Explanatory document for the amended Nordic synchronous area methodology for ramping restrictions for active power output in accordance with Article 137(3) and (4) of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation

Explanatory document to the methodology of 2 December 2021

1. Introduction

The Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (hereinafter **"SO Regulation"**) sets out rules on relevant subjects that should be coordinated between Transmission System Operators, as well as between TSOs and Distribution System Operators and with significant grid users, where applicable. The goal of the SO Regulation/Regulation (EU) 2019/943 is the safeguarding of operational security, frequency quality and the efficient use of the interconnected system and resources. In order to deliver these objectives, a number of steps are required.

One of these steps is to define the ramping restrictions for active power output for the Nordic LFC block. Pursuant to Article 119(1)(c) of the SO Regulation, all Transmission System Operators in the Nordic LFC block shall jointly develop common proposals for ramping restrictions for active power output in accordance with Article 137(3) and (4).

According to Article 6(3)(e)(i) of the SO Regulation the methodology for ramping restrictions for active power output in accordance with Article 137(3) and (4) shall be submitted for approval by the relevant national regulatory authorities (hereinafter "NRAs").

The methodology that is accompanied by this explanatory document amends the methodology that has been approved by the NRAs in November 2020 and takes into account the Request for Amendment of the Nordic NRAs of 1 October 2021. This methodology is from all TSOs of the Nordic synchronous area (hereinafter **"TSOs"**).

This explanatory document contains an explanation of the amendments. It is structured as follows. The legal requirements for the Methodology are presented in Chapter 2. Chapter 3 starts with describing the objective of the ramping restrictions. Chapter 4 provides an overview of the existing situation and Chapter 5 describes and explains the amendments. An outlook to future developments is described in Chapter 6. Chapter 7 describes the expected impact on the relevant objectives of the SO Regulation. Finally, Chapter 8 provides the timeline for implementation and Chapter 9 describes the public consultation.

2. Legal requirements and interpretation

2.1 Legal references and requirements

Several articles in the SO Regulation set out requirements which the Methodology must take into account. These are cited below.

(1) Article 119(1)(c) and (2) of the SO Regulation constitutes the legal basis that the Methodology should take into account. Article 119 has the following content:

> *"1. By 12 months after entry into force of this Regulation, all TSOs of each LFC block shall jointly develop common proposals for:[…]*
>
> *(c) ramping restrictions for active power output in accordance with Article 137(3) and (4); […]*
>
> *2. All TSOs of each LFC block shall submit the methodologies and conditions listed in Article 6(3)(e) for approval by all the regulatory authorities of the concerned LFC block. Within 1 month after the approval of these methodologies and conditions, all TSOs of each LFC block shall conclude an LFC block operational agreement which shall enter into force within 3 months after the approval of the methodologies and conditions"*

(2) Article 137(3) and (4) of the SO Regulation has the following content:

> *"3. All connecting TSOs of an HVDC interconnector shall have the right to determine in the LFC block operational agreement common restrictions for the active power output of that HVDC*

interconnector to limit its influence on the fulfilment of the FRCE target parameter of the connected LFC blocks by agreeing on ramping periods and/or maximum ramping rates for this HVDC interconnector. Those common restrictions shall not apply for imbalance netting, frequency coupling as well as cross-border activation of FRR and RR over HVDC interconnectors. All TSOs of a synchronous area shall coordinate these measures within the synchronous area.

4. All TSOs of an LFC block shall have the right to determine in the LFC block operational agreement the following measures to support the fulfilment of the FRCE target parameter of the LFC block and to alleviate deterministic frequency deviations, taking into account the technological restrictions of power generating modules and demand units:

(a) obligations on ramping periods and/or maximum ramping rates for power generating modules and/or demand units;

(b) obligations on individual ramping starting times for power generating modules and/or demand units within the LFC block; and

(c) coordination of the ramping between power generating modules, demand units and active power consumption within the LFC block."

(3) Article 6(3)(e)(i) of the SO Regulation states:

"The proposals for the following terms and conditions or methodologies shall be subject to approval by all regulatory authorities of the concerned region, on which a Member State may provide an opinion to the concerned regulatory authority: […]
(e) methodologies and conditions included in the LFC block operational agreements in Article 119, concerning:
(i) ramping restrictions for active power output in accordance with Article 137(3) and (4);

2.2 Interpretation and scope of the Methodology

Article 137(3) of the SO Regulation provides the TSOs with the right to determine common restrictions for the active power output of that HVDC interconnector. These restrictions may impact both operation of the HVDC interconnectors and market exchanges over these interconnectors.

Since the Nordic synchronous area only consists of one LFC block, the HVDC interconnectors to other LFC blocks are always HVDC interconnectors to other synchronous areas. The restrictions for the active power output of HVDC interconnectors between synchronous areas as referred to in Article 137(1) and (2) of the SO Regulation shall therefore be the same as the restrictions for the active power output of the HVDC interconnectors that are proposed in this Methodology.

Article 137(4) of the SO Regulation provides the TSOs with the right to determine ramping restrictions for power generating modules and demand units. Article 137(4)(a) and (b) allow defining obligations for power generating modules and/or demand units while Article 137(4)(c) allows the TSOs to actively coordinate between generating modules, demand units and active power consumption within the LFC block.

3. Objective of ramping restrictions for active power output

The objective of the ramping restrictions for active power output is to balance momentary generation, consumption and exchange over HVDC interconnectors and by that limit large FRCE and frequency deviations. This will contribute to that the frequency and FRCE quality target parameters for the LFC block are fulfilled.

Currently the Nordic frequency restoration process is based on frequency deviation in the synchronous area. The Nordic LFC block is however divided in several LFC areas corresponding to the bidding zones. In balancing, the potential congestions between these bidding zones and sometimes within the bidding zones will have to be considered and controlled. Ramping restrictions on LFC area level will contribute to safeguarding the Nordic FRCE quality. Consequently, these ramping restrictions ensure secure and efficient operation of the total electricity transmission system. The TSOs will define FRCE quality target parameters also for LFC areas to be used when ACE based balancing is implemented.

4. The existing situation

In this chapter, the existing ramping restrictions for active power output are presented. Section 4.1 describes the existing ramping restrictions for HVDC interconnectors and section 4.2 describes the existing ramping restrictions for production plans. Section 4.3 describes the existing possibilities for the TSOs to coordinate ramping between production plans. Ramping of consumption is currently not restricted nor coordinated.

The TSOs have investigated the efficiency of the existing ramping restrictions based on figures and simulations of 2019. Section 4.4 provides a summary of the results.

4.1 Existing restrictions for HVDC interconnectors

The trading plans on the HVDC interconnectors between the Nordic LFC block and other LFC blocks can potentially change so much from one hour to the next that the changes in power flows at the change of hours must be restricted to manage balance regulation and to stay within system security limits. For this reason, since 2007 the Nordic TSOs apply ramping restrictions on HVDC interconnectors in a harmonised way on the gradient for change in flow and on changes to the trading plans from one hour to the next in the energy market.

After the first introduction of these ramping restrictions, new HVDC interconnectors have been commissioned. For all these new interconnectors the same ramping restriction was applied as for the already existing interconnectors resulting in an increasing aggregated ramping rate for the Nordic LFC block.

Table 1 provides an overview of these restrictions for the existing bidding zone borders. The TSOs apply different ramping periods on the HVDC interconnectors.

