SUPPORTING DOCUMENT

Proposal for amendments on capacity calculation methodology in accordance with Article 20(2) of Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management by all TSOs of Nordic Capacity Calculation Region

12 April 2019

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1. Introduction

This document is a supporting document concerning the proposed amendments to the approved capacity calculation methodology as requested by the NRAs of CCR Nordic (hereafter "RfA").

According to CACM Regulation Article 9(13), NRAs may request amendments to the capacity calculation methodology. The TSOs of CCR Nordic shall submit the amendment for consultation and after the consultation amendment will be approved in accordance with procedure set in Article 9.

The amendments to comply with NRAs' RfA are explained in this document.

The NRAs of CCR Nordic, i.e. regulatory authorities of Denmark, Finland and Sweden, have requested amendments to capacity calculation methodology. Thus, Danish, Finnish and Swedish TSOs have developed the proposal for amendments in co-operation.

2. Background

2.1 NRAs' decision on capacity calculation methodology in July 2018

The TSOs submitted the original proposal for a capacity calculation methodology to the NRAs on 17 September 2017. The NRAs made a request for amendments and submitted the request to the TSOs on 16 March 2018. The TSOs submitted the amended proposal to the NRAs on 16 May 2018.

The regulatory authorities of CCR Nordic together with the Norges vassdrags og energidirektorat (NVE) reached an agreement on 10 July 2018, that the amended proposal meets the requirements of Regulation 2015/1222 and can be approved. The national decisions by NRAs based on this agreement were taken by 16 July 2018 at the latest.

Although the regulatory authorities agreed that the CCM proposal was generally deemed compliant with relevant articles of Regulation 2015/1222, the NRAs of CCR Nordic noted that capacity calculation is a regional task which, according to CACM, should be assigned to the coordinated capacity calculator (hereinafter referred to as "CCC") in the CCR Nordic. The proposal did not provide sufficient clarity on the roles in capacity calculation, especially regarding dynamic stability calculation. The NRAs of CCR Nordic agreed that the TSOs should start preparing to refine the agreed capacity calculation methodology with processes and elements to enable the CCC to handle dynamic stability in capacity calculation on a regional level. The NRAs of CCR Nordic agreed to initiate a request for amendment of the capacity calculation methodology to clarify the roles and responsibilities of the CCC and individual TSOs by the end of 2018.

Without prejudice to each TSOs' task to ensure operational security, all NRAs of CCR Nordic did agree that the model for operational capacity calculation for the CCR Nordic in the future includes that:

- CCC shall calculate the capacities using the technical limitations of the system needed to ensure secure system operation i.e. operational security limits, defined in the CACM Regulation as the acceptable operating boundaries for secure grid operation such as thermal limits, voltage limits, short-circuit current limits, frequency and dynamic stability limits.

- Each Nordic TSO is required to provide the operational security limits to the CCC in an appropriate format[1] as well as all the relevant data needed to use the security limits in the regionally coordinated capacity calculation process. The appropriate format for the operational security limits shall not include any pre-calculation by the individual TSO where the operational security limits are transposed to flow limits presented with MW values.

The Common Grid Model (CGM) methodology has been approved by all EU NRAs[2]. All NRAs of CCR Nordic agreed, as regards the development and future use of a CGM for dynamic stability calculations, that each Nordic TSO is required to share all relevant data, including dynamic data, among the TSOs to ensure that an appropriate CGM can be developed. Also, each Nordic TSO is required to contribute actively to the development of an appropriate version of the CGM, which includes also dynamic data. The CCC shall use the appropriate version of the CGM for capacity calculation.

Also, although the NRAs of CCR Nordic and NVE agreed to approve the capacity calculation methodology, the NRAs of CCR Nordic did foresee that the methodology should be evaluated further to ensure that the CACM objectives for coordinated capacity calculation are fully realised. The up-coming implementation process, especially the parallel runs, gives the NRAs of CCR Nordic and market players valuable knowledge on how the methodology works in practice and how it might be developed. The NRAs of CCR Nordic follow the work by the TSOs in close cooperation with NVE and the Agency for the Cooperation of Energy Regulators. The NRAs of CCR Nordic agreed to come back with request for amendments when/if deemed appropriate.

2.2 Request for amendment on the all TSOs' of CCR Nordic capacity calculation methodology in accordance with Article 20 of the CACM Regulation from NRAs of CCR Nordic

The RfA as received from the NRAs of the CCR Nordic, is embedded in the Annex I.

As explained in the previous sub-chapter the NRAs of CCR Nordic agreed to make a further request for amendment to the capacity calculation methodology. The specifics regarding the deficiencies and unclarities of the approved methodology were agreed in a common document[3] (as explained in previous sub-chapter), which acts as the basis for the changes required in request for amendment ("RfA") dated on 12 December 2018.

Article 9(13) of the CACM Regulation constitutes the legal basis for the NRAs of CCR Nordic to request an amendment to the methodology after the approval.

Any request in the RfA referring to a specific article is to be interpreted to apply for the whole methodology and requested changes to the capacity calculation methodology include:

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[1] Operational security limits can be effectively presented in appropriate units describing a specific power system physical property such as thermal limits in MVA, voltage limits per unit, frequency relative to nominal and dynamic stability limits per unit for voltages and damping for electromechanical oscillations.

[2] All TSOs' proposal for a common grid model methodology in accordance with Article 17 of Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management

[3] Agreement by all Regulatory Authorities of CCR Nordic on the next step after the approval of TSOs' Proposal for a Capacity Calculation Methodology in accordance with Article 20.2 of Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a Guideline on Capacity Allocation and Congestion Management on the Determination of Capacity Calculation Regions, 10.7.2018

