONS

- **aFRR:** Automatic Frequency Restoration Reserve
- **ACE:** Are Control Error
- **CACM:** Capacity Allocation & Congestion Management
- **CCM:** Continuous-conduction mode
- **CEP:** Central Energy Plant
- **DSO:** Distribution System Operator
- **EC:** European Commission
- **EMG:** Nordic Energy Market Group
- **FCR:** Frequency Containment Reserve
- **FCR+N:** Frequency Containment Reserve for Normal Operation
- **FCR+D:** Frequency Containment Reserve for Disturbances
- **FFR:** Fast Frequency Reserves
- **ICT:** Information Communications Technology
- **LER:** Limited Energy Resources
- **LFC:** Load Frequency Control
- **MAF:** Mid-term Adequacy Forecast
- **mFRR:** Manual Frequency Restoration Reserve
- **NBM:** Nordic Balancing Model
- **NEMF:** Nordic Energy Market Forum
- **NEMO:** Nominated Electricity Market Operators
- **NEWEPS:** Nordic Early Warning and Early Protection System
- **NGDP:** Nordic Grid Development Plan
- **NUCS:** The Nordic Unavailability Platform
- **NRA:** National Regulatory Authorities
- **PMUs:** Phasor Measurement Unit
- **RD&I:** Research Development and Innovation
- **RSC:** Regional Security Center
- **Sandie:** Nordic Sandbox Research and Development Digital Infrastructure Environment
- **TSO:** Transmission System Operator
- **UMM:** Unavailability Market Messages

