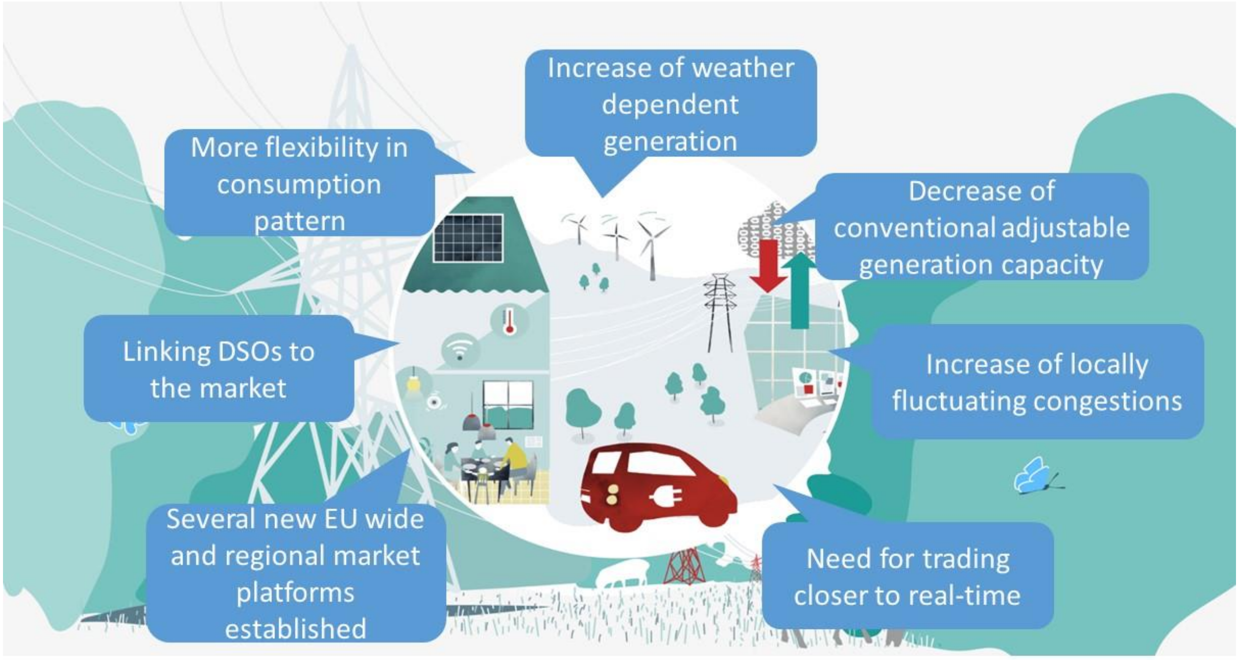

Short-term markets

DISCUSSION PAPER

Nordic TSOs | April 2019

Foreword

The Nordic TSOs are currently working intensively to develop and implement new solutions for short-term markets. This is done in response both to the challenges arising from the changing power system, but also due to new European regulations. In most cases it involves development of new market design, new operational procedures but also significant IT development. The work is carried out within very demanding time lines and requires the full attention of the TSOs and a good cooperation with stakeholders.

At the same time as this work is ongoing it is also necessary to look further ahead. The power system is in continuous change and we do not expect that the changes that are currently being implemented will be the last development in market design. Going beyond the currently agreed solutions implies far bigger uncertainties and possible alternative pathways.

To initiate an early dialogue with all stakeholders the Nordic TSOs have developed this discussion paper that explores possible market based solutions for future short-term markets. The discussion paper does not contain firm positions or decided actions in terms of long-term development, but rather discussions on possible changes of the markets that could be relevant as a response to foreseen changes in the power system. Our view is that the involvement of all stakeholders is vital for setting the vision for future developments and then implementing the vision. By publishing this discussion paper for consultation with stakeholders the Nordic TSOs both hope to stimulate a broader discussion among stakeholders and receive valuable input for our further thinking on future short-term markets amongst the TSOs.

Executive summary

This discussion paper prepared by the Nordic TSOs (Energinet, Fingrid, Statnett and Svenska kraftnät) addresses agreed solutions and timelines for short-term markets and presents elements for discussion for future short-term markets. In this discussion paper, "short-term markets" indicate the present intraday and balancing market timeframes, as well as potential future stronger integration with the day-ahead market timeframe.

The purpose of this paper is to present topics for discussion, to consult stakeholders and after consultation to finalize the paper addressing the possible further actions needed to move towards future-proof solution for short-term markets. Stakeholders' active involvement is vital for the planning of future short-term markets and with this paper, the Nordic TSOs would like to facilitate the discussion towards a shared vision among all stakeholders how markets should evolve to meet the challenges introduced by the transition towards a clean energy system.

Nordic TSOs have already agreed several solutions relevant for short-term markets including[1]: implementation of 15-minute time resolution, common capacity calculation methodology, modernized Area Control Error (ACE) for balancing with automatic/manual Frequency Restoration Reserves (aFRR/mFRR) platforms and establishment of the Nordic Regional Security Coordinator (RSC). According to the TSOs' plans, these will be implemented during the years 2020 – 2022.

Nordic TSOs expect that trading in short-term markets increases in the future implying that market timeframes such as day-ahead, intraday and balancing timeframe and market time units[2] could be reconsidered to reflect trading needs in shorter timeframes and market time units. Furthermore, it could be considered, if there is a need to move gate closure times closer to real-time to facilitate short-term markets and still meet the TSO need to maintain grid security.

Several EU wide and regional platforms will be established – to comply with legal requirements – requesting access to physical transmission capacity for the same delivery period. These platforms will request tighter coordination in the allocation of transmission capacity. In addition, a new allocation model should be considered in order to take into account effectively the grid constraints and location of production and consumption offers.

The discussion paper presents a possible timeline towards real-time trading vision until the 2030's reflecting the changes to be considered in the future allocation model, common transmission capacity management and revised market timeframes and platforms. Some of these possible changes will require amendments to EU legislation and co-operation at the European level. Possible actions to be taken to move towards real-time markets with indicative timetables identified by Nordic TSOs (Figure 1) could be as follows (darker colours indicate already planned initiatives and lighter colours indicate new possible arrangements):

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[1] Extracted from the TSOs report "The Way forward – Solutions for a changing Nordic power system", March 2018.