- The Whereas-section lays out details concerning the Common Grid Model ("CGM") and its role in the capacity calculation methodology. The NRAs request the TSOs to start developing an appropriate grid model in coordination with each other, in order for the CCC to handle dynamic stability in capacity calculation. CCR Nordic NRAs expect the requirements concerning the calculation of dynamic stability limits could be fulfilled by creating the necessary processes and elements that would function alongside the current approved all-European CGM, without the need to amend the CGM methodology itself. The TSOs shall thus revise the methodology by correcting the descriptions on the role and relevance of CGM to match the requirements set in this RfA on the development of capacity calculation methodology if required. This can be interpreted as a requirement to create an add-on, which would be connected to the approved CCM, but it can as well be interpreted to refer to any other kind of operation or tool, which will enable dynamic capacity calculation in the Nordic CCR in a manner that would be compatible with the CGM.
- The TSOs shall clarify the methodology by clearly defining and describing the roles and rules, according to which the CCC will handle dynamic stability in capacity calculation in CCR Nordic, after the methodology has been implemented in accordance with the milestones and criteria.
- The details concerning capacity calculation performed by the CCC shall be in line with the following CACM-principles: The CCC shall calculate the capacities using the technical limitations of the system needed to ensure secure system operation i.e. operational security limits, defined in CACM as the acceptable operating boundaries for secure grid operation such as thermal limits, voltage limits, short-circuit current limits, frequency and dynamic stability limits.
- The TSOs shall expand the sentence in Article 4(1) in the methodology to state that each Nordic TSO is required to provide the operational security limits to the CCC in an appropriate format as well as all the relevant data needed to use the security limits in the regionally coordinated capacity calculation process.
- The TSOs shall include a detailed description in the CCM of the appropriate format used for the provision of operational security limits, according to the following principles: The methodology shall be amended to state that operational security limits shall be presented in appropriate units describing a specific power system physical property. For example, thermal limits shall be presented in MVA, voltage limits per unit, frequency relative to nominal and dynamic stability limits per unit for voltages and damping for electromechanical oscillations. As the end target, the appropriate format for the operational security limits shall not include any pre-calculation by the individual TSO where the operational security limits are transposed to flow limits presented with MW values.
- Article 31 on capacity calculation process shall be amended to also include the process presented in Figure 2 in a written format clarifying the roles and responsibilities of TSOs and the CCC in legally robust manner. The TSOs shall go through each entity, task, role, input and output of data through the process, explaining the respective details, while also referring to the relevant articles of the methodology.

The NRAs of CCR Nordic state that as the changes required in this RfA will require big alterations in the current operations such as development of new IT tools and processes, the methodology should be expanded to define the temporary capacity calculation method used until the methodology fulfilling the requirements in this RfA can be implemented in line with milestones and criteria set in Article 32.

Furthermore, the NRAs of CCR Nordic write in their RfA that Article 32 includes tables on milestones and criteria. As the NRAs are requesting the TSOs to develop an appropriate CGM or the necessary processes and elements to function alongside the current CGM, there should be additions in the implementation and milestones. The TSOs should update the plans and timelines in accordance with the upcoming work and to match the requirements set in the RfA. The NRAs of CCR Nordic expect the TSOs to amend the methodology by presenting a plan with milestones that define the step-wise implementation of the fully coordinated methodology as described in the RfA. The NRAs of Nordic CCR consider the work to be done in order to fulfil the requirements of the RfA to be interlinked with the milestones described in Article 32 on implementation of the FB approach. The NRAs of Nordic CCR also expect that the implementation plan for having the CCC calculate the dynamic stability limits will progress simultaneously with the implementation of the FB approach and thus expect the work to start without delay. The target model for calculating capacities, as described in NRAs' list of requested changes above, should be considered throughout the continued implementation of the CCM.

The RfA requests that the TSOs of CCR Nordic shall deliver an amended capacity calculation methodology within 6 months following the reception of the RfA (i.e. by 20 June 2019). The TSOs' proposals for amendment to the terms and conditions of the methodology shall also be submitted to consultation in accordance with the procedure set out in Article 12 of the CACM Regulation.

3. Amendments to the approved capacity calculation methodology

This chapter presents explanations of the proposed amendments to take into account the RfA from the NRAs of CCR Nordic. The aim of the chapter is to provide explanation on the content of each article amended due to RfA and the thinking that lies behind these amendments.

3.1 Article 4: Methodology for determining operational security limits

According to the CACM Regulation Article 21.1(a) (ii), operational security limits, contingencies and allocation constraints are three features described as part of in capacity calculation:

> "*the methodologies for determining operational security limits, contingencies relevant to capacity calculation and allocation constraints that may be applied in accordance with Article 23".*

The following sub-sections give more details how these issues are taken into account in the capacity calculation.

3.1.1 Operational security limits

In the CACM Regulation Article 2 (7), operational security limits are defined as follows:

> *"'operational security limits' means the acceptable operating boundaries for secure grid operation such as thermal limits, voltage limits, short-circuit current limits, frequency and dynamic stability limits."*

Boundaries for secure grid operation are independent of whether the CNTC or FB approach is applied.

The list of operational security limits consists of limits applied in the operational security analysis. All operational security limits shall, however, be respected both during the normal operation and in application of the N-1 criterion when defining allowed power flows across the power system. The list of operational security limits may change in the future when the characteristics of the power system will change due to foreseen change towards sustainable electricity system.

Thermal limits are limits on the maximum power carried by transmission equipment due to heating effect of electricity current flowing through the equipment, and depend on the physical structure of the equipment and the voltage level. Ambient conditions like temperature, wind and the duration of overload will influence the limit. Larger power flows may be allowed for a short period of time. Thermal limits define the maximum allowed power flow on the specific equipment, unless other more restricting limits (e.g. voltage or dynamic stability limits) exist.

Voltage limits for each substation and its equipment are defined in kVs. Both maximum and minimum limits for voltages are defined. The voltage limits are based on voltage ranges as defined in the connection network codes. Power flows across the power system have an effect on the voltages; increasing power flows decrease voltages. The minimum voltage limit defines for each operational situation the maximum allowed power flows in the transmission grid to avoid too low voltages and the disconnection of the equipment by the protection systems.

Short-circuit current limits are defined for each substation and its equipment in kAs. Both minimum and maximum limits for short-circuit currents are defined. The minimum limit is important for selective operation of protection devices, so that faults can be timely and selectively cleared. The maximum limit is set to ensure that devices connected to the grid can withstand induced fault currents. These limits do not influence the allowed power flows in the AC grid, but are there to ensure the functioning of protection systems and that devices connected to the grid can withstand fault currents and that the probability of cascading faults beyond the N-1 criterion is minimized.

Frequency stability limits are based on frequency ranges set in the connection network codes and in the SO Regulation. Frequency stability limits are taken into account during dynamic stability studies to see if the limits would have affected the allowed power flows on the transmission grid. It is foreseen that these limits will have more effect in the future system operation, due to changes in the generation mix.

Dynamic stability limits consist of voltage and rotor angle stability limits. For voltage stability studies, the voltage limits during the fault in the power system and after clearance of the fault shall be studied to define the allowed power flows within the power system, respecting the voltage limits. For rotor angle stability studies, the power flow and generator rotor angle oscillations are studied for each operational situation to define the allowed power flows within the power system with predefined damping coefficients for power and rotor angle oscillations. The magnitude of oscillations and their damping depends on the structure of the power system and the power flows across the power system.

The acceptable operating boundary for secure grid operation is defined by a maximum flow on a CNE ($F_{u,max}$, $u \in \{T,V,DV,DD\}$), that is monitored in the operational security analyses and in real time operation defined as a MW limit for maintaining the voltage and short circuit current level, frequency and dynamic stability within its limits.

T = Thermal
V = Voltage, Static
DV = Voltage, dynamic
DT = Transient stability
DD = Damping

Figure 1 shows an example of how $F_{u,max}$ will be defined and how it relates to the F_{max} on a CNE.