ATTACHMENT B: ROADMAPS

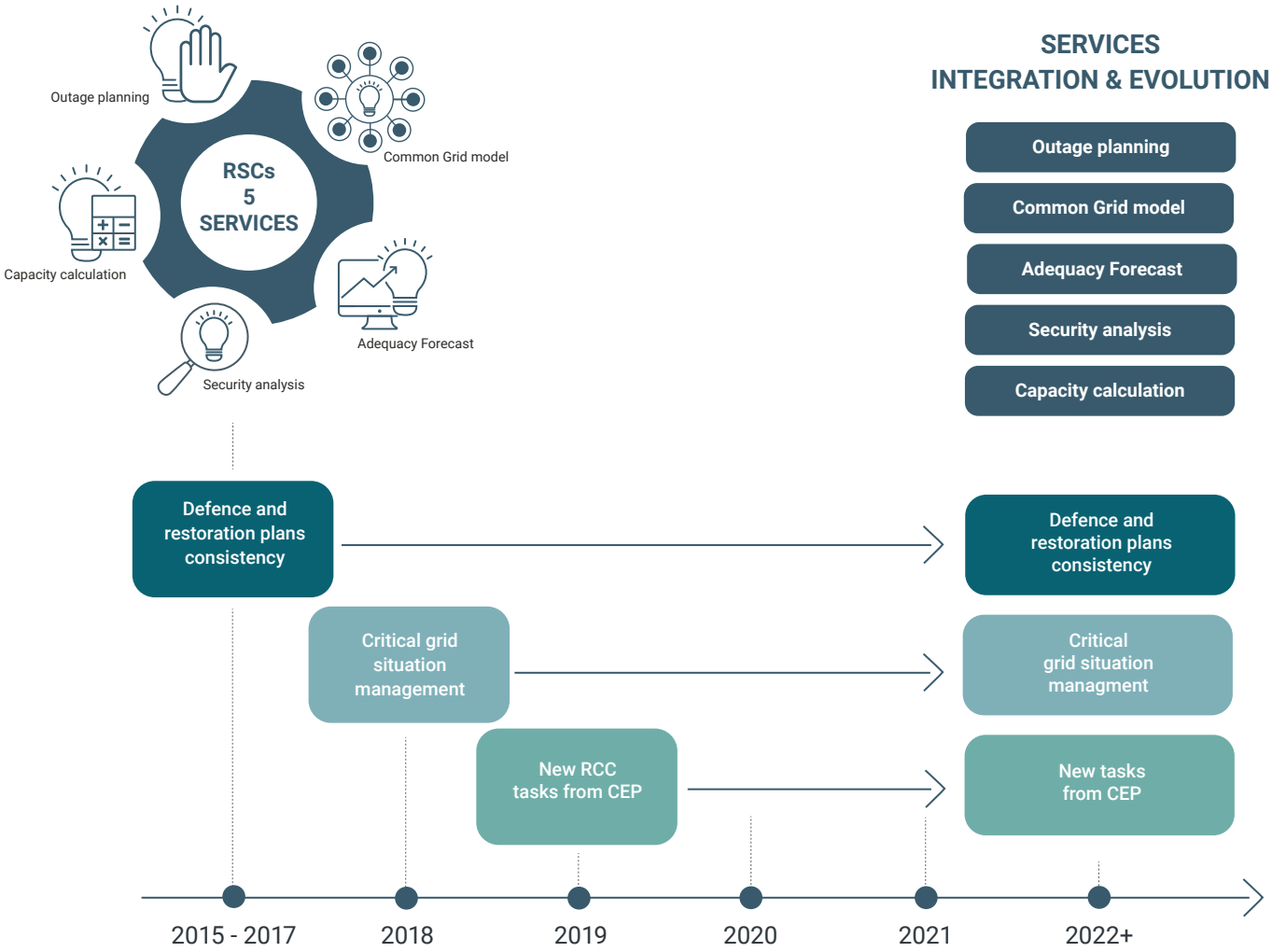


Figure 8: Regional Security Coordinator to Enhance Cooperation Roadmap

ATTACHMENT B: ROADMAPS

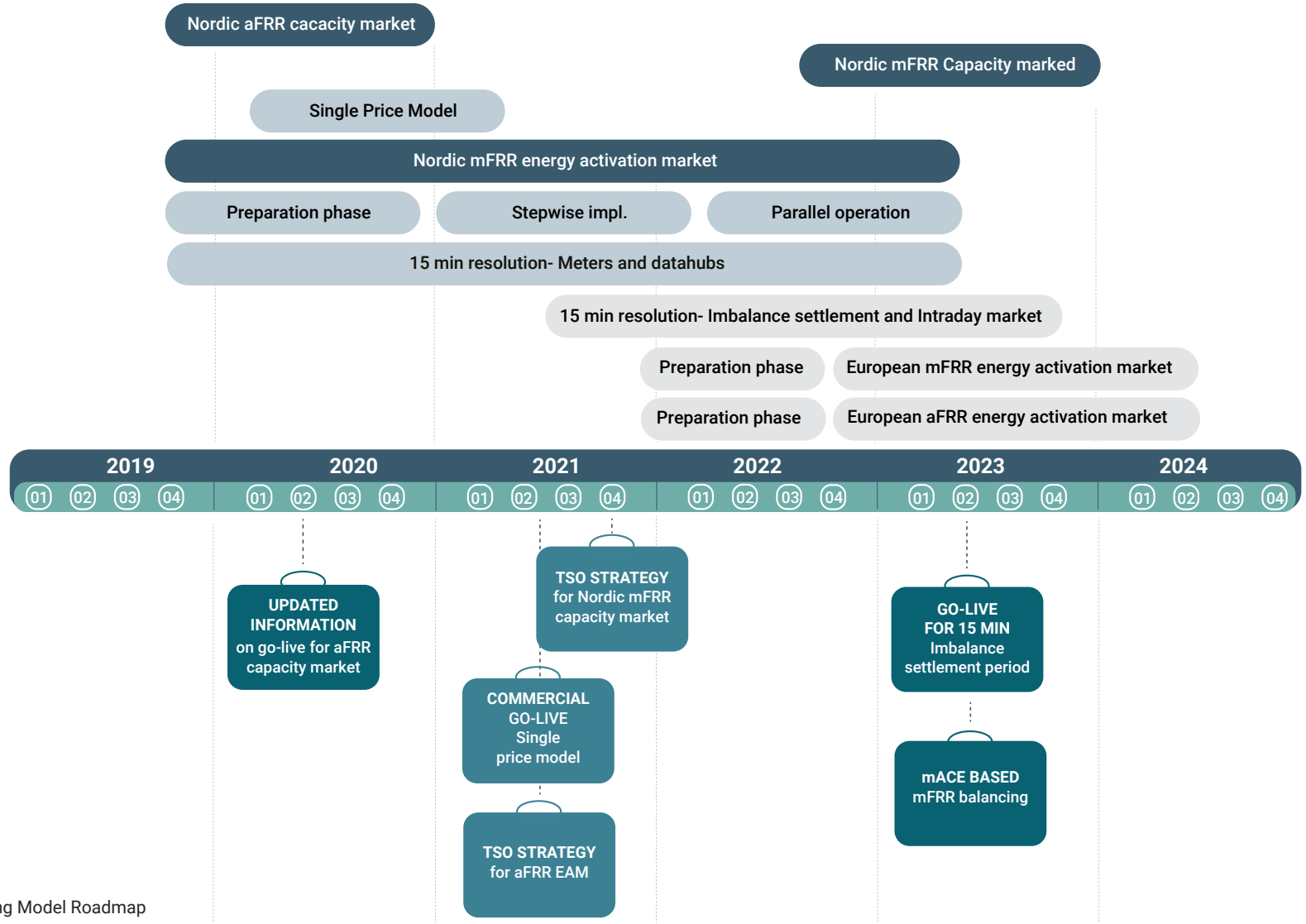