[2] Market time unit means the period for which the market price is established or the shortest possible common time period for the two bidding zones, if their market time units are different

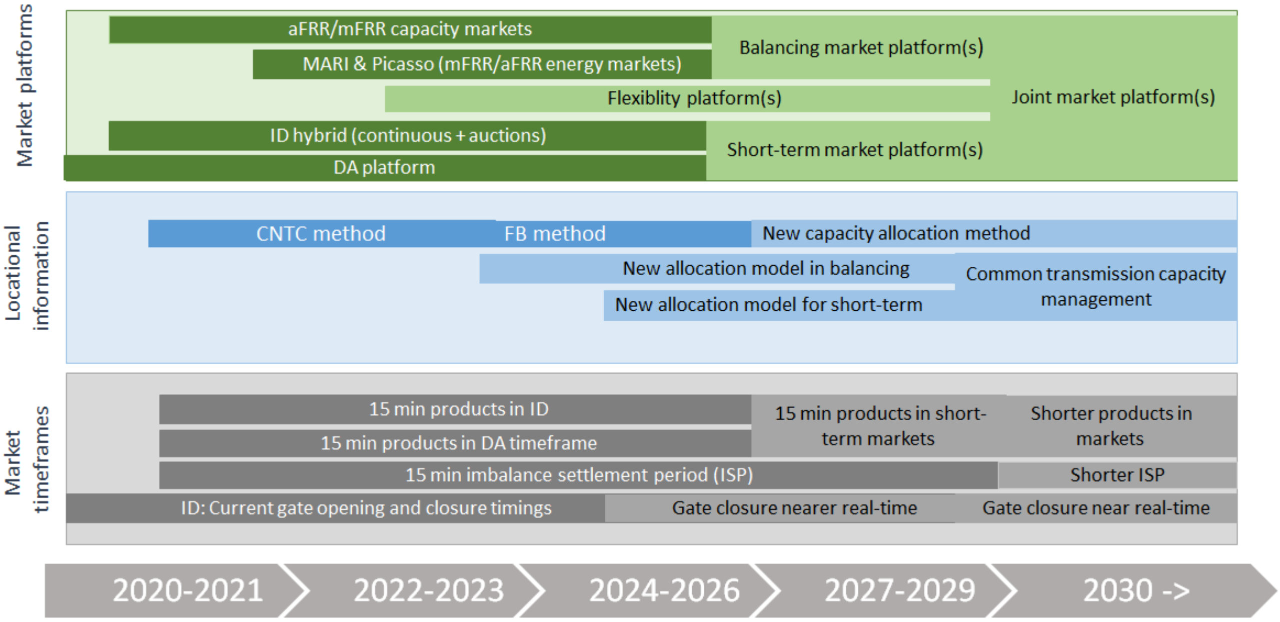

Figure 1. Indicative timetables identified by Nordic TSOs (darker colours indicate already planned initiatives and lighter colours indicate new possible arrangements).

The discussion paper includes questions to stakeholders below each subchapter. Topics of these questions are related to market platforms, locational information and market timeframes. The views from stakeholders are collected through public consultation.

1. Introduction

In this discussion paper, "short-term markets" indicate the present intraday and balancing market timeframes, as well as potential future stronger integration with the day-ahead market timeframe.

The transition of energy system towards sustainability will increase the amount of variable generation resources in form of wind and solar production in the electricity power system as seen in Figure 2. This transition changes the physical characteristics (such as frequency deviations, inertia and short-circuit current) of the electricity power system.

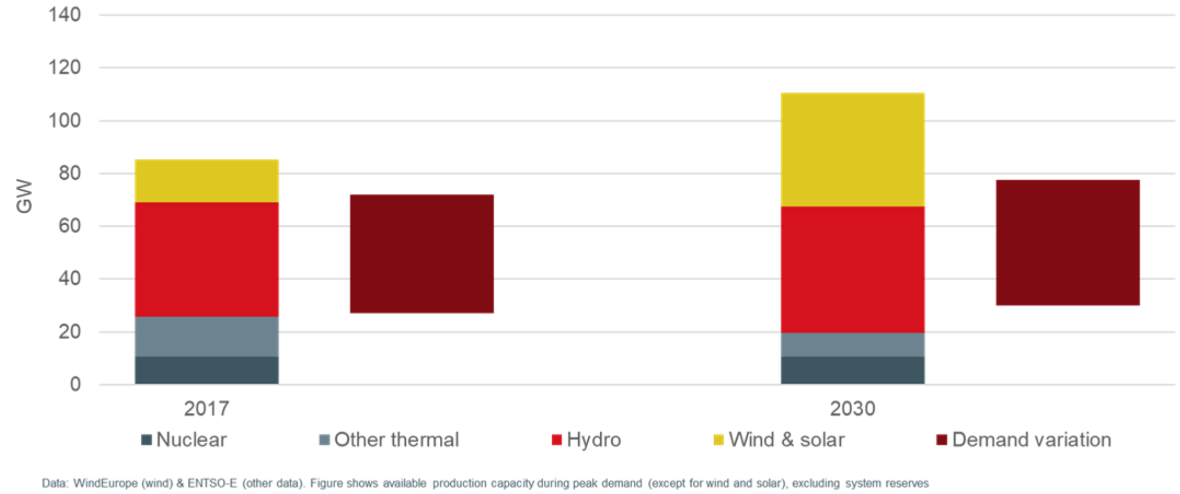

Figure 2. Forecast of production capacity in Nordic countries in 2017 and 2030 together with demand variations.

As can be seen fromFigure 2, there is an expectation that generation from wind and solar, intermittent energy sources, will increase in the coming decade.

Figure 3 shows frequency deviations in years 2003 – 2017. The increase of frequency deviations has somewhat stabilised in the recent years, but it is still higher than the target value (below 10 000 minutes) set by Nordic TSOs.

The market design should reflect and facilitate the changes in production resources and physical characteristics of the electricity power system.