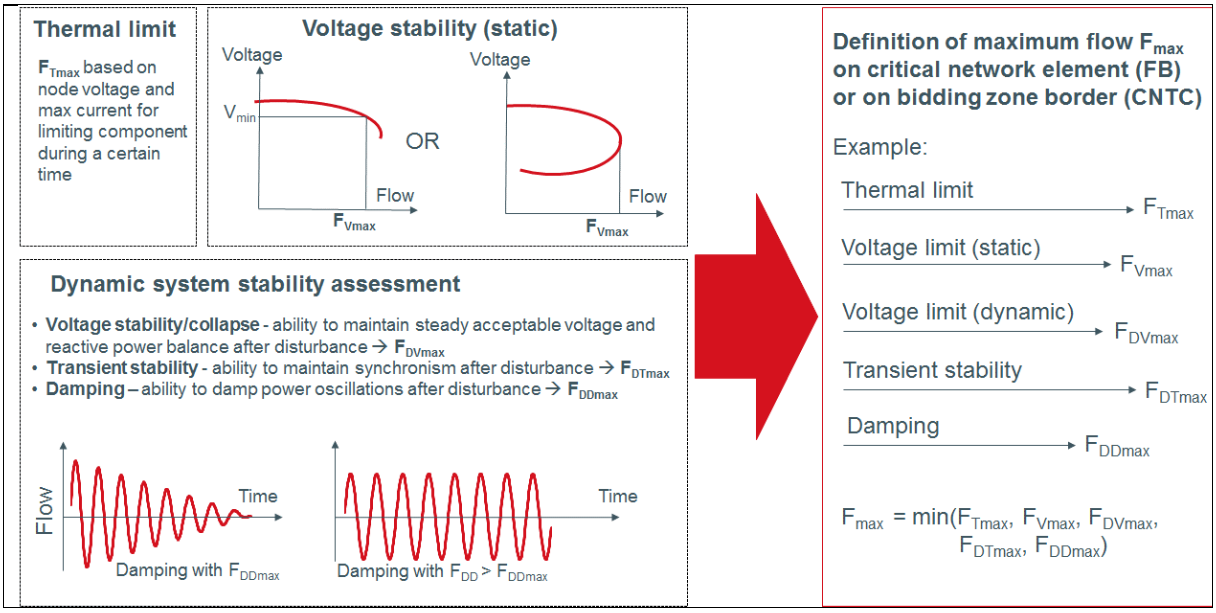

Figure 1 Definition of maximum flow (F_{max}) for CNEs

Generally, the $F_{u,max}$ are found by performing a network analyses on a relevant grid model, currently the TSOs' local grid models adjusted by the relevant grid topology, and considering an N-1 situation. The CGM will be used when sufficient data quality and performance is secured within this model.

3.1.2 RfA from NRAs of CCR Nordic

NRAs have requested that the TSOs shall expand the sentence in Article 4(1) in the methodology to state that each Nordic TSO is required to provide the operational security limits to the CCC in an appropriate format as well as all the relevant data needed to use the security limits in the regionally coordinated capacity calculation process.

Furthermore, the TSOs shall include a detailed description in the CCM of the appropriate format used for the provision of operational security limits, according to the following principles: The methodology shall be amended to state that operational security limits shall be presented in appropriate units describing a specific power system physical property. For example, thermal limits shall be presented in MVA, voltage limits per unit, frequency relative to nominal and dynamic stability limits per unit for voltages and damping for electromechanical oscillations. As the end target, the appropriate format for the operational security limits shall not include any pre-calculation by the individual TSO where the operational security limits are transposed to flow limits presented with MW values.

The TSOs have amended Article 4(1) and Article 4(2) to comply with the RfA. The TSOs have included the provision for appropriate units so that:

- thermal limits shall be presented as MVA or kA, for DC lines this implies MW;
- voltage limits shall be presented related to nominal voltage (per unit) or kV;
- frequency limits shall be presented related to nominal frequency or Hz; and
- dynamic stability limits shall be presented per unit for voltage and damping for electromechanical oscillations

In addition to this, the TSOs have clarified in Article 4(2) that these operational security limits shall not include any pre-calculation by the individual TSO, where the operational security limits have been transposed to power flow limits presented with MW values.

3.2 Article 31: Capacity calculation process

Article 31 presents a graphical overview that depicts the roles and entities involved, and the input and output data in the capacity calculation process for the day-ahead market timeframe. The same process applies for the capacity calculation process for the intraday market timeframe.

The NRAs of CCR Nordic request in their RfA that Article 31 on capacity calculation process shall be amended to also include the process presented in Figure 2 in a written format clarifying the roles and responsibilities of TSOs and the CCC in legally robust manner. The TSOs shall go through each entity, task, role, input and output of data through the process, explaining the respective details, while also referring to the relevant articles of the methodology.

The TSOs have amended Article 31 and included in written format the process shown in Figure 2. TSOs have clarified the roles and responsibilities of TSOs and the CCC by defining tasks for each entity with inputs and outputs of each task and referring to relevant articles of the capacity calculation methodology for each task.

3.3 Article 32: Publication and implementation

Today each Nordic Transmission System Operator (TSO) calculates the dynamic capacity limits based on local systems for Dynamic Security Analysis tailored for each area. The dynamic limits are then translated to dynamic Critical Network Elements (CNE / PTCs) which are passed on to the CCC.

The Nordic NRAs require Dynamic Stability Assessment (DSA) to be performed on a dynamic CGM for the CCR Nordic using a coordinated methodology.

The CCR Nordic NRAs has requested the CCR Nordic TSOs to prepare a plan for empowering the CCC to perform DSA based on operational security limits. This requires dynamic calculations to take place at the CCC.