Table 1: Existing restrictions between bidding zones

from	to	HVDC link	maximum gradient for change in flow (MW/min)	maximum changes to the trading plans from one hour to the next(MW)
Sweden (SE4)	Germany (DE/LU)	Baltic Cable	30	600
Finland (FI)	Estonia (EE)	Estlink 1	30	600
		Estlink 2	30	
Denmark (DK2)	Denmark (DK1)	Great Belt	30	600
Denmark (DK2)	Germany (DE/LU)	Kontek	30	600
Sweden (SE3)	Denmark (DK1)	Konti-Skan 1	30	600
		Konti-Skan 2		
Norway (NO2)	Denmark (DK1)	Skagerrak 1	30	600
		Skagerrak 2		
		Skagerrak 3		
		Skagerrak 4		
Sweden (SE4)	Lithuania (LT)	NordBalt	30	600
Norway (NO2)	Germany (DE/LU)	NordLink	30	600
Norway (NO2)	Netherlands (NL)	NorNed	30	600
Sweden (SE4)	Poland (PL)	SwePol	30	600
Finland (FI)	Russia (RU)	Vyborg	30	600

4.2 Existing ramping restrictions for production plans

The TSOs apply a ramping restriction on BRPs representing power generating modules in Finland, Norway and Sweden when their hourly production plan changes more than 200 MW at hour shift. In this case BRPs need to reschedule their plan with quarterly steps 15 minutes before hour shift, at hour shift and 15 minutes after hour shift in order to adjust the plans to better correspond to the consumption pattern. In Norway, the steps can be applied 30 minutes before the hour shift until 30 minutes after the hour shift. The detailed terms and conditions are specified on national level. This obligation is not relevant in Denmark East due to the physical characteristics for production.

4.3 Coordinate ramping of production plans

Based on the planning information and real-time information, each TSO assesses the impact of ramping around hour shifts from a national perspective. In addition, Svenska kraftnät and Statnett assess whether the changes in production plans in the Nordic area and the HVDC exchange around hour shift will impact the system frequency in a way that cannot be entirely handled by control centres in the minutes before and after hour shift. If so, there is a need to advance or delay parts of planned production steps at the hour shift. The power schedules may be changed from 30 minutes before hour shift till 30 minutes after the hour shift.

This coordination is mainly important during morning and evening hours and also around day shift. If the changes in the production plans are deemed to be too high, the TSOs make a coordinated plan on how to level out these changes by an agreement with BRPs that represent power generating modules to reschedule the production. In situations with congestions, there is also a need to decide in which order the rescheduling should take place. E.g. in case of close to congestion on Hasle from Norway to Sweden it may be wise to start with increased production in Sweden/Finland 15 minutes before hour shift and decreased production in Norway in the first 15 minutes after the hour shift[1]. The volumes to be shifted after the hour shift might be reassessed closer to real time if something unplanned occurs that would interfere with the initial plan.

4.4 Assessment of the efficiency of ramping restrictions

Steps in electricity trade have increased over the last decades due to tighter market integration and an increasing number of interconnections between countries and synchronous areas. As a result of this, increasing steps in production make it more and more difficult to ensure the security of supply in the Nordic synchronous area in general and the Nordic system frequency quality in particular. To mitigate this, the Nordic TSOs developed a 'package of measures' which include – among other measures – ramping restrictions on both HVDC interconnectors and production plans. Both ramping restrictions aim for reducing the deterministic steps in minute-by-minute plans. While the ramping restrictions on HVDC interconnectors limit the size of the steps from one hour to the next, ramping restrictions for production aim for splitting-up the steps at the hour shift to smaller quarterly steps. Together, these ramping restrictions limit the minute-by-minute imbalances and help the TSOs to maintain the system frequency.

The TSOs assessed these ramping restrictions in 2020. The assessment covered the ramping arrangements described in sections 4.1 to 4.3 and assesses operational and market issues with a focus on the Nordic synchronous area in 2019.

To evaluate the efficiency of the ramping restrictions on HVDC interconnectors (as described in in section 4.1), the Nordic TSOs assessed the socioeconomic cost of ramping restrictions and compared them with the cost of alternatives, while keeping the current frequency quality at today's level. For this, the TSOs performed market simulations, using the Euphemia algorithm: Both the situation with the existing ramping restrictions on HVDC interconnectors and the hypothetical situation without ramping restrictions have been simulated for January, March, June and October 2019, using historical grid situations and historical bids.

The simulation results in Figure 1 show that ramping restrictions on HVDC interconnectors are most effective when they are most needed: In the approx. 1% of the hours that without ramping restrictions the steps would have been the largest, ramping restrictions reduce the total step on all Nordic HVDC interconnectors to other synchronous areas by 570 to 2200 MWh/h (830 MWh/h on average) and prevent for situations with a step of more than 4300 MWh/h. In the other 99% of the hours, ramping restrictions reduce the steps by up to 630 MWh/h (33 MWh/h on average). The simulation results show that the steps on restricted HVDC interconnectors are either shifted to other hours or to other HVDC interconnectors. This results in only minor changes in average Nordic bidding zone prices. The impact of the restrictions on the socioeconomic welfare is limited to less than 1 million Euro per year.

[1] In Norway and Sweden, it is sometimes possible to reschedule production steps within the hour if there are available production changes to reschedule.

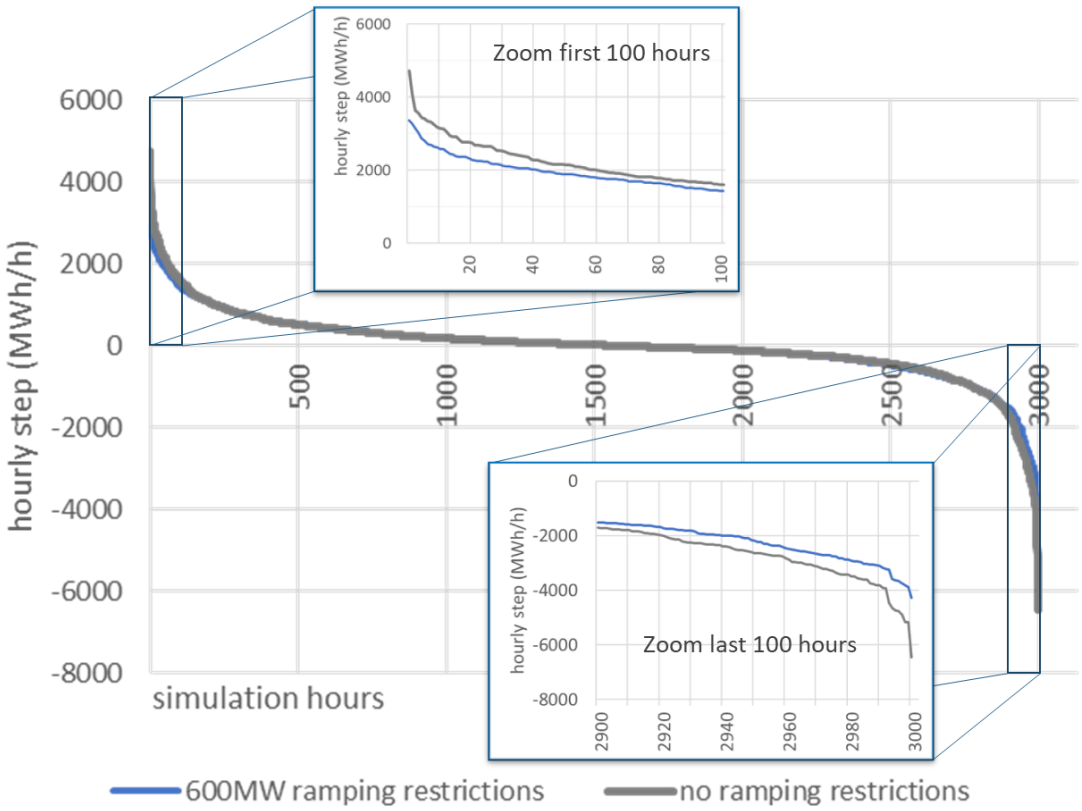


Figure 1: Total hourly steps for all Nordic HVDC interconnectors (except Vyborg), ranked to the simulation results, for January, March, June and October 2019.