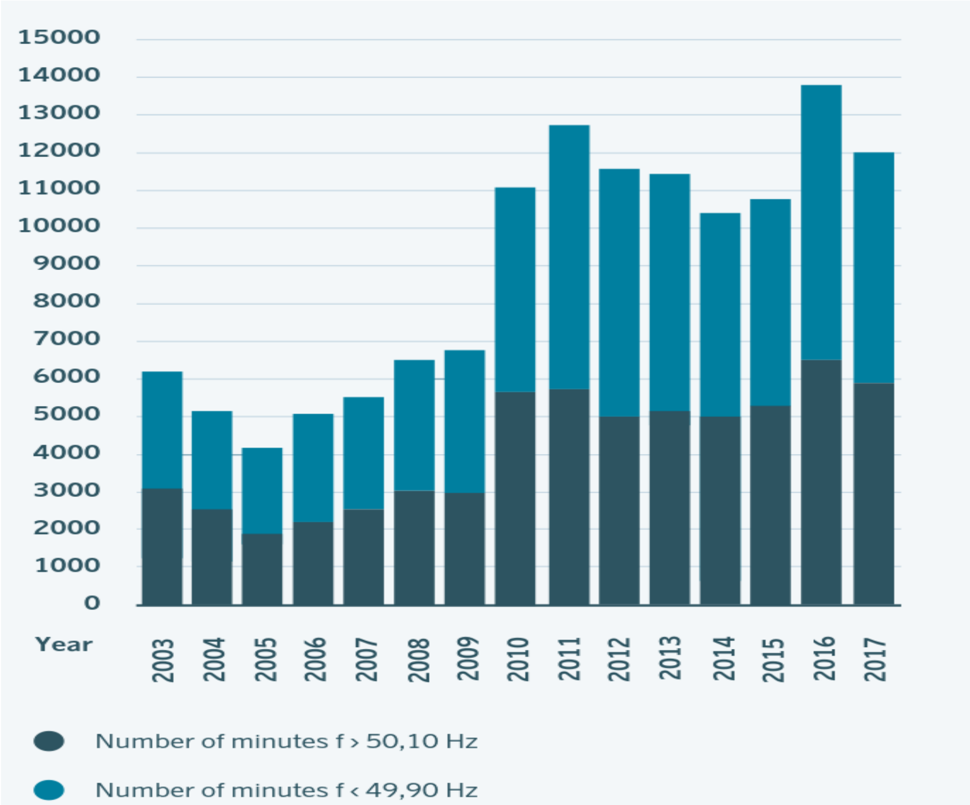

Figure 3. Frequency deviation in years 2003 – 2017.

Given the above expectation for the development of generation and the high number of minutes in frequency deviations, the importance of short-term markets increases in the future. There could be an increasing need for market participants to balance themselves closer to real-time operation as forecasting of available resources might be challenging for the day-ahead timeframe. This is due to changing demand patterns (such as electric vehicles, flexible loads and storages) and the intermittent wind and solar generation. New generation resources and demand patterns might increase fluctuation of power flows in the transmission and distribution grids and complicate also forecasting of congestions in these grids.

Several EU wide and regional platforms are planned according to the current EU legislation inclusive Clean Energy Package (CEP). These platforms may need to allocate cross-zonal transmission capacity for the same delivery period. The coordination between these platforms is vital for the efficient capacity allocation. Besides these new platforms, the electricity market will move towards higher resolution in time wise and towards geographically larger markets with smaller bidding zones.

EU legislation (especially guideline on capacity allocation and congestion management (CACM)[3]) sets requirements to cross-zonal capacity pricing for day-ahead and intraday timeframe. Pricing shall reflect market congestion. For the day-ahead timeframe with implicit auction, this shall amount to the difference between the corresponding day-ahead

[3] COMMISSION REGULATION (EU) 2015/1221 of 24 July establishing a guideline on capacity allocation and congestion management. OJ L 197. 25.7.2015, pages 24 – 72.

clearing prices of the relevant bidding zones. For the intraday timeframe, where the continuous trading matching algorithm is applied, capacity pricing shall be based on actual orders. The first step for the intraday timeframe is to allow implicit auctions to complement the continuous trading (so-called hybrid model). In addition to this, the solution for pricing in shorter timeframes is to be addressed to ensure that trades are treated equally in all timeframes and the pricing reflects scarcity of cross-zonal capacity.

New technologies – like automation, robots and smart grids – may challenge the market design, but also provide opportunities to change it. These possibilities can be used to enable trading closer to real-time, to introduce geographically larger markets (including also DSOs' grids) and to establish a variety of smarter market platforms communicating with each other.

Stakeholders are requesting more transparency in the short-term markets. Transparency helps market participants in their planning and bidding resources to different market platforms. Transparency contributes to setting 'a level playing field' for all market participants.

This discussion paper explores market-based solutions for future short-term markets taking into account the foreseeable changes in electricity market and power system. Some of these changes have already been required by EU legislation (such as 15-minute imbalance settlement period, balancing platforms) or been proposed as solutions by the Nordic TSOs (such as demand side activation, modernized ACE). These changes are described in chapter 2. The Nordic TSOs expect developments beyond the solutions described in chapter 2 and propose to start the discussions with the stakeholders of topics as described in chapter 3 to facilitate the future short-term markets.

2. Already agreed implementation initiatives for short-term markets by Nordic TSOs

This chapter presents solutions relevant for short-term markets timeframe extracted from Nordic TSOs' report "The Way forward – Solutions for a changing Nordic power system", which was published in March 2018. Table 1 in chapter 2.6 summaries implementation timetables for solutions presented in the report.

Nordic TSOs are currently reassessing the timetable for implementing the new balancing concept with higher time resolution. This may lead adjustment to the timetables presented in March 2018.

2.1 Implementation of 15-minute time resolution

Introducing a 15-minute imbalance settlement period aims at reducing the magnitude of imbalances. However, this is possible only if the market actors are able to trade these imbalances in a 15-minute intraday market.

The guideline on electricity balancing (EB)[4] requires TSOs to apply an imbalance settlement period of 15-minute no later than December 2020[5] . The Nordic TSOs have agreed on a common project to implement a higher time resolution, and the ambition is to implement a 15-minute imbalance settlement period by the end of the year 2020[6]. Besides this[7], NEMOs should implement 15-minute products in the day-ahead and intraday markets by the end of the year 2020.

2.2 Imbalance pricing and settlement schemes

Market participants should have proper incentives to support system balancing and this can be achieved through correct imbalance pricing. This means that imbalance prices should be cost-reflective and allowed to be high especially in scarcity situations[8]. As the imbalance settlement period will also be reduced, very high imbalance prices will – all else equal – affect a smaller aggregated energy volume during imbalance settlement period.

The methodology for pricing imbalances is under review by Nordic TSOs. The common Nordic TSO project has analysed how to improve incentives to market participants by looking at scarcity pricing, harmonization needs and implications from the inter–TSO settlement.