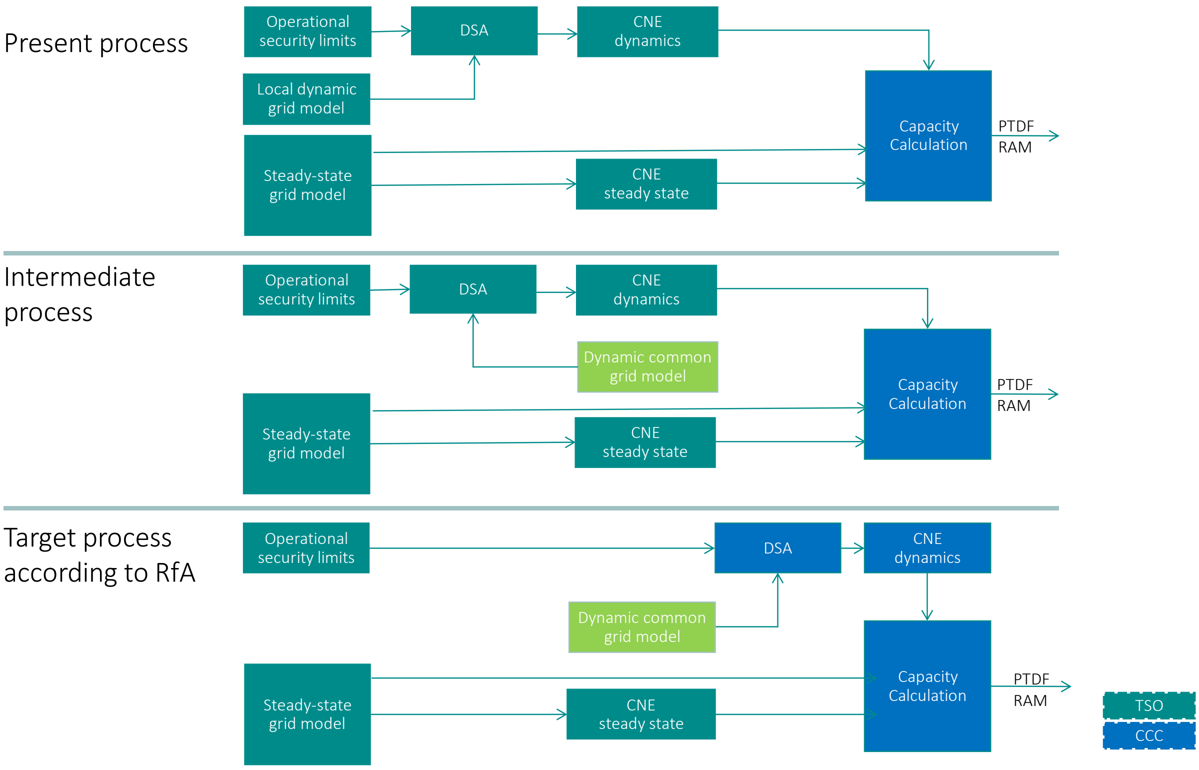

Figure 2 Present, intermediate, and target calculation processes

Today, the Nordic TSOs do not have a DSA for all capacity calculation timeframes for the Nordic power system.

In order to achieve the ambitious goal of enabling the CCC to perform DSA for capacity calculation, several fundamental prerequisites are necessary

- For all hours a successful creation of Individual Grid Models (IGM) from the TSOs and CGM merging at the CCC.
- Availability plans are included in the IGM for the all IGM timestamps. Planned outages must be considered.
- All necessary information to allow calculations is available for all participants (TSOs and CCC).

3.3.1 The way forward

First step is to identify each TSOs’ current process and needs for dynamic calculations on power transfer corridors and on bidding zone borders. Information on how dynamic calculations are performed today at each Nordic TSO, will bring clarity and give directions to the discussions on scope and wanted outcome. The first solution may be as today's process, but may include a TSO coordination and sharing of information.

Further on, new possibilities will probably arise when an online monitoring tool with continuous calculations is in place. This may reveal earlier hidden limitations in our power systems, and will contribute to new relevant information and knowledge. This information is not only relevant for operational planning and grid operators in daily operations, but also for grid planning.

Comparing grid reinforcement plans to new knowledge on grid components that limit the capacity due to DSA limitations, will bring an important perspective to the project organizations at each TSO. The new knowledge may lead to important perspectives on prioritizing grid reinforcements in a cost-efficient way with high value creation for Nordic countries – as a whole.

3.3.2 Implementation plan

As elaborated upon in the following sub-sections, the Nordic TSOs propose the following work items and milestones to fulfil the NRA requirements:

0. Clarification of security issues related to exchange of IGMs and dynamic data
1. Calculation methodology
2. Dynamic CGM - initial (proof of concept)
3. Dynamic CGM - extended (production grade)
4. Pilot testing
5. Processes and Rules
6. Development of IT requirements and specifications
7. Tendering and procurement
8. Implementation (including parallel run)
9. Go live

Overall timeline:

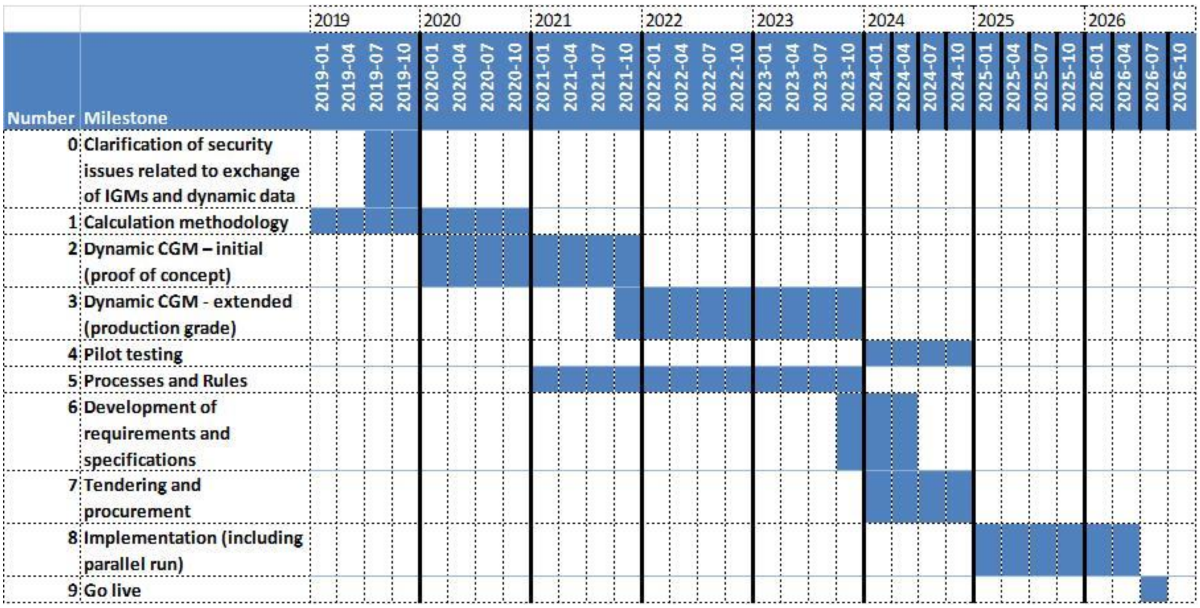

Figure 3 Overall time line for the DSA project

3.3.2.1 Security issues related to exchange of IGMs and dynamic data (milestone 0)

The interconnected power system is critical infrastructure and measures are taken to restrict data exchange to authorised personnel only. The closer to operational processes the stricter the security rules.

The current security policy does not allow all Nordic TSOs to share the necessary information to develop the dynamic CGM unless access, local storage and processing takes place on dedicated servers, only accessible via a separate local area network, in separate rooms and for agreed processes. This policy also restricts use of third party applications and enforces higher standards on the security clearance of the TSO employees. Such a policy is enforced for data exchanges to the CCC.