The second type of ramping restrictions aim at minimising minute-by-minute imbalance by distributing hourly steps in production plans over different quarters (as described in section 4.2). The rules require that when the hourly production plan of a BRP changes more than 200 MWh/h at hour shift, the BRP is obliged to send in a quarterly production plan. BRPs ramping above 200 MWh/h usually have a larger number and mix of production units, which can be reoptimized across hours without deviating from the optimal setpoints of production units. In contrast, applying these rules to smaller steps than 200 MWh/h would also affect BRPs with less production units. If they cannot reoptimize across production units, this would result in a deviation from operating at optimal setpoints and, thus, a reduction in production efficiency. This would harm the level playing field and results in energy losses in the Nordic power system.

In practice, these rules mainly affect BRPs that operate hydro units with storage since these BRPs are able to quickly ramp at hour shift. This does not mean that the rules are not applicable to other types of production. However, due to their technical restrictions these other units implicitly follow the requirements (thermal units) or are hardly able to adjust (e.g. intermittent generation and run-of-river hydro generation). Consequently, the rules mainly impact Norway and Sweden, have limited impact in Finland (limited hydro with storage) and are not applied at all in Denmark (no hydro with storage).

The rules further allow the TSOs to adjust the production plans in order to minimise the minute-by-minute imbalance in the Nordic synchronous area (as described in section 4.3). The TSOs mainly adjust the plans during morning ramp hours and the day shift. But also during the evening there is quite significant quarterly adjustment. During these hours the TSOs shift up to 480 MW on average weekdays. In total, the TSOs shifted 403 GWh in 2019, which is less than 0,1% of the total Nordic production in 2019. For these adjustments the TSOs paid a compensation payment of 2.8 million Euros to mainly Norwegian and Swedish BRPs.

The restrictions above reduce the Nordic imbalance around the hour shift. To further reduce the minute-by-minute imbalance, the Nordic TSOs procure 600 MW of FCR-N around the clock and 300 MW aFRR (upward and downward) for the hours with the largest ramps. This is however not sufficient to meet the aimed frequency quality of 10.000 minutes outside the standard frequency range , but meets the target frequency quality parameter of 15.000 minutes outside the standard frequency range as specified in SOGL.

It can be argued that if more automatic reserves would be available, the ramping restrictions could be relaxed. However, this comes at a far larger cost: Contracting aFRR in order to slightly relax the ramping restrictions (from 600 MWh/h to 700 MWh/h) would cost 10 to 20 million Euros/year while the socioeconomic benefit in terms of avoided ramping restrictions would be less than 1 million Euro/year (resulting from the simulations described above). A reason for the big difference is that ramping restrictions only reduce socioeconomic welfare in hours that they are effective. Conversely, aFRR capacity needs to be procured for all the hours that large steps on interconnectors could be the result of the energy market clearing. It has to be further noted that – at least in the short term – this alternative is only a theoretical one since insufficient aFRR capability would be available to relax the potential ramping restrictions. Furthermore, it may be operationally challenging to operate with very large amounts of aFRR with current setup since these may also create additional flows and bottlenecks in the system. Additional aFRR is therefore not considered more efficient and effective than ramping restrictions.

Counter trading may also be considered as an alternative to mitigate ramping issues after the market results are known. The assessment shows that this alternative does not result in higher socioeconomic welfare than ramping restrictions while increasing the complexity in operations and the risk of market power abuse. Furthermore, an important challenge of the use of counter trade is that the prices in the spot market will not reflect the real value of power in the different bidding zones with detrimental consequences for use of hydro power storage as well as investments in consumer flexibility or generation capability. The TSOs therefore do not consider counter trading as a more efficient solution for ramping restrictions either.

To sum up, the TSOs consider ramping restrictions on HVDC interconnectors and production BRPs an efficient tool for mitigating large minute-by-minute imbalances at hour shifts, at least until the introduction of the new Nordic Balancing Model and the 15 minutes ISP. However, the assessment also provides some indication that ramping restrictions may be improved and better adapted to the increasing number of HVDC interconnectors.

5. Methodology for Ramping Restrictions

5.1 Overview

Momentary imbalances result from the momentary difference between generation and import on one side, and export and demand on the other side. However, a balanced ISP does not mean that system balance exists in every moment. A major reason for this is the difference in behaviour between generation and demand: Generation units tend to ramp quickly to their new set-point at the beginning of the ISP and keep their generation stable over the ISP. Conversely, demand increases linearly. The difference between the generation ramp and the consumption increase creates the momentary imbalance within the ISP and accordingly results in a FRCE. The effect is similar for import/export vs. generation. Also here there may be a mismatch between the quickly changing generation units and the gradually ramping HVDC interconnectors. It must be noted that these imbalances represent substantial volumes.

The mechanism that is described above is particularly present in the Nordic synchronous area because of the abundance of fast ramping hydro generators that increase their production in large steps during the morning hours to catch up with the increasing demand and increasing export (or decreasing import) on HVDC interconnectors with large aggregated exchange capacity. The opposite happens in the evening. It is clearly the size of the steps between the ISPs that are important.

In order to limit the momentary imbalance (and FRCE), the Nordic TSOs apply a number of measures. Some of these measures intend to mitigate consequences of the momentary imbalance (e.g. aFRR) and others try to prevent for them. Two of the latter ones are included in this methodology.

All TSOs' measures together result in the Nordic LFC block's FRCE quality and consequently the Nordic synchronous area's frequency quality. Since all measures affect each other and measures cannot be seen independently from each other, identifying the individual effect of one of the measures is difficult, if possible. The Nordic TSOs consider that – at this moment – they do not have another choice than applying all the measures. By relying on all these measures, the Nordic frequency quality during the previous decade was in between the Nordic aim (not more than 10,000 minutes per year outside the standard frequency range) and the limit set by the SO Regulation (15,000 minutes per year outside the standard frequency range). There seems to be an improvement in this trend in 2020 but then it must be noted that this year is characterised by an operational situation with large reductions in exchange capacity and very high hydro reservoir levels. The consequence has been small ramping volumes on HVDC interconnectors.

The TSOs have earlier informed about the increased operational challenges from increased volumes of renewables, increased exchange capacity and further market integration in a specific report[2] (see Textbox 1). This development will continue and the TSOs must safeguard system security as aimed for in the SO Regulation. However, the TSOs foresee that development in some of the measures, like expected larger aFRR volumes related to implementation of the mACE balancing, will contribute to an improved FRCE quality. The substantial increase in aFRR volumes will however take some time to be realised. Consequently, the TSOs propose to be careful with relaxing the existing ramping restrictions now. I.e. the proposed ramping restrictions are determined as per current operational conditions (see section 6 for outlook).