[4] COMMISSION REGULATION (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. OJ L 312. 28.11.2017, pages 6 – 53.
[5] On the condition that a derogation has been granted by the regulatory authority. The Nordic energy regulators have informed that they expect a move to a 15 minutes imbalance settlement period by 18 December 2020 (https://www.nordicenergyregulators.org/2018/12/the-nordic-energy-regulators-expect-a-move-to-a-15-minutes-imbalance-settlement-period-by-18-december-2020/) and thus no decision on derogation will be made in Nordic countries.
[6] Article 7 of Clean Energy Package's electricity market regulation requires imbalance settlement period to be 15-minutes by 1.1.2021 unless NRAs have granted a derogation or exemption.
[7] Article 7 of Clean Energy Package's electricity market regulation requires NEMOs to provide market participants with the opportunity to trade in energy in the time intervals at least as short as the imbalance settlement periods in both day-ahead and intraday markets.
[8] Article 5 of Clean Energy Package's electricity market regulation requires that imbalances shall be settled at price that reflects the real time value of energy. Article 9 forbids maximum and minimum limits for wholesale electricity price (including also balancing energy and imbalance prices). However, technical price limits are allowed on conditions that they are sufficiently high so as not to unnecessary restrict trade, are harmonized for the common market area and take into account the maximum value of lost load.

2.3 Common Nordic capacity calculation methodology

Transmission capacities express the limits of power flows within a bidding zone and between bidding zones, taking into account outages and potential faults in the power system.

The Nordic TSOs work on a new capacity calculation methodology is to meet the requirements set in CACM, which requires the development of a common calculation methodology and establishment of a coordinated capacity calculator for each Capacity Calculation Region (CCR). Nordic TSOs have assigned the Nordic RSC as the coordinated capacity calculator in the CCR Nordic.

The NRAs of the CCR Nordic have approved the TSOs' proposal for a new capacity calculation methodology in July 2018. In the day-ahead and intraday timeframe, the methodology is the Flow-Based (FB) approach, while the Coordinated Net Transmission Capacity (CNTC) approach is an interim solution for the intraday timeframe. Implementation of the FB approach for the day-ahead market is planned for mid-2021 and for the intraday market at a later stage.

2.4 Activating the demand side

A more responsive demand side would bring benefits, such as reducing the probability of extreme price spikes and demand curtailment in the day ahead market. One incentive might be to expose consumers to hourly day ahead prices to invoke more flexible demand in the day-ahead market. More flexibility could also be made available to the intraday and balancing markets.

Much of the demand response potential is connected to the distribution grid. The Nordic TSOs believe that closer TSO-DSO cooperation is crucial in relation to making the retail customer an active player in the markets. In practice, the Nordic TSOs currently work on three types of solutions to activate the demand side:

Clearer roles and terms in the balancing markets

The Guideline on Electricity Balancing requires TSOs to set national terms and conditions related to balancing. Clarifying the roles (e.g. the role of balance service provider, flexibility service provider) will make it easier for market participants to participate, which will lead to increased resources for balancing.

Roll-out of smart-meters and data hubs across the Nordic region

With the introduction of smart meters, consumers have the opportunity to optimize their consumption patterns. The national data hubs will provide a level playing field for the retail market actors, make retail market processes more efficient and enable new type of service providers to develop services to the retail customers. Linking the data hubs together could ease the exchange of data across national borders and facilitate an integrated Nordic retail market.

Pilot projects with consumers and new technologies

These projects[9] test the barriers to demand side participation. An important part of this is to enable aggregators to open the market for smaller resources, i.e. smaller consumption or generation units. Allowing third parties to aggregate multiple loads and offers will increase flexibility and competition in the market.

2.5 Modernized ACE and balancing products

The balancing services in the Nordic countries consist of several products: Frequency Containment Reserves (FCR), automatic Frequency Restoration Reserves (aFRR) and manual Frequency Restoration Reserves (mFRR). These are activated to contain and restore the frequency. Until the FCR has been activated, the inertia and system damping reduce the frequency drop. The FCR is freed and the frequency restored when the aFRR and mFRR have been activated. The development of the new balancing concept takes into account the new standard products for balancing and may involve also new specific products.

The new balancing concept controls the system frequency based on the ACE concept. While traditional ACE focuses on one Load Frequency Control Area (LFC) area, the proposed concept also includes imbalance netting and cross border activation of balancing reserves (aFFR and mFFR), and is therefore called modernized ACE. Modernized ACE will be gradually implemented over the next four years.

Handling of inertia

Inertia (rotating mass of the power system) is vital to ensure stability in the power system. In the future, situations may occur resulting in insufficient amount of inertia in the Nordic power system. Nordic TSOs develop new solutions to manage decreasing inertia in the system at all times. Implementation of simple and robust remedial actions for handling low inertia situations will be considered e.g. by exploring the possibilities for new, faster frequency reserves.

Improvement of FCR

Adjustments in the technical specifications of FCR are necessary to ensure operational security in normal and alert states and implementation of a Nordic FCR market.

Common Nordic market for aFRR and mFRR capacity

The introduction of a common Nordic market for aFRR and mFRR capacity with daily dynamic reservation of transmission capacity between bidding zones will increase the availability of balancing resources.

Common market for mFRR energy

One milestone for the Nordic modernized ACE model is the introduction of a new determination method for mFRR energy. With modernized ACE, each TSO will be

[9] Overview of recent projects can be found at TSOs report "The Way forward – Solutions for a changing Nordic power system", March 2018.

responsible for determining the need of mFRR energy for its own LFC area(s) (i.e. bidding zone(s) in Nordic synchronous area). The TSOs will request a volume per LFC area for every 15-minute period, and will eventually use the European standard products for balancing energy. When the European platform for mFRR energy, MARI, is in operation, the Nordic countries will be part of a European market for mFRR energy.

Common market for aFRR energy

The implementation of the Nordic modernized ACE model is completed by the new activation method for aFRR energy. Each LFC area will have their own aFRR controller regulating the power balance in the area, including energy bids for aFRR and price based activation, according to a merit order list. A central activation optimization function (AOF) will secure optimal use of the cheapest bids and effective and safe use of available cross-zonal capacity. When the European platform, PICASSO, is in operation, the Nordic countries will be part of a European market for aFRR energy.

2.6 RSC coordination for operational planning

The new generation patterns lead to increasing and more fluctuating power flows across Europe, and hence an increased need for closer coordination in the operational planning of the power systems. The Nordic TSOs have responded to this development through enhanced coordination and operational collaboration in all timeframes of operational planning. The established Nordic RSC office is vital in this Nordic TSO cooperation.