The challenge is that dynamic experts are typically with grid planning and that their working environment is not configured according to the security rules applicable for the operational process.

It remains to be clarified which classification level apply to the IGMs and dynamic data to allow for data exchange between Nordic TSOs and if the existing application environment is sufficiently secure.

This clarification is a prerequisite for starting the development of the dynamic CGM (milestones 3 and 4).

3.3.2.2 Milestone Calculation methodology (milestone 1)

This milestone is associated with a work package which shall further elaborate on a coordinated calculation methodology for dynamic studies based on the Nordic TSO's proposal for capacity calculation methodology in accordance with CACM.

The expected deliverables are:

- Document current practices for each TSO concerning the event definitions, treatment of System Integrity Protection Scheme (SIPS), scaling rules and evaluation criteria.
- Event definitions (contingencies) used in the calculation process.
    - The events, methods, and/or principles of determining the most critical events. The event definitions should cover also the outage scenarios in the system.
- Treatment of system integrity protection schemes (SIPS).
    - Document how the SIPS works and how they are handled in the calculation process. The definition should include whether they are integrated as part of the simulation model or as part of the event definition (response based or event based).
- Scaling rules when changing base case power flow.
    - Defining the rules for scenario scaling for power transfer capacity calculations across bidding zones.
    - Defining the rules for use of generation shift keys (GSK)[4], merit order lists as well as scaling of loads and HVDCs.
- Evaluation criteria (rotor angle, voltage and frequency stability) for defining whether the calculated scenario is stable in terms of rotor angle, voltage and frequency stability where the thermal limits are not exceeded.
    - Common and harmonized evaluation criteria are preferred.

Different criteria can be considered for different areas or areas with different importance when properly justified.

3.3.2.3 Milestone Dynamic CGM – initial (milestone 2)

DSA shall be calculated on the Nordic CGM exchanged for operational planning. The underlying IGMs are collected in the CGMES format and comprise steady-state information to which the dynamic data shall be added.

The model shall enable all tools used by the Nordic TSOs and in the future the CCC to execute DSA.

Currently, not all IGMs have sufficient steady-state models to support dynamic calculations (for instance missing step-up transformers, missing plant auxiliary load, different medium-voltage grid

[4] The linear generation shift keys proposed in the CACM will not work for dynamic studies if operational limits are exceeded.

representation, and different equivalent of embedded generation). Some IGMs (for instance the Norwegian) may require network reduction in order to align with the scope of the planning model and facilitate dynamic simulations. The gaps shall be identified and actions shall be proposed to reach a sufficient level of detail.

It is **not** defined in the NRAs' decision whether Common Grid Model Exchange Specification (CGMES) standard format should be used for the dynamics data exchange or whether some custom data format (e.g. PSS/E dyr) can also be used. Therefore, this work package is heavily dependent on the decision to be taken on the exchange format for dynamic models.

Data exchanges shall be prepared for interoperability for relevant simulation tools of the CCR Nordic. The intermediate solutions can be based on proprietary formats but it is recommended that the long-term solution is based on open data formats such as CGMES with extension for user-defined models.

Careful testing of the resulting dynamic models is required for both the separate models as well as the complete grid model. To ensure interoperability each tool will have to provide thorough test data for the comparison (such as step response test).

Generally, each TSO shall be responsible for preparing his own models while adaptations of commonly used models can be shared. In particular, this is expected to impact Statnett and Svenska kraftnät (having the largest number of user-defined models).

A first deliverable of the work package could be a simplified dynamic model using generic models for hydro, nuclear, thermal, and wind. Such a simplified model can then be gradually improved by adding more specific models. An initial model will be useful for prioritising the further developments.

The dynamic calculation shall be evaluated against "Operational Security Limits". Examples are maximum rotor angle, voltage envelopes or frequency limits. This information is not part of the currently approved CGM. The details for this data exchange is determined.

3.3.2.4 Milestone Dynamic CGM – extended (milestone 3)

Experience from simulations using the initial dynamic model is used to improve the simulation environment. This allows for an agile approach where findings from shortcomings identified in the initial model are addressed. This could both lead to models with higher level of details or removal of parts which impact simulation performance and are less significant.

The RfA specifically focuses on the Coordinated Capacity Calculation (CC) process. However, from a TSO perspective it is important that the use cases for Security Analysis (SA) and Outage Planning Coordination (OPC) are also fully addressed by the simulation environment. From a TSO perspective CC, SA and OPC are closely related.

The dynamic CGM shall support full interoperability between different simulation tools used in the CCR Nordic environment. This requires detailed model comparison between the different implementations.

System model validation against system disturbances is particularly important, and this carried out whenever a significant event has taken place. Examples are short circuit-faults, activation of SIPS, trip of large power stations, emergency power activation, interarea oscillations.

As a part of milestone 3, a Request for Information (RFI) should be initiated. The purpose of the RFI is to gain knowledge about tool providers and product based solutions available on the market. The acquired information from the RFI will be utilized in the preparations for an upcoming procurement process. Information such as generic standard solutions, readiness, cost estimates, project scale and implementation set up and references are essential to gain a better understanding of the potential solutions available in the market. In order to better understand the necessary requirements and specifications, it is good practice to share goals and objectives with a potential supplier. The general requirements are specified in terms of high-level functionalities needed to perform the business process. The compiled information of the RFI supports the specification of the functional and non-functional requirements that will be utilized in the upcoming request for tendering (RFT). The learnings from the potential suppliers shall be cross-checked and reviewed with business leads in the organization in order to construct both the business processes as well as the functional requirements.

3.3.2.5 Pilot testing (milestone 4)

The tasks of creating a Pilot are:

- To describe different dynamic situations and calculate these within each TSO using methodology of today
- Compare the result of today with new calculations in a new tool/new tools when it's available and tested
- To make good quality studies, the different dynamic situations must contain all the different problems to be addressed. The task force must do a common detailed task description covering the different dynamic issues for further investigations

The differences in method of assessing dynamic limitations at each TSO, if there are any, must be acceptable. The TSOs shall not change the process in dynamic calculations, unless the new online monitoring tool requires new information and assessment of this task.

3.3.2.6 Milestone Processes and Rules (milestone 5)

The data flow, calculation process in a general level, responsibilities, and description of the intermediate and target solutions are described in the following figures. In the target solution, the CCC will do the actual calculation. The TSOs will be in supporting role by providing all the necessary data.