[2] Report 'Challenges and Opportunities for the Nordic Power System' (by Energinet, Fingrid, Statnett and Svenska Kraftnät), available on https://www.fingrid.fi/globalassets/dokumentit/fi/yhtio/tki-toiminta/report-challenges-and-opportunities-for-the-nordic-power-system.pdf

Textbox 1: Operational challenges for Nordic TSOs

Figure 2 shows that the Nordic power system is exposed to many changes, including the phasing out of the nuclear plant in Sweden, increasing wind production and new HVDC interconnectors. These changes require reinforcements in the TSOs' AC transmission networks and result in major challenges for the Nordic TSOs' system operation. The TSOs need to keep the related risks under control to be able to deliver high capacities to the market. The main issue is that the effect of all these changes on the power system cannot be predicted with great accuracy as many changes happen at the same time. Consequently, also changes in system operation have to be implemented stepwise.

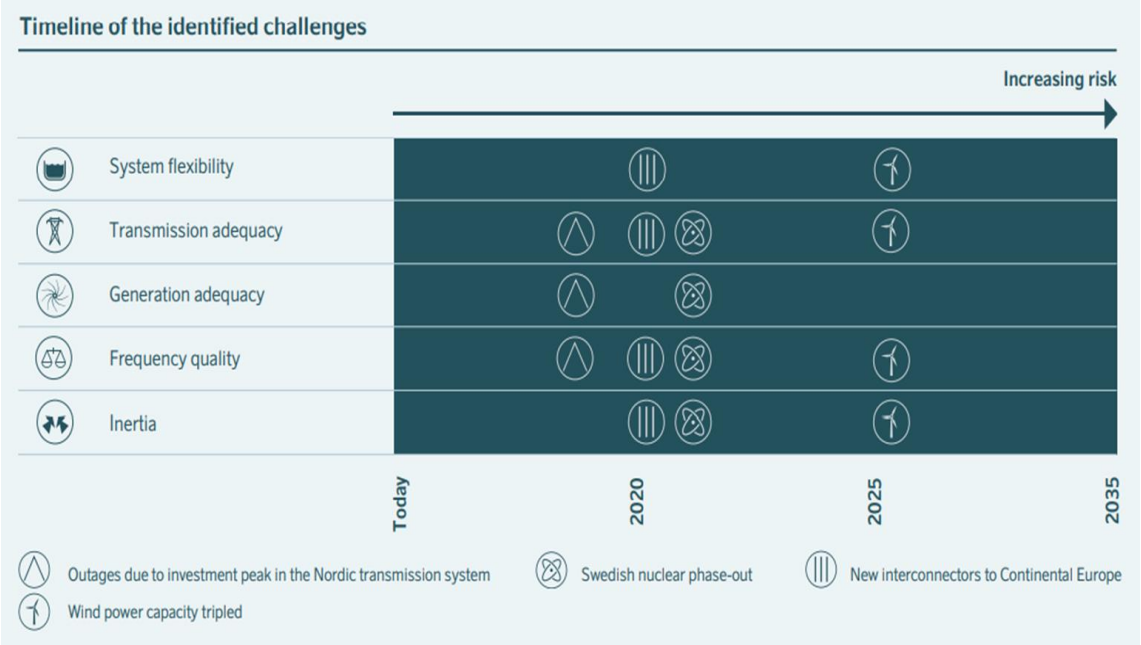


Figure 2: Timeline of challenges for the TSOs' system operation as identified[2]

The existing ramping restrictions for HVDC interconnectors and production plans (see sections 3, 4.1 and 4.2) and the existing possibilities for the TSOs to coordinate ramping between production plans (see section 4.3) limit large FRCE and frequency deviations and contributes to that the frequency and FRCE quality target parameters will be fulfilled. Consequently, the TSOs conclude that it is required to keep the existing ramping restrictions and coordination possibilities. Therefore, the TSOs only propose minor adjustments in the ramping restrictions and coordination possibilities to increase efficiency.

5.2 Amendments to the methodology

The connection of new HVDC interconnectors NordLink (in 2020) and North Sea Link (NSL) (in 2021) are the trigger for the proposed amendments to the methodology. Without additional measures, starting the operation of these HVDC interconnectors will result in increased ramping on the HVDC interconnectors to the Nordic synchronous area and accordingly harm the FRCE quality, the frequency quality and operational security.

Also in 2021, the 'Kriegers Flak combined grid solution' will start operation. This interconnector will operate in parallel to the existing Kontek HVDC cable that already connects bidding zone DK2 (Eastern Denmark) to Germany. The existing ramping rate between DK2 and Germany will consequently be used by both the Kontek cable and the Kriegers Flak combined grid solution.

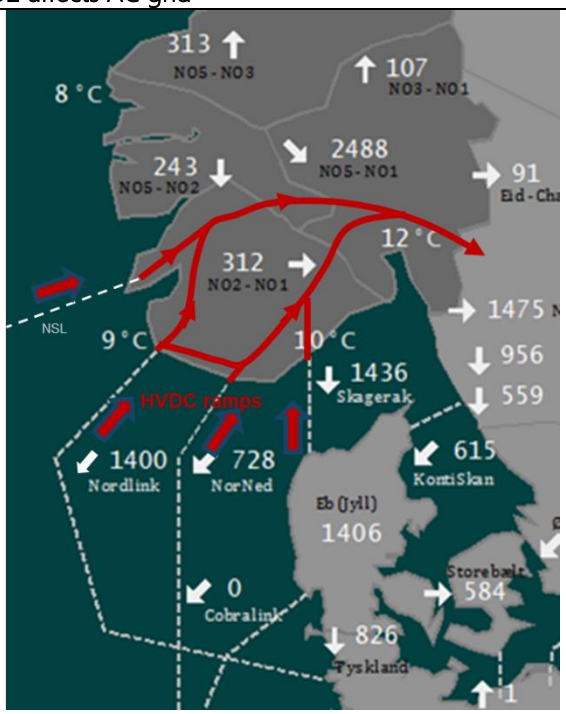
As argued above, the TSOs need to avoid further deterioration of the frequency quality. This means that the TSOs need to ensure that the very large steps from one hour to the next are avoided.

Although the new HVDC interconnectors affect the FRCE quality in the entire Nordic LFC block, the biggest impact will be on the FRCE quality and the flows in bidding zone NO2, to which both NordLink and NSL connect. Due to very quick changes in the flow in the grid over potentially congested corridors in southern Norway and towards Sweden in the Hasle corridor, additional measures are needed to be able to handle the increased ramping from these two new interconnectors without breaching operational securitiy limits. Textbox 2 elaborates on this issue.

Textbox 2: Increased ramping on HVDC interconnectors to NO2 affects AC grid

The ramping on the HVDC interconnectors connected to NO2 is currently restricted to 30 MW/min per HVDC interconnection. For the four interconnectors that will connect to NO2 this could result in a total flow change of 120 MW/min. At the same time, the margins between grid capacity given to the market and the maximum flow (the TRM), is 50 to 150 MW, dependent on the bidding zone border. With four HVDC interconnectors, the flow in the grid may change so much and fast that it is impossible to prevent overloads in the grid. It is noted that there are many potential congestions between Norwegian HVDC terminal points and Sweden. Consequently, the speed and magnitude of flow changes from ramping needs to be restricted to safeguard system security.