2.7 Roadmap for the market and balancing solutions

Table 1 presents timelines for implementing the solutions described in chapters 2.1 – 2.6 adapted from Nordic TSOs' report "The Way forward – Solutions for a changing Nordic power system" published in March 2018.

Nordic TSOs are currently reassessing the timetable for implementing the new balancing concept with higher time resolution and this may lead adjustment to Table 1 implementation timelines.

Topic	**Timeline**
Introduction 15-minute imbalance settlement period and products	End 2020
Imbalance pricing and settlement scheme	2021
Common capacity calculation methodology	2021
Activating demand side	
– Clearer roles and terms in balancing markets	mid-2020
– Roll-out of smart-meters and data hubs in all Nordic countries	2021
– Pilot projects for demand side activation	
Modernized ACE	2021
Improved balancing products and processes	
- Handling less inertia	2025
- Improvements in FCR	2021
- Nordic market for aFRR capacity	2020
- Common procurement of mFRR capacity	2020
- Modernized ACE activation of mFRR	mid-2020
- Modernized ACE activation of aFRR	2021
- Expansion towards European platforms	2022
RSC coordination for operational planning	2018 - 2022

Table 1. Agreed actions and timelines by Nordic TSOs adapted from report "The Way forward – Solutions for a changing Nordic power system" published in March 2018.

3. Discussion on possible future developments of short-term markets

Discussions initiated in this paper by the Nordic TSOs for the future short-term markets includes effects of several market platforms, solutions for better usage of the locational information and impacts on the market timeframes. The developments should reflect the needs of market participants, TSOs and DSOs to facilitate future short-term markets and secure system operation due to the ongoing transition in the energy system. The Nordic TSOs' view is that involvement of all stakeholders is vital for setting the vision for future developments and implementing the vision. The Nordic TSOs would like to start the vision work with this discussion paper.

3.1 Market platforms

In continuous trading, incoming orders are executed one by one based on a "first come first serve" principle. On the contrary, in auctions orders are competing with each other directly. It is also possible to have combinations of the solutions where the continuous and auction models take place one after other or to have consecutive auctions. Currently single intraday coupling (SIDC) is based on continuous trading and single day-ahead coupling (SDAC) on auction model.

Once transmission capacity pricing is introduced into the intraday timeframe, the pricing shall reflect market congestion (as defined in CACM) and shall be based on actual orders. It has been decided by ACER[10] that a hybrid model, where transmission capacity is priced in auctions, will be implemented. To reach efficiency it is important that the liquidity is adequate and that the geographical scope is large enough.

There are also several other development trends that should be considered. Robotic trade has significantly increased the number of transactions in the markets with continuous trading leading to needs of system performance upgrade. CACM requires implementation of many new features of the trading algorithm and the number of bidding zones in the platform continues to increase. In addition, demand side participation by offering the flexibility to the wholesale markets and the impacts to trading behaviour coming from the change of the market timeframes places new requirements to the market platforms.

Introduction of transmission capacity pricing and other changes explained in this document leads to a need for an updated platform structure. There are several alternatives for how the future structure could look like:

- In medium term a hybrid solution finds a permanent place in the short-term market structure; liquidity increases and both auctions and continuous trading will have natural roles
- It could also happen that hybrid solution turns out to be less successful and new solutions for future are needed. One solution could be returning to continuous trading,

[10] Decision No 01/2019 of the Agency for the cooperation of energy regulators of 24 January 2019 establishing a single methodology for pricing intraday cross-zonal capacity.

or another structure is found. (For example, some kind of continuous mini auctions could be established to comply with requirements set in Article 55 of CACM).

- In the longer term, a solution where different markets and products are more coordinated/integrated might be an alternative. There would be integrated transmission capacity allocation, including day-ahead, intraday and balancing timeframes, and market results could be optimized collectively. In this case an auction model (consecutive or not) for the matching could be a possible solution.
- There may be also come creative solutions based on robotic trade based on decentralized matching or rolling timeframe e.g. rolling intraday auctions for the subsequent 24 hours and shorter continuous trading before intraday auctions as delivery period or apply only intraday auctions for day-ahead and intraday timeframe.

Questions to stakeholders:

1. ***What developments do you expect in the next 10 – 15 years for the market structure and market platforms covering the short-term market timeframe?***
2. ***Any other views/comments related to the future short-term market structure and market platforms?***

3.2 Using flexibility to solve congestions in distribution grids

It is expected that the new market-based congestion-management solutions will be beneficial for the market participants, DSOs and TSOs. In many situations, flexibility from market participants can be used to solve congestions in distribution grids. This requires coordinated access mechanisms to the customers with flexibility resources.

Flexibility markets could enable energy resource owners (e.g. storage operators, demand response actors, electric vehicles, end users, (renewable) power plants) to provide their flexibility in consumption or generation to the market platform. These resources can be used by markets or by TSO or DSO. These markets can be local or wider-area markets and market participants can to balance themselves near real-time (e.g. after intraday gate closure) and in real-time.

In order to utilize the flexibility, there is a need to adjust the market structure to make it possible to accept bids and offers from new flexibility providers. Goal should be to bring an easy access for the customers' "hidden" flexibility to the markets and let it freely compete with the traditional resources of flexibility. Role of the market platforms could possibly be a neutral intermediary between flexibility demand from system operators and flexibility providers active in the relevant region, supervise price formation and guarantee a high level of transparency for this new market.

New market platforms could support TSO and DSO needs by procurement of ancillary services. To facilitate this, offers on the new market platforms need to include additional information (like locational information and ramp rate for a balancing product) compared to regular offers in the current intraday market. Besides, utilization of data as near real-time as possible and as transparently as possible (based on open data, smart meters and data hub) are important for successful implementations.

It is important to support, participate and share experiences from ongoing pilot projects – as described in chapter 2.4 - in order to learn more about practical solutions for coordination mechanisms between TSO and DSO needs and market platforms.

Questions to stakeholders:

1. ***How do you see the role of flexibility providers in the future short-term markets?***
2. ***Other possibilities to facilitate linking resources located in DSO grid to the short-term market?***

3.3 Locational information for allocation

New transmission and distribution assets can be commissioned to facilitate fluctuating power flows due to increased variable production resources, but it is not economically efficient to build grids that all possible power flows can be accommodated. Fluctuations in power flows may introduce changes in the location of congestions, and it could be challenging to define bidding zones based on frequently changing location of congestions. These fluctuations therefore might call for changes in the capacity calculation and capacity allocation model to ensure efficient congestion management.