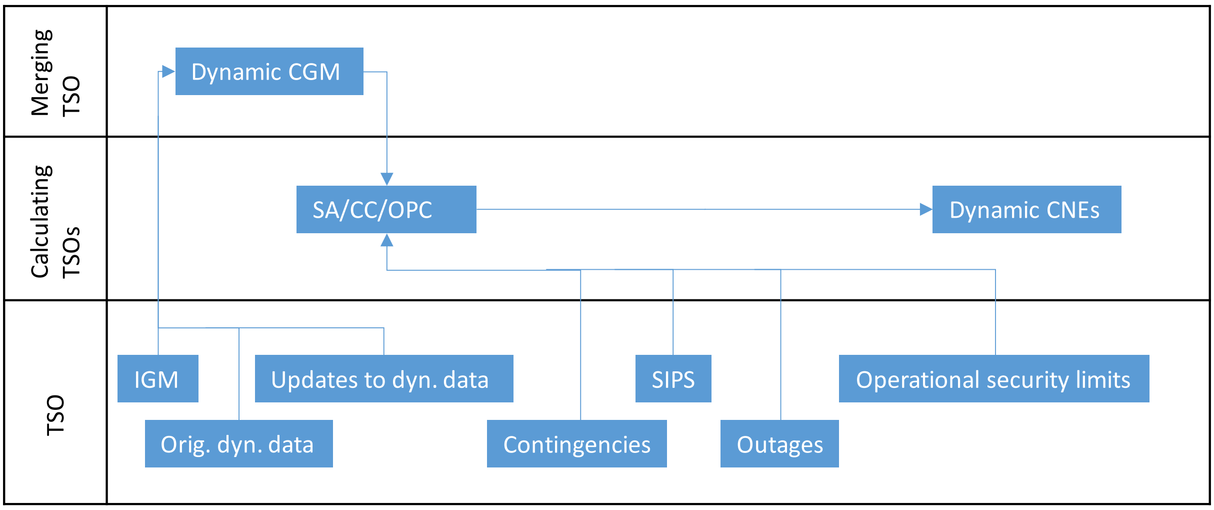

Figure 4 Process for intermediate solution

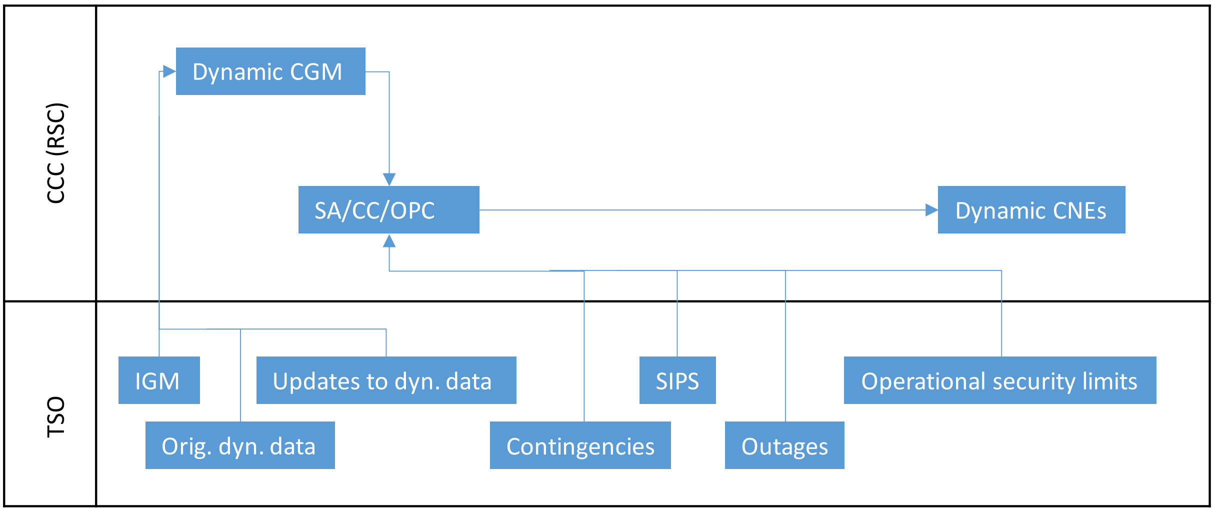

Figure 5 Process for target solution

In carrying out the actual calculation process (SA/CC/OPC), the methodology described in milestone 1 (Calculation methodology) will be applied. The dynamic model for calculation will be created in milestones 2 (Dynamic model – Initial) and 3 (Dynamic model – extended). Information for the dynamic model and updates to it will be provided by the TSOs. The TSOs will also provide all the other relevant data for calculation, including the IGMs, relevant contingencies, SIPS, outages, and operational security limits.

The business process tells us what activities should be accomplished to reach the goal of DSA. In short, the DSA business process is to perform a set of assessments in order to accomplish the delivery that determines transmission capacities considering dynamic stability limits. The information flow should be specified, meaning what information is the input (e.g. IGM, CGM) and output (e.g. stability assessment report and stability limitations).

3.3.2.7 Development of requirements and specifications (milestone 6)

The objective of this milestone is to develop requirements in order to make a request for tendering.

The requirements can be divided into functional and non-functional requirements. The functional requirements specify what the system should do, that is what functionalities it should have to satisfy the users' needs. Based on the methodology described in milestone 1 those functionalities should be specified in terms of requirements. The functional requirements should describe data to be entered into the system, operations performed, work-flows performed by the system, reports or other outputs/exports of results, who can enter the data into the system. Some concrete examples of functional requirements are: read the CGM, run load-flow, run various dynamic simulations.

The non-functional requirements are requirements that do not actually do anything, however, needed to have a functioning system. Such requirements are performance, adaptability, reliability, availability, redundancy, capacity and expansibility, security (including cyber security), credibility, sensibility, accuracy, standards, system construction. The non-functional requirements also include IT requirements such as database solution and operative system.

It also needs to be specified how the requirements should be tested and validated. The specifications work as the basis for the request for tendering process and the requirements are divided into *shall, should* and *could* requirements.

3.3.2.8 Tendering and procurement (milestone 7)

First recommendation is to set the procurement team right from the beginning, and make sure both IT people, Business people and Procurement people are very experienced, are very cooperative and that the chemistry of the team is good. Next recommendation is to do comprehensive market research before starting the tender process. This serves two purposes 1) the Suppliers become aware of the tender process and can influence the tender material and 2) you can develop a clearer tender strategy and help pointing in the right direction.

It is recommended to include a live demonstration or proof of concept as part of the tender process.

3.3.2.9 Implementation (including parallel run) (milestone 8)

The required IT and software tools must be properly commissioned both at the TSOs and CCC before moving to the parallel run period. It is possible that some form of development or customizations are needed. Therefore, it is important to carefully design the System. This takes particular importance in case the System needs to interface to other existing systems. The experts with sufficient skills should be assigned to this task in order to guarantee successful commissioning. Testing needs to be carried out along the process and depending on the magnitude of the task ahead, several releases may be scheduled, grouped by functionality and dependencies on other systems.