The proposed measures in this methodology safeguard a secure starting position of the daily operation. In cases with unforeseen operational situations or situations not dimensioned for, the TSOs may require additional measures, including the remedial actions as listed in Article 22(1) of the SO Regulation. A large scale and regular use of counter trade between TSOs using mFRR, would require that mFRR volumes had to be secured and considered in the FRR dimensioning. This would tie up resources from use in the energy markets.



Although often considered separately in regulation from a market perspective, in the operational practice frequency quality and network constraints are strongly linked to each other. To relieve congestions and to balance frequency is done simultanously using the same bid list and the two activation objectives effect each other continously. It has been observed more minutes outside the frequency band when the grid is congested and especially when there are several congestions at the same time. Incidents may also cause both issues with the frequency and the network. For example, a trip of a line that is loaded above its security limits may cascade into trips of more lines and consequently trips of power plants or HVDC interconnectors resulting in large and lasting frequency deviations or possibly blackouts. For this reason the congestion control is required to reach FRCE targets.

This means that in order to maintain FRCE quality of the Nordic LFC block and the frequency quality of the Nordic synchronous area, the increased flows in southern Norway due to the connection of NordLink and NSL need to be considered carefully. The flow changes on the individual HVDC interconnectors will all affect the potential congestions in the AC grid. For this reason, the amended methodology includes a total restriction for all the HVDC interconnectors connected to NO2. For practical reasons this total restriction consists of a combined restriction for three interconnectors and a separate restriction for NSL.

The connection of the new HVDC interconnectors NordLink and NSL also requires reinforcements in the AC grid in Southern Norway. Although these works are done in parallel to the completion of these HVDC lines, the completion will take three more years. During this time, some existing lines will need to be disconnected in the summer and spring periods.

Within the operational limits described above, the TSOs want to maximise Nordic socioeconomic welfare, and relax the ramping restrictions where possible. This needs to be done carefully to safeguard system operation. Therefore, it requires a gradual approach and some flexibility for TSOs to optimize between the objectives.

The assessment of the ramping restriction (see section 4.4) showed that ramping restrictions on HVDC interconnectors are an efficient tool with rather low socio-economic cost. The main reason is that the ramping restrictions are only active when they are needed, i.e. when the steps would otherwise be very large. The proposed amendments therefore use ramping restrictions on HVDC interconnectors for mitigating the issues described above. At the same time the proposed amendments intend to increase the efficiency of these ramping restrictions by introducing a combined restriction on bidding zone NO2 and by that making it possible to increase the ramping rates on individual HVDC interconnectors.

In summary, the TSOs therefore propose the following amendments:

- Keep the exisiting ramping restrictions as a starting point and make them applicable to new HVDC interconnector North Sea Link. Include Kriegers-Flak in the existing DK2-DE interconnection (implemented in Article 3(1) and 3(2));
- Introduce a combined ramping restriction for NorNed, NordLink and Skagerrak of 1200 MW from one hour to the next; and allow for increasing the individual maximum gradient for change in flow in MW/minute and the changes to the trading plans from one hour to the next in MW/hour on these three HVDC interconnectors. It is noted that NSL cannot be included because this interconnector is not part of the Internal Energy Market and its exchange is settled before the IEM (implemented in Article 3(3), 3(4), 3(5) and 3(6));
- After implementation of the combined restriction for NO2, the TSOs consider that the existing combined ramping restriction on Konti-Skan and Skagerrak is not required anymore (removed from the methodology);

5.3 Amendments to the methodology per amended Article.

This section repeats the amendments proposed in section 5.2, but now per article.

5.3.1 Article 2(2)

For clarification reasons and without the intention to change the meaning, the definition of the HVDC interconnector has been changed from *'a HVDC interconnector means one or more cables between two synchronous areas connected to the transmission grid in the same connection point on both sides'* to *'a HVDC interconnector means one or more HVDC cables between a bidding zone in the Nordic synchronous area and a bidding zone in another synchronous area.*

5.3.2 Article 3(1)

-The new HVDC interconnector North Sea Link has been added to the list. Kriegers-Flak has been included in the DK2-DE interconnection, by adding its name to Kontek.

5.3.3 Article 3(2)

The new HVDC interconnector North Sea Link has been added to the list. Kriegers-Flak has been included in the DK2-DE interconnection, by adding its name to Kontek.

5.3.4 Article 3(3)

To allow for a more efficient allocation of the ramping (see paragraph 4) and also based on the response of the stakeholders to the public consultation on the previous methodology, Article 3(3) adds the obligation for the TSOs to implement a combined maximum restriction in the energy markets in bidding zone NO2 1200 MW from one hour to the next. This combined maximum ramping restriction will cover three of the four HVDC interconnectors connected to bidding zone NO2: NordLink, NorNed and Skagerrak.

The combined restriction for NO2 provide two additional opportunities:

- The individual ramping restrictions on NorNed, NordLink and Skagerrak may be enlarged (see Article 3(4));
- The existing combined restriction for Skagerrak and Konti-Skan will be removed.

5.3.5 Article 3(4)

Since the combined restriction of Article 3(3) limits the total step of the NordLink, NorNed and Skagerrak, it is a possibility to enlarge the ramping restriction in Article 3(1) and 3(2) on these HVDC interconnectors, without increasing the total step for the Nordic LFC block and bidding zone NO2. This would allow the market algorithm to better optimise the allocation of the flows to the HVDC interconnectors. Article 3(4)(a) opens for this. However, some conditions need to be fulfilled, including the technical feasibiliy of the HVDC interconnector (Article 3(4)(b)). Furthermore, increasing the enlarged ramping restrictions must not result in network issues on both ends of the HVDC interconnector (Article 3(4)(c)+(d)).

The maximum individual ramping restrictions will in practice not be larger than the combined maximum ramping restrictions in accordance with Article 3(3).

5.3.6 Article 3(5) and 3(6)

5.4 Article 3(5) describes the high-level processes of increasing the ramping limits and Article 3(6) describes how the limits could be reduced after they have been increased in accordance with Article 3(4).Impact of the methodology

To assess the impact of the proposed ramping restrictions on HVDC interconnectors, the TSOs have performed market simulations. The simulations have been performed using the Euphemia algorithm and historical grid situations and bids of four months in 2019: February, March, May and June. Textbox 3 provides further background on the simulations.

Table 2 lists the four scenarios that have been simulated. The 2019-scenario is a reference case in which both NordLink and NSL were not yet operational. The 'base' scenario is the situation that both the NordLink and the NSL interconnector have been added to the model and are in operation with the same maximum change from one hour to the next of 600 MW as all other HVDC interconnectors (see Table 1). The CCR scenario adds a combined restriction of 1200 MW on the three HVDC interconnectors between bidding zone NO2 and the Netherlands, Germany and Western Denmark (DK1). In this scneario, also the existing combined ramping restriction between Western Denmark (DK1) and Norway (NO2) and Sweden (SE3) has been removed. In the scenario '1000', the individual maximum change from one hour to the next has been increased to 1000MW on the three HVDC interconnectors between bidding zone NO2 and the Netherlands, Germany and Western Denmark (DK1).