Figure 9: Nordic Balancing Model Roadmap

ATTACHMENT B: ROADMAPS

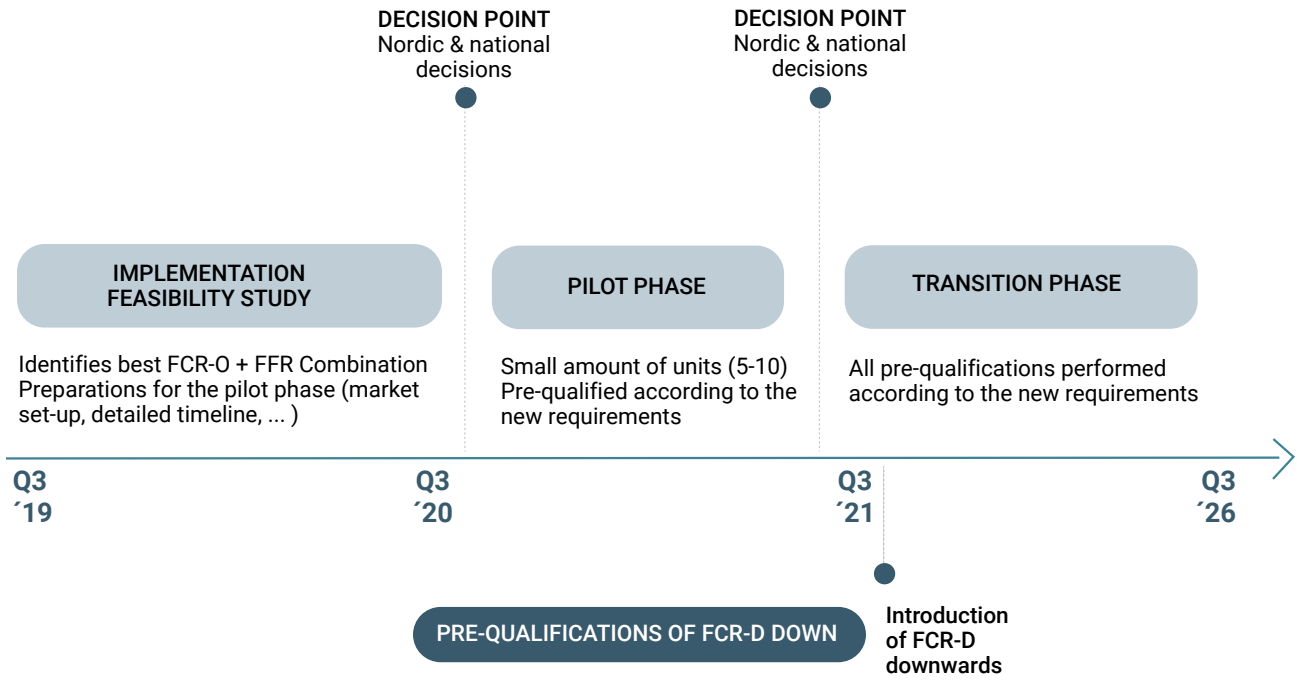


Figure 10: FCR Implementation Roadmap

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