In accordance with CACM, the FB approach is the target capacity calculation approach for the intraday timeframe. For an interim period, the CNTC approach is applied, but it will be substituted by the FB approach when SIDC (XBID) allows FB constraints to be taken into account instead of currently applied cross-zonal capacities on bidding zone borders. Reassessment of the intraday cross-zonal capacity shall be done at the frequency the Common Grid Model (CGM) for the intraday timeframe is made available, and in case of a fault in the power system. The latest available CGM is applied in the reassessment of cross-zonal capacities. Any change in the cross-zonal capacity (increase or decrease) due to a reassessment shall be released to the intraday market without undue delay.

Implementation of the FB capacity calculation methodology is a step forward from the current NTC approach as it models better the power flows in the meshed transmission grids for the capacity allocation phase[11]. Yet, it still might not solve efficiently the congestion management in the grid, where the location of congestions frequently changes. Furthermore, it applies forecasts of generation and consumption – not actual bids – when defining the FB parameters for the cross-zonal capacity allocation, which might lead to inefficiencies in the capacity allocation phase.

The new approach for transmission capacity allocation could include the topology of the grid and its parameters, enabling the more accurate calculation of power flows in the meshed grids and taking into account the grid losses and location of generation and consumption. This more accurate allocation model requires that generation and consumption bids should be given at the nodal level. This means that current portfolio bidding with bidding zone resolution should be substituted by bidding with higher geographic resolution, even with

[11] The two step model is used, where the first step is to calculate FB parameters and available margins, and the second step is to allocate cross-zonal capacity based on calculations in the first step.

unit bidding[12].It is also possible that unit bidding is applied only in those bidding zones, where grid constraints within the bidding zone limit the trading. The bidding zones without internal grid constraints may still apply the current approach with portfolio bidding. This solution may however have consequences with respect to a "level playing field" of market participants that need to be assessed.

The essence of the new model would be the application of optimal power flow (OPF) related techniques to determine the optimal allocation of generation and consumption, while satisfying the physical laws that govern the power flows and the grid constraints. The result of this new model is an economically efficient allocation of resources. This does not necessarily require nodal pricing, as one might still choose to use zonal pricing. Pricing rules should be carefully designed to ensure proper incentives.

In general, locational signals for generation and consumption are expected to become more important in the future, where the ongoing transition in the electricity power system may make it increasingly challenging to apply a pure zonal model. Possibilities of a zonal model with smaller bidding zones should be investigated as an alternative for nodal modelling. Maybe, firstly nodal modelling (based on OPF) could be developed for balancing markets while retaining the zonal model in current day-ahead and intraday timeframes[13]. The pricing model (with or without nodal pricing) should be carefully investigated to avoid e.g. gaming.

The benefit of nodal modelling is short-term efficiency because grid constraints are observed during the market clearing. However, a transition to a nodal model implies significant complexity and transition costs. There may also be issues of market power in nodes, but this may not be fundamentally different from today's situation, and mitigation measures have been developed in nodal US markets.

If a transition to a nodal model is envisaged, there is a need a stepwise approach. The overall interest and demand from the stakeholders should be reviewed; then the roadmap for such a change should be prepared in consultation with stakeholders. Furthermore, it has to be explored which changes are possible within the current legal framework – especially for CACM and EB[14] - and start preparing for changes that are deemed necessary for the future Nordic power system. Pilot project(s) and further studies could be launched to study promising new ideas in more detail. It should be recognized that time horizon for such change covering the short-term market timeframe would be 8 – 10 years. Possible extension to day-ahead timeframe, where needed, would take at minimum 10 – 15 years.

Questions to stakeholders:

1. ***Which actions from TSOs are needed to ensure that the existing transmission capacity will be allocated efficiently to the short-term market taking into account transition in the energy system?***

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[12] In Norway, this is already the case today

[13] Due to huge increase in model size distribution grids and transmission grids might be modeled applying stepwise approach, where both grids have nodal modelling and price formation.

[14] Guideline on Electricity Balancing, Article 14.2 states: "Each TSO shall apply a self-dispatching model for determining generation schedules and consumption schedules. TSOs that apply a central dispatching model at the time of the entry into force of this Regulation shall notify to the relevant regulatory authority in accordance with Article 37 of Directive 2009/72/EC in order to continue to apply a central dispatching model for determining generation schedules and consumption schedules." Because nodal pricing approaches require central dispatch, there seems to be an immediate barrier in existing legislation.

2. ***Have you experienced that grid has constrained offering your resources to the short-term market (or markets in general)? If so, how much have such grid constraints increased in the recent years and are you expecting them to increase in the coming years?***
3. ***What challenges would there be from the perspective of resource owner when moving from portfolio bidding to nodal or unit bidding?***
4. ***Any other views/comments related to capacity calculation and allocation?***

3.4 Market timeframes

Gate opening time for the intraday timeframe

ACER decided in accordance with CACM that gate opening time shall be 15 CET D-1 from 1 June 2018 on all bidding zone borders in CCR Nordic. Other European bidding zone borders apply this opening time from the beginning of 2019 or 30 days after the approval of intraday capacity calculation methodology. Nordic TSOs do not foresee a need to change gate opening time of 15 CET D-1 in near future, which change would require also an amendment request for the current ACER decision. Future changes in the gate opening time could be linked to the redesign of day-ahead and intraday timeframes. However, it is important that all EU TSOs develop their scheduling system and processes in order to start being able to provide non-zero cross-zonal capacity, e.g. the remaining capacity from day-ahead allocation, to the market at the gate opening time.

Different gate opening times for cross-zonal trading and trading within a bidding zone may be applied, but preferably they should be aligned. Any change to the current gate opening times should be carefully analysed in order to minimize the negative effects to the integrated markets.

Gate closure time for intraday timeframe

ACER has decided that gate closure time shall be 30 minutes before delivery period for the bidding zone border Estonia – Finland, and 60 minutes before delivery period for all other European bidding zone borders. After 1 January 2021, the gate closure time shall be defined in relation to the start of the relevant intraday market time unit.

European TSOs propose to have gate closure time for mFRR/aFRR energy market to be 25 minutes before real-time, which is nearer real-time than gate closure time for intraday timeframe and is compliant with CEP legislation.