Table 2: Simulated scenarios

Scenario name	New HVDC interconnectors	Combined ramping restrictions	Individual ramping restrictions NO2-NL, NO2-DE and NO2-DK1
2019	none	NO2- DK1 + SE3- DK1 ≤ 600 MW	600 MW
Base	NordLink, NSL	NO2- DK1 + SE3- DK1 ≤ 600 MW	600 MW
CCR	NordLink, NSL	NO2-NL + NO2-DE + NO2-DK1 ≤ 1200 MW	600 MW
1000	NordLink, NSL	NO2-NL + NO2-DE + NO2-DK1 ≤ 1200 MW	1000 MW

Figure 3 shows the sum of the flow change on NO2-NL, NO2-DE and NO2-DK1 for all simulation hours and the four scenarios, ordered from largest to smallest. The figure shows that in 2019, the total flow change on the HVDC interconnectors (in 2019 only NO2-DK1 and NO2-NL) was only at the maximum of 1200 MW for 1.3% of the hours. However, after adding NordLink and NSL (base scenario), the total ramping significantly increases and in 7.6% of the hours the flow change would be more than 1200 MW. The combined ramping restriction (CCR scenario) prevents for the flow changes larger than 1200 MW. The figure also shows that increasing the individual ramping restrictions on NO2-NL, NO2-DE and NO2-DK1 (1000 scenario) will provide some more room for the market.

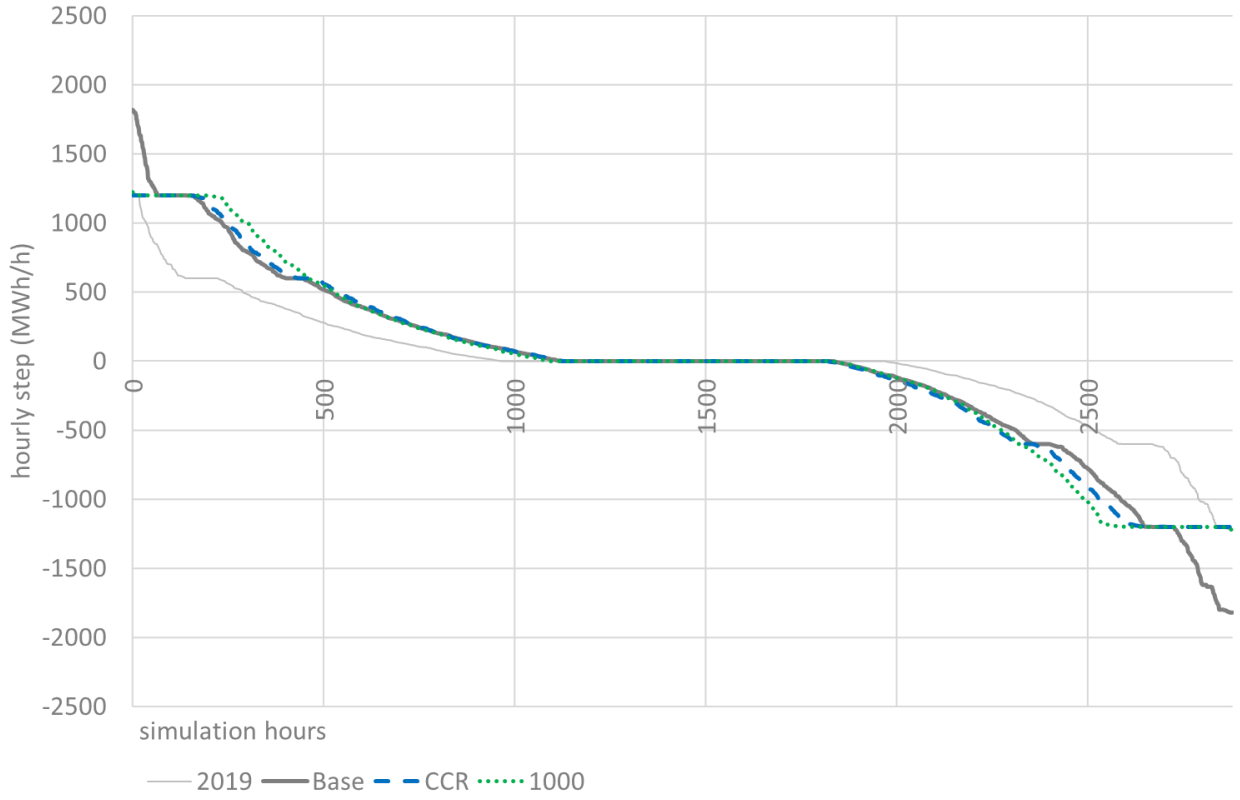


Figure 3: Sum of hourly flow change on NO2-NL, NO2-DE and NO2-DK1 for four simulated scenarios/.

Figure 4 shows the impact on Nordic socio-economic welfare of the different scenarios, starting from the situation in 2019 (2019 scenario). The figure shows that adding NordLink and NSL (base scenario) add more than 33 million Euro to the Nordic socio-economic welfare in the four simulation months. The negative

impact of the CCR scenario is very limited compared to this (0.09 million Euro). Also the impact on Nordic economic welfare of increasing the maximum change from one hour to the next on NO2-NL, NO2-DE and NO2-DK1 is only limited to 0.08 million Euro. Figure 5 shows a similar picture for the impact on European socio-economic welfare.

The TSOs conclude that the combined ramping restrictions effectively limit the flow changes in the hours that this is required for securing the system. The impact of the ramping restrictions to the socio-economic welfare is very small both in absolute terms and compared to the benefits of the new interconnectors, which makes the proposed combined ramping restrictions an efficient measure for mitigating the risks related to ramping.

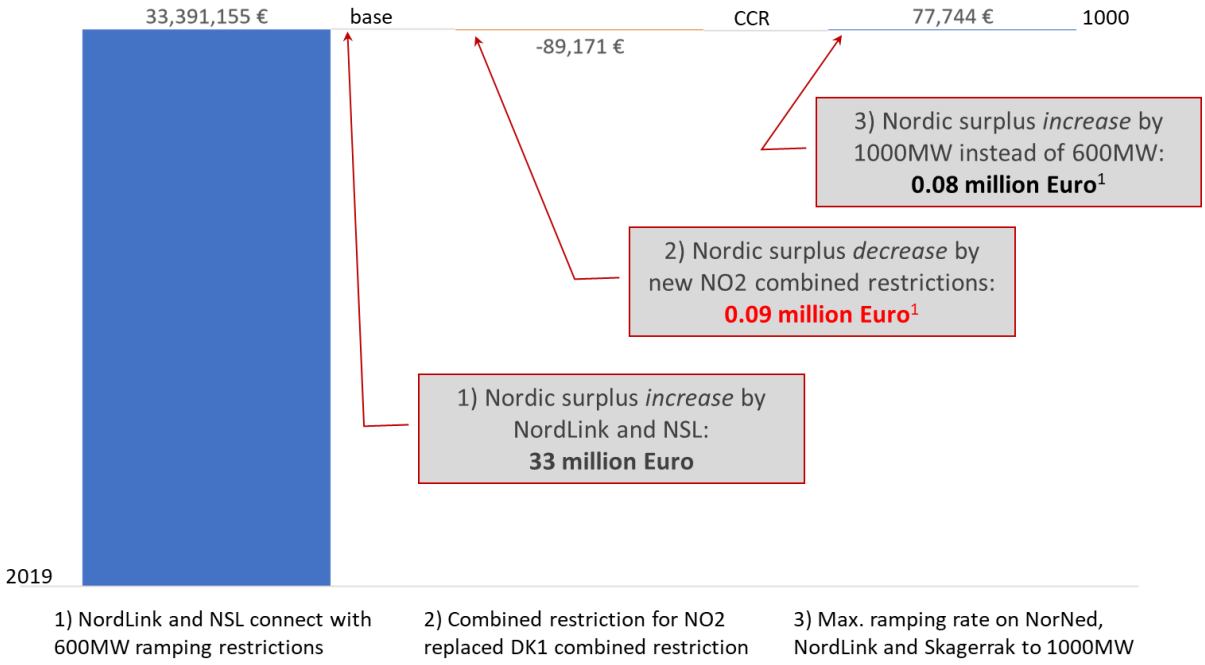


Figure 4: Impact of three steps on *Nordic* socio-economic welfare (Note that figures are based on simulations with market data for four months in 2019).