A lengthy parallel run period (about one year) is needed between the new and old processes in order to secure that the shift to the new process is secure. The parallel run is needed both at the TSOs with old and new processes but also between the TSOs and CCC in order to secure smooth handover to the CCC. Parallel run is also needed to make users accustomed with the new tools and also to provide hands-on training, before the system goes finally into full operation.

Both the TSO and CCC staff needs to be properly trained to use the commissioned IT, tools, models, and methodologies for successful DSA.

3.3.2.10 Go live (milestone 9)

A Go Live date depends upon the chosen tool for dynamic calculations, and the realization of plans regarding procurement of new online monitoring tool.

Annex I – Request for amendment on the all TSOs' of the Nordic Capacity Calculation Region Capacity Calculation Methodology in accordance with Article 20 of the Commission Regulation (EU) 2015/1222

Request for amendment on the all TSOs' of the Nordic Capacity Calculation Region Capacity Calculation Methodology in accordance with Article 20 of the Commission Regulation (EU) 2015/1222

12 December 2018

1) The TSOs delivered an amended capacity calculation methodology ("methodology") to the NRAs on 16th May 2018. Having assessed the amended methodology in a coordinated manner, the CCR Nordic NRAs concluded that the methodology had improved significantly, and that it could be approved. The CCR Nordic NRAs approved the amended methodology in July 2018. While approving, the CCR Nordic NRAs however recognized a need to further clarify individual sections of the methodology. Because of this, the CCR Nordic NRAs agreed to make a further request for amendment to the methodology by the end of the year 2018. The specifics regarding the deficiencies and unclarities of the approved methodology were agreed in a common document[1] (CCM Annex 1), which acts as the basis for the changes required in this Request for Amendment ("RfA").

2) CACM GL Article 9 (13) constitutes the legal basis for the NRAs to request an amendment to the methodology after the approval.

3) The CCR Nordic TSOs shall deliver an amended methodology within 6 months following the reception of this RfA. The TSOs' proposals for amendment to the terms and conditions of the methodology shall also be submitted to consultation in accordance with the procedure set out in CACM Article 12.

4) Regulation (EC) No. 714/2009 with its Annex 1 on the [Guidelines on the Management and Allocation of Available Transfer Capacity of interconnections between national systems] and CACM GL constitute the main legal basis for the development and implementation of a common CCM. In particular, the CCM with its various components is subject to requirements set in CACM GL Section 3 and should after an overall assessment fulfil the objectives laid down in CACM GL Article 3.

List of requested changes to the Capacity Calculation Methodology

5) Any request in the RfA referring to a specific article, shall be interpreted to apply for the whole methodology:

6) The Whereas -section lays out details concerning the Common Grid Model ("CGM") and its role in the Capacity Calculation Methodology. The NRAs request the TSOs to start developing an appropriate grid model in coordination with each other, in order for the CCC to handle dynamic stability in capacity calculation. CCR Nordic NRAs expect the requirements concerning the calculation of dynamic stability limits could be fulfilled by creating the necessary processes and elements that would function alongside the current approved all-European CGM, without the need to amend the CGM methodology itself. The TSOs shall thus revise the methodology by correcting the descriptions on the role and relevance of CGM to match the requirements set in this RfA on the development of Capacity Calculation Methodology if required. This can be interpreted as a requirement to create an add-on, which would be connected to the approved CCM, but It can as well be interpreted to refer to any other kind of operation or tool, which will enable dynamic capacity calculation in the Nordic CCR in a manner that would be compatible with the CGM.

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[1] Agreement by all Regulatory Authorities of CCR Nordic on the next step after the approval of TSOs' Proposal for a Capacity Calculation Methodology in accordance with Article 20.2 of Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a Guideline on Capacity Allocation and Congestion Management on the Determination of Capacity Calculation Regions, 10.7.2018

7) The TSOs shall clarify the methodology by clearly defining and describing the roles and rules, according to which the CCC will handle dynamic stability in capacity calculation in CCR Nordic, after the methodology has been implemented in accordance with the milestones and criteria.

8) The details concerning capacity calculation performed by the CCC shall be in line with the following CACM -principles: The CCC shall calculate the capacities using the technical limitations of the system needed to ensure secure system operation i.e. operational security limits, defined in CACM as the *acceptable operating boundaries for secure grid operation such as thermal limits, voltage limits, short-circuit current limits, frequency and dynamic stability limits*.

9) The TSOs shall expand the sentence in Article 4(1) in the methodology to state that each Nordic TSO is required to provide the operational security limits to the CCC in an appropriate format as well as all the relevant data needed to use the security limits in the regionally coordinated capacity calculation process.

10) The TSOs shall include a detailed description in the CCM of the appropriate format used for the provision of operational security limits, according to the following principles:

    The methodology shall be amended to state that operational security limits shall be presented in appropriate units describing a specific power system physical property. For example, thermal limits shall be presented in MVA, voltage limits per unit, frequency relative to nominal and dynamic stability limits per unit for voltages and damping for electromechanical oscillations. As the end target, the appropriate format for the operational security limits shall not include any pre-calculation by the individual TSO where the operational security limits are transposed to flow limits presented with MW values.

11) Article 31 on capacity calculation process shall be amended to also include the process presented in Figure 2 in a written format clarifying the roles and responsibilities of TSOs and the CCC in legally robust manner. The TSOs shall go through each entity, task, role, input and output of data through the process, explaining the respective details, while also referring to the relevant articles of the methodology.

12) As the changes required in this RfA will require big alterations in the current operations such as development of new IT tools and processes, the methodology should be expanded to define the temporary capacity calculation method used until the methodology fulfilling the requirements in this RfA can be implemented in line with milestones and criteria set in Article 32.

13) Article 32 includes tables on milestones and criteria. As the NRAs are requesting the TSOs to develop an appropriate CGM or the necessary processes and elements to function alongside the current CGM, there should be be additions in the implementation and milestones. The TSOs should update the plans and timelines in accordance with the upcoming work and to match the requirements set in this RfA. The CCR Nordic NRAs expect the TSOs to amend the methodology by presenting a plan with milestones that define the step-wise implementation of the fully coordinated methodology as described in this RfA. The Nordic CCR NRAs consider the work to be done in order to fulfil the requirements of this RfA to be interlinked with the milestones described in Article 32 on implementation of the FB approach. The Nordic CCR NRAs also expect that the implementation plan for having the CCC calculate the dynamic stability limits will progress simultaneously with the implementation of the FB -approach and thus expect the work to start without delay. The target model for calculating capacities, as described in point 6-11 of this RfA, should be considered throughout the continued implementation of the CCM.

Annex II NRA Request for Amendment – relevant sections for DSA

The “relevant sections of the RfA” for DSA, as listed below, are referred to in the conditional timeline in the Annex III.