It should not be ruled out that in some bidding zones there could be different gate closure times for cross-zonal trading and trading within a bidding zone. There might not be any immediate need to harmonize the gate closure time across Europe. However, there is a need to understand the impacts of changing the gate closure time closer to the delivery moment. It should be noted that as long as the intraday market is based on a zonal model, this may also result in infeasible schedules that need to be corrected by the TSO during real-time operation. A practical next step could be to conduct a Nordic study with stakeholders about the need to change the gate closure times towards real-time (45, 30 and 15 minutes).

Products and imbalance settlement period (ISP)

15-minute products are expected to be available for day-ahead and intraday market around year 2021[15]. Nordic TSOs have taken actions to have 15-minute imbalance settlement period December 2020. The imbalance settlement period should be equal to the minimum timeframe for traded products. It is vital to have 15-minute product available in the Nordic intraday market at 15-minute ISP implementation.

Redesign of market timeframes

Forecasting wind and solar production for 12 – 36 hours before delivery period is challenging which might make the management of variable generation and increased flexibility in the current market design difficult. The accuracy of the forecasts increases near real-time operation implying that short-term market timeframes could be used to adjust forecasts made in the day-ahead timeframe. Thus, there might be a need to reconsider the present market timeframes: the purpose of the day-ahead market might be moving towards hedging rather than real-time physical trading, and short-term markets - including intraday and flexibility markets – might be used more for real-time physical trading. Introduction of the 15-minute imbalance settlement period and 15-minute products in the short-term markets could also help market participants to balance themselves better.

The Nordic TSOs expect that market participants may increase their trading in the intraday timeframe implying that traded volumes move from the day-ahead timeframe to the intraday timeframe. Market participants might consider the day-ahead timeframe too long before delivery period for bidding their volatile physical resources. However, need for liquid price formation (i.e. reference price) for physical resources remains. Redesigning day-ahead and intraday timeframes – including implicit auctions and continuous trading – with changes in gate opening and closure times could be studied.

Increased trading in the intraday timeframe may have effects also to the financial markets and hedging in the forward market timeframe because the financial markets apply prices from the day-ahead market as reference price. Volumes and liquidity of the day-ahead markets could be monitored together with other physical markets and appropriate actions taken to ensure the reliable reference price formation for the financial markets.

Questions to stakeholders:

1. ***When is the optimal intraday gate opening time for future short-term markets from your perspective and why? Shall gate opening time be different for cross-zonal trading and trading within a bidding zone?***
2. ***When is the optimal intraday gate closure time for future short-term markets from your perspective and why? Shall gate closure time be different for cross-zonal trading and trading within a bidding zone?***

[15] Article 7 of Clean Energy Package's electricity market regulation requires imbalance settlement period to be 15-minutes by 1.1.2021 and NEMOs to provide market participants with the opportunity to trade in energy in the time intervals at least as short as the imbalance settlement periods in both day-ahead and intraday markets. Besides this, in accordance with ACER decision the day-ahead algorithm has to facilitate day-ahead products by 1 August 2022.

3. ***Do you see the need for redesign of market timeframes? If so, which issues are underlying, that would have to be solved by the redesign? Why?***
4. ***Any other views/comments related to the market timeframes?***

3.5 Towards real-time trading

Common transmission capacity management across products

Several EU wide and regional platforms will be established for the short-term market timeframe in the coming years. Some of these platforms will allocate the transmission capacity for the same delivery period. Furthermore, time span between the gate closure of the previous market timeframe and gate opening of the following market timeframe will be shorter (e.g. 10 minutes between ID auction and following ID continuous trading session). Common transmission capacity management could help to ensure the efficient use of the scare transmission capacity in different platforms and for different timeframes. The physical transmission capacity will be accessed by different platforms, i.e. platforms where different kind of resources – like intraday energy, balancing energy, reserves, flexibility – are traded as shown in Figure 4. Access rules to the transmission capacity should be defined for each platform, including such as matching model (including grid modelling) and access timings (gate opening and closing times). Platforms could be decentralized or centralized. However, it should be made easy for market participants to submit their bids to these different platforms.

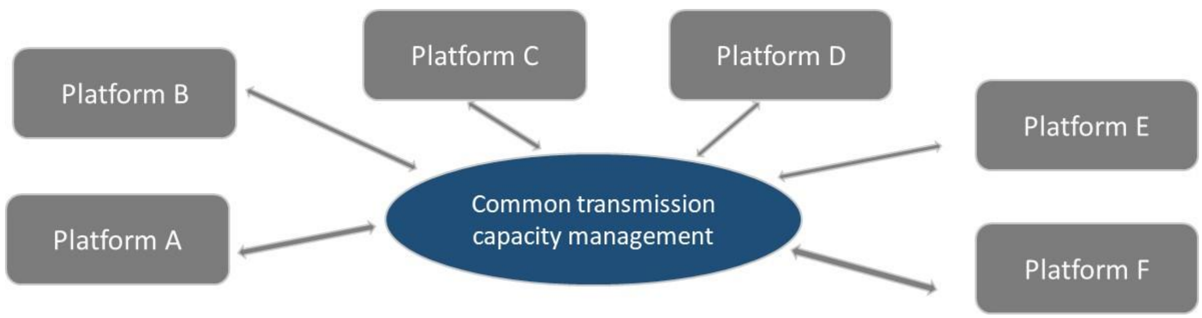

Figure 4. Transmission capacity management for market platforms.

Principal overview of practical implementation for common transmission capacity management

Market participants from the Nordic countries can trade in several European platforms (e.g. currently DA price coupling and ID continuous trading platforms and in the future mFRR/aFFR energy trading platforms) and Nordic platforms (e.g. aFRR/mFRR capacity trading platforms, aFRR/mFRR energy trading platforms[16]). Besides, there will be also ID auctions on the European level (three ID auctions in accordance with recent ACER

[16] To be substituted by European aFRR/mFRR platforms.

decision[17]) and foreseen platforms for flexibility markets on national/regional level. All these platforms need to have access to physical transmission capacity in different timeframes as seen in Figure 5.