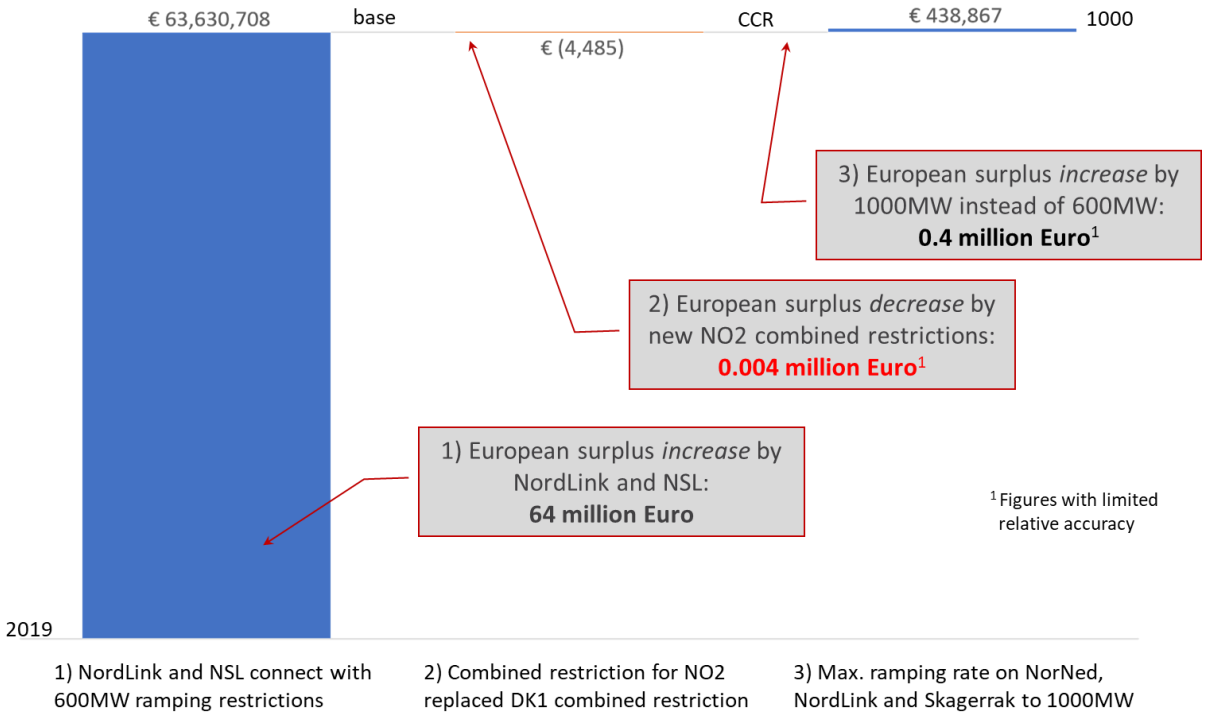


Figure 5: Impact of three steps on *European* socio-economic welfare (Note that figures are based on simulations with market data for four months in 2019).

Textbox 3: Background information of market simulations

The quantitative figures presented in this chapter are the result of market simulations of the day-ahead market covering 120 days in 2019. The simulations have been performed on an hourly basis applying the Euphemia algorithm which is the algorithm used by TSOs and power exchanges for European market simulations3.

For this analysis, the following had to be assumed:

- The assessment is based on day-ahead markets only;
- The comparison is done with the 2019 grid situation, restrictions and actual bids. This implicitly assumes that the new interconnectors and the new ramping restrictions do not change bidding behavior in day-ahead market. In addition, differences between hydrological years will not be addressed;
- The simulations cover the European electricity market area.

Note on the accuracy of simulation results:
The objective of the Euphemia algorithms is to find the market outcome for which the socioeconomic European welfare is maximized. Since this algorithm needs to find an optimal combination of very many parameters which do not have a linear relationship, it is in practice impossible to calculate and compare results of all different possible combinations. Mathematically this is called a 'non-linear optimization problem'. The mathematical techniques applied by the simulation facility to solve this problem do not always find the optimum solution, but most likely finds a solution that is very close to the highest socioeconomic European welfare.

If several runs with the simulation facility are performed for identical situations, experience shows that there may be a spread in the results for European socioeconomic welfare of 250kEUR for extreme days, which is high, but negligible compared to the total European electricity market. However, in this report the impact of ramping restrictions is analyzed by reviewing the difference between simulation results. If the difference in socioeconomic welfare between these scenarios for a particular day is in the order of 250kEuro, it is in the same order of magnitude as the inaccuracy in the results. Hence, it should be noted that the difference in socioeconomic welfare cannot be exactly quantified for these relatively small numbers.

The assessment described in section 4.4 is based on a comparison of 3000 hours in 2019. For these hours the simulation results of the existing situation have been compared with the historical market data as published by Nordpoolspot[4]. The comparison shows a correlation (R2) of 99,5% for both the interconnector flows and the bidding zone prices.

6. Outlook

The restrictions for HVDC ramping discussed in section 4.1 above were determined on the basis that the total change for the Nordic synchronous system at one hour shift should not exceed an acceptable maximum level and this total level was evenly distributed on individual HVDC interconnectors.

The ramping restrictions have not been changed after they were first introduced in 2007 even if new interconnectors, increased volumes of renewables and further market integration have led to that the potential change above have increased. This has been possible by improvements in other operational measures like e.g. introduction of Nordic aFRR as well as the fact that the increase in the total ramping so far have shown not to effectuate the full potential.

By adding ramping restrictions of 600 MW/hour for the new NordLink (in 2020) and NSL (in 2021) HVDC interconnectors, the addition of a combined restriction on NordLink, NorNed and Skagerrak and the removal

[3] See http://www.nemo-committee.eu/assets/files/190410_Euphemia%20Public%20Description %20version %20NEMO%20Committee.pdf

[4] https://www.nordpoolgroup.com/historical-market-data/

of the sum restriction on Skagerrak and Konti-Skan, the aggregated maximum ramping on all Nordic HVDC interconnectors will increase with 1200 MW/hour from 2020. This may have a negative impact on the FRCE / frequency quality of the Nordic LFC block/Synchronous Area and will therefore be monitored carefully. The TSOs evaluated the possibility to also propose a cap on the total ramping on all Nordic HVDC interconnectors towards other synchronous areas, as suggested by stakeholders in accordance with article 137 of SOGL. The TSOs will propose an amendment to this methodology and investigate including a combined Nordic ramping restriction by the introduction of an ISP of 15 minutes in 2023.

Future development with changed flow pattern, the stepwise implementation of the mACE concept, the introduction of an ISP/MTU of 15 minutes and development for other mitigating measures such as aFRR and remedial actions requires that the ramping limits, ramping periods and the methodology to determine these limits are re-evaluated. In the same process, the restrictions and coordination of production plans discussed in section 4.2 and 4.3, will be assessed.
It is envisaged that the ramping restrictions on both HVDC and production plans will have to be modified before the implementation of the 15 min ISP.