RfA 6	The Whereas -section lays out details concerning the Common Grid Model (“CGM”) and its role in the Capacity Calculation Methodology. The NRAs request the TSOs to start developing an appropriate grid model in coordination with each other, in order for the CCC to handle dynamic stability in capacity calculation. CCR Nordic NRAs expect the requirements concerning the calculation of dynamic stability limits could be fulfilled by creating the necessary processes and elements that would function alongside the current approved all-European CGM, without the need to amend the CGM methodology itself. The TSOs shall thus revise the methodology by correcting the descriptions on the role and relevance of CGM to match the requirements set in this RfA on the development of Capacity Calculation Methodology if required. This can be interpreted as a requirement to create an add-on, which would be connected to the approved CCM, but It can as well be interpreted to refer to any other kind of operation or tool, which will enable dynamic capacity calculation in the Nordic CCR in a manner that would be compatible with the CGM.
RfA 7	The TSOs shall clarify the methodology by clearly defining and describing the roles and rules, according to which the CCC will handle dynamic stability in capacity calculation in CCR Nordic, after the methodology has been implemented in accordance with the milestones and criteria.
RfA 8	The details concerning capacity calculation performed by the CCC shall be in line with the following CACM -principles: The CCC shall calculate the capacities using the technical limitations of the system needed to ensure secure system operation i.e. operational security limits, defined in CACM as the acceptable operating boundaries for secure grid operation such as thermal limits, voltage limits, short-circuit current limits, frequency and dynamic stability limits.
RfA 9	The TSOs shall expand the sentence in Article 4(1) in the methodology to state that each Nordic TSO is required to provide the operational security limits to the CCC in an appropriate format as well as all the relevant data needed to use the security limits in the regionally coordinated capacity calculation process.
RfA 10	The TSOs shall include a detailed description in the CCM of the appropriate format used for the provision of operational security limits, according to the following principles: The methodology shall be amended to state that operational security limits shall be presented in appropriate units describing a specific power system physical property. For example, thermal limits shall be presented in MVA, voltage limits per unit, frequency relative to nominal and dynamic stability limits per unit for voltages and damping for electromechanical oscillations. As the end target, the appropriate format for the operational security limits shall not include any pre-calculation by the individual TSO where the operational security limits are transposed to flow limits presented with MW values.
RfA 11	Article 31 on capacity calculation process shall be amended to also include the process presented in Figure 2 in a written format clarifying the roles and responsibilities of TSOs and the CCC in legally robust manner. The TSOs shall go through each entity, task, role, input and output of data through the process, explaining the respective details, while also referring to the relevant articles of the methodology.
RfA 12	As the changes required in this RfA will require big alterations in the current operations such as development of new IT tools and processes, the methodology should be expanded to define the temporary capacity calculation method used until the methodology fulfilling the requirements in this RfA can be implemented in line with milestones and criteria set in Article 32.

RfA 13	Article 32 includes tables on milestones and criteria. As the NRAs are requesting the TSOs to develop an appropriate CGM or the necessary processes and elements to function alongside the current CGM, there should be be additions in the implementation and milestones. The TSOs should update the plans and timelines in accordance with the upcoming work and to match the requirements set in this RfA. The CCR Nordic NRAs expect the TSOs to amend the methodology by presenting a plan with milestones that define the step-wise implementation of the fully coordinated methodology as described in this RfA. The Nordic CCR NRAs consider the work to be done in order to fulfil the requirements of this RfA to be interlinked with the milestones described in Article 32 on implementation of the FB approach. The Nordic CCR NRAs also expect that the implementation plan for having the CCC calculate the dynamic stability limits will progress simultaneously with the implementation of the FB -approach and thus expect the work to start without delay. The target model for calculating capacities, as described in point 6-11 of this RfA, should be considered throughout the continued implementation of the CCM.

Annex III Process implementing coordinated DSA

The RfA# as mentioned in the various milestones in red in the table below, refers to the "relevant sections of the RfA" for DSA; those "relevant sections" are listed in the Annex II.

#	Milestone	Deliveries before moving to the next milestone
0	Clarification of security issues related to exchange of IGMs and dynamic data	• Data exchange method between TSOs for the development phase. • Requirements to local storage. • Requirements to third party applications. • Employer security clearance.
1	Calculation methodology RfA6 Benefit for Capacity Calculation: *TSOs apply a coordinated methodology for calculation of dynamic CNEs*	• Document the current calculation methodology used by each TSO for dynamic security analysis. • Align the existing calculation methodologies and develop a new harmonised approach where this is needed. • Ensure transparency between TSOs so that everybody is able to reproduce the result of the neighbouring TSO. • Review of principles for season ahead CGM (Outage Planning Coordination).
2	Dynamic CGM – initial (proof of concept) RfA6, RfA8, RfA9, RfA10	• Make the dynamic data compatible with the Nordic CGM for operational planning. For dynamic coming from the Nordic planning model identify gaps between the operational and planning models to enable mapping of dynamic data on operational models. • Agree on how to exchange dynamic models (standard and user-defined models, parameters, current mode of operation). • Validate the implementation of individual generic dynamic models between simulation tools. • Issue an initial dynamic model to capture the "rough" system dynamics (intended proof of concept and test if information on methodology is sufficiently described). • Exchange format for dynamic "Operational Security Limits".
3	Dynamic CGM - extended (production grade) RfA6 Benefit for Capacity Calculation: *TSOs apply a dynamic CGM for calculation of dynamic CNEs*	• Request for information from tool vendors. • Include more details necessary for Coordinated Capacity Calculation (CCC), Security Analysis (SA), Outage Planning Coordination (OPC) • Validate the implementation of individual dynamic models between simulation tools. • Perform system model comparison against other simulation tools. • Perform system model validation against system incidents (measurement data). • Correction of modelling errors to provide correct response.
4	Pilot testing Benefit for Capacity Calculation: *Higher quality and higher resolution of dynamic CGM*	• Parallel run between new and existing processes (TSO-to-TSO). • Identification and solving differences in results.

5	Processes and Rules RfA7, RfA11, RfA12	• Develop processes for updating methodologies and tools. • Develop processes for upgrading and validating Dynamic CGM. • Description of intermediate (TSO-to-TSO) and target (including the CCC) solutions. • Development of business processes.
6	Development of requirements and specifications	• Specification of functional requirements. • Specification of non-functional requirement. • Development of IT requirements.
7	Tendering and procurement	• Assessment criteria. • Tendering. • Procurement and demonstration.
8	Implementation (including parallel run)	• Commissioning of IT and tools. • Parallel run between new and target processes (TSO-to-CCC). • Training of staff.
9	Go live Benefit for Capacity Calculation: *The CCC will calculate dynamic operational security limits for the CCC process*	• The CCC (and all TSOs) are fully empowered to do CCC. • TSOs have implemented the coordinated processes for Dynamic Stability Assessment (DSA).