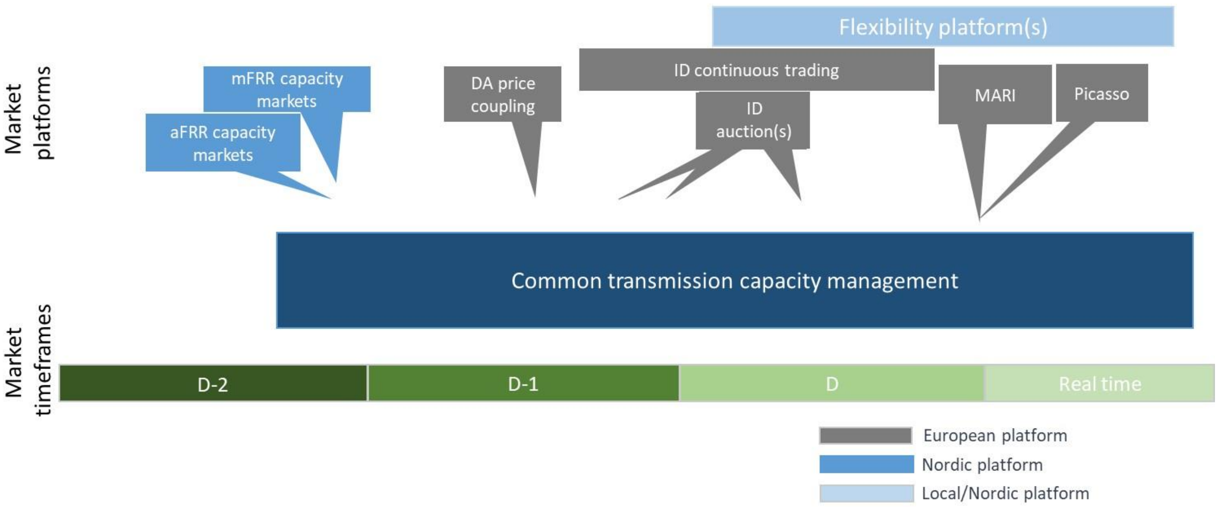

Figure 5. Overview of current and planned market platforms for Nordic market participants and market timeframes for their access to transmission capacity.

The vision for the future

In order to facilitate trading near or during real-time operation, changes to the market timeframes, coordination between different platforms and introduction of locational information for generation and consumption in grid models during the capacity allocation phase could be expected.

The intraday gate closure timing could be moved towards real-time from current 60 minutes in the Nordic bidding zone borders and to shorten imbalance settlement period; starting with 15-minute imbalance settlement period and possibly even shorter towards the year 2030. In parallel with shorter imbalance settlement period, 15-minute products have to be implemented in market couplings; for intraday coupling and subsequently the day ahead timeframe. Even shorter products could be introduced to the market by year 2030 to comply with shorter imbalance settlement period (after the imbalance settlement period is adjusted accordingly). Experiences from implementation of 15-minute imbalance settlement period and 15-minute products in markets could be used to evaluate if it is beneficial to move towards shorter time interval – e.g. 5 minutes – for the imbalance settlement period and trading time units[18]. Such evaluations could be performed when the 15-minute imbalance settlement period and products have been in place for 3 – 5 years.

[17] Decision No 01/2019 of the Agency for the cooperation of energy regulators of 24 January 2019 establishing a single methodology for pricing intraday cross-zonal capacity.
[18] Note however that Article 7.2 in the Electricity Regulation of the Clean Energy Package states: "Nominated electricity market operators shall provide market participants with the opportunity to trade in energy in time intervals at least as short as the imbalance

There will be several platforms requesting access to transmission capacity as indicated in Figure 5. A common capacity management could be applied for these platforms starting with intraday platforms (hybrid model) and afterwards extending the capacity management to cover also the day-ahead platform. These platforms may still apply the zonal model, where capacities for different platforms are managed by the common capacity management and results of the transmission capacity allocation could be transferred between different platforms by the common transmission capacity management solution. Parallel with this development, platforms for balancing markets (platforms for aFRR/mFRR capacity and energy markets) could apply also the common transmission capacity management (possibly with nodal modelling). By year 2030 – 2035 the common transmission capacity management could cover all timeframes from day-ahead until real-time operation. This solution could allow access also from flexibility platforms, where modelling of grid constraints are needed.

There might be a need to change the allocation model of market platforms to facilitate locational information of generation and consumption to be included This means that bidding with higher geographic resolution (instead of current portfolio bidding) could be implemented where generation and consumption may have limitations due to grid constraints[19] could be implemented. Locational information in the allocation phase could be used to set clearing prices for the zonal setup or facilitate nodal pricing. The new allocation model could substitute current allocations by year 2030 – 2035: firstly, the locational information through nodal modelling could be implemented for the balancing timeframe. This could evolve towards the intraday and day-ahead timeframes at later stages.

Questions to stakeholders:

1. ***Have the TSOs described the most important issues from your perspective for changes towards the real-time trading? What should be kept/added/deleted?***
2. ***Which design aspects should be considered to facilitate market participants' bid submission in the several platform environment?***
3. ***Any other views/comments related to future market design of short-term market timeframe?***

settlement period in both day-ahead and intraday markets". This may be reasonable for a 15-minute settlement period, but might look unrealistic if this should be shortened to 5 minutes. In this case, this Article needs to be changed.

[19] Zonal model with portfolio bidding can be used in parallel and these bidding zones can be named as 'virtual nodes'. Same kind of approach can be considered for aggregators and their offers.

4. Conclusion

Chapter 2 described the activities and timelines already agreed by the Nordic TSOs and presented in the report "The Way forward – Solutions for a changing Nordic power system" published in March 2018. These activities – as seen in

Table 1– are mainly bound by European legislation (CACM, SO[20] and EB) and their implementation timelines are in accordance with these regulations.

Chapter 3 identified discussion topics for platforms, market timeframes and allocation model to move towards real-time trading. These topics may request changes in the European legislation and European wide implementation, especially in Regulation 714/2009 and amendments in existing network codes. Clean Energy Package (CEP) might not deliver the needed changes and another legislative package beyond CEP might be needed to facilitate better the transition occurring in electricity power system.

The TSOs' aim is to present topics for discussion, to consult stakeholders and after consultation to finalise the paper addressing the possible further actions required to move towards solution for future short-term markets. Stakeholders' active involvement is vital for the planning of future short-term markets and with this paper, the Nordic TSOs would like to facilitate the discussion towards a shared vision among all stakeholders how markets should evolve to meet the challenges introduced by the transition towards a clean energy system.

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[20] COMMISSION REGULATION (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation. OJ L 220. 25.8.2017, pages 1 – 120.