7. Expected impact of the Methodology on the relevant objectives of the SO Regulation

The Methodology generally contributes to and does not in any way hamper the achievement of the objectives of Article 4 of the SO Regulation. In particular, the Methodology serves the objectives to:

- Article 4(1)(c) determining common load-frequency control processes and control structures;
- Article 4(1)(d) ensuring the conditions for maintaining operational security throughout the Union;
- Article 4(1)(e) ensuring the conditions for maintaining a frequency quality level of all synchronous areas throughout the Union.

The Methodology contributes to these objectives by specifying ramping restrictions for HVDC interconnectors and production plans. These ramping restrictions are required to maintain the operational security by reducing the risk for automatic Low Frequency Demand Disconnection (LFDD) and for system blackouts due to under or over frequency. Furthermore, the ramping restrictions are required to maintain the frequency quality level of the synchronous areas involved.

8. Timescale for the implementation

The implementation of the amendments to Article 3 depends on a required update of the XBID system, which is expected by the 2nd half of 2022. The full implementation of this proposal will therefore take place without undue delay as soon as the required update is complete. By November 2021, the TSOs will replace the existing combined restriction on Skagerrak and Konti-Skan by introducing a combined restriction of 900 MW/hour from one hour to the next for the HVDC Interconnectors NordLink and NorNed and an individual ramping restriction of +/- 450 MW from one hour to the next on HVDC interconnectors Skagerrak and North Sea Link.

9. Public consultation

Article 11 of the SO Regulation states that: *"TSOs responsible for submitting proposals for terms and conditions or methodologies or their amendments in accordance with this Regulation shall consult stakeholders, including the relevant authorities of each Member State, on the draft proposals for terms and conditions or methodologies listed in Article 6(2) and (3). The consultation shall last for a period of not less than one month."*

The Proposal has been consulted in the period 21 January 2021 to 22 February 2021.The appendix to this document includes the views of stakeholders resulting from the consultations and explains if and how these views have been taken into account in the Methodology.

Appendix: Results of Public Consultation

Article 11(3) of the SO Regulation states that: *"The TSOs responsible for developing the proposal for terms and conditions or methodologies shall duly take into account the views of stakeholders resulting from the consultations prior to its submission for regulatory approval. In all cases, a sound justification for including or not including the views resulting from the consultation shall be provided together with the submission of the proposal and published in a timely manner before, or simultaneously with the publication of the proposal for terms and conditions or methodologies."*. Table 3 lists the views of stakeholders on the proposal resulting from the consultations and explains if and how these views have been taken into account in the Methodology.

Table 3: Views of stakeholders resulting from the consultations and explains if and how these views have been taken into account in the Methodology.

no.	organisation	comment	response TSOs
1	Nord Pool European Market Coupling Operator AS	We find the implementation of the combined ramping limit of 1200 MW on Skagerrak, NordNed and Nord Link and removal of the group-ramping on Skagerrak and KontiSkan as a positive change. We see that this gives a bit more flexibility and thus a better optimization of the utilization of the interconnectors. At the same time we will urge the TSOs to actively consider application of article 3 point 4 and increase the individual ramping rate in order to make the effects of ramping limitations as small as possible. It is important that the ramping restrictions placed on SDAC and SIDC shall be strictly set at what is physically needed to maintain operational security.	Comment acknowledged and did not result in a change of the Methodology. It is the aim of the Nordic TSOs to enlarge the individual ramping restrictions as soon as possible in order to make the effects of ramping limitations as small as possible. For this, Statnett has already started discussions with the TSOs at the other side of the HVDC interconnectors.
2	Nord Pool European Market Coupling Operator AS	We welcome the implementation of a combined ramping rule which TSOs plan to implement with 15 min ISP in 2023, but think that TSOs could consider implementing the combined ramping also sooner.	Comment acknowledged and did not result in a change of the Methodology. Considering the number of required changes in many systems such as HVDC interconnectors, IT systems at TSOs on both sides of the HVDC interconnectors etc.., the implementation time of a combined Nordic ramping restriction should not be underestimated. The TSOs will therefore focus on properly designing and implementing the new combined ramping restrictions for 2023.
3	Statkraft Energi AS	Even if Statkraft recognize that the Nordic TSOs needs to secure safe operation of the power system we are concerned about restrictions reducing the possibility to utilize the HVDC as efficient as possible and according to the outcome of the power market. The current ramping rate restriction of 600 MW/h has been the rule for a long time independent of technology and market development. We are not convinced that applying this ramping rate restrictions is the optimal value based on a balance between security of supply and the best possible utilization of the power system. Smooth and proper ramping for DC-interconnectors will in our opinion mean continuous ramping, in order to reduce the possibility of frequency excursions during the ramping phase. This can be supported by generators.	Comment acknowledged and resulted in a change of the Explanatory document. The analysis in section 4.4 of this Explanatory document shows that the socio-economic cost of the ramping restrictions was limited. The analysis added in section 5.4 confirms that the addition of the new ramping restrictions and combined ramping restrictions has very limited impact on both the Nordic and the European socio-economic welfare.

			The support of generation during the ramping phase is indeed very valuable as an additional measure which the TSOs will keep using (see Article 4 of the Methodology and section 4.2 and 4.3 of this Explanatory document). However, if there would not be ramping restrictions, the impact of small time-wise deviations in following the schedules by production units may result in large breaches of security constraints. This is why – in addition to other measures – ramping restrictions are required. The newly added Textbox 2 further elaborates on this.
4	Statkraft Energi AS	We would also like to refer to the GB system, which is of similar size as the Nordic synchronous system and has a number of DC-interconnectors installed with different countries. As far as we know it does not impose any ramping restrictions on its interconnectors.	Comment acknowledged and did not result in a change of the Methodology. Although the size of the GB system may be comparable, many other characteristics are different, including market design, number of bidding zones, share of hydro units, number and capacity of interconnectors, hourly steps over HVDC interconnectors, imbalance settlement period etc.. Consequently, it cannot be concluded that ramping restrictions in the Nordic synchronous area would not be required based on a simple size comparison with the GB system.
5	Statkraft Energi AS	Regarding the concrete proposal we have the following view: • Even if the Nordic TSO now has done an analysis, we ask for a thorough analysis to re-assess the need and efficiency of applying ramping rate restrictions for the Nordic system.	Comment acknowledged and resulted in a change of the Explanatory document. The TSOs performed additional market analysis and the results included in the new section 5.4 of the explanatory document confirm that the addition of the new ramping restrictions and combined ramping restrictions has very limited impact on both the Nordic and the European socio-economic welfare. In Textbox 2 the TSOs further elaborate on the need of the ramping restrictions.
6	Statkraft Energi AS	• If the Nordic synchronous power system can cope with 10* 600 MW/h, thus totally 6000 MW/h, the current proposal seems to conservative and do not optimize the utilization of the Nordic power system. We believe that applying one aggregated ramping rate restriction of 6000 MW/hr for all 10 interconnectors combined, instead of 10 individual ramping rate restrictions would be beneficial. If applying such single	Comment acknowledged and did not result in a change of the Methodology. The Nordic TSOs note that in practice not all HVDC interconnectors ramp at the same time and that a total of 6000 MW/h is only a theoretical maximum, in practice the maximum step is

		aggregated ramping rate restriction for all interconnectors is not possible, then application of this idea to a smaller subset of interconnectors should be considered. The aim should be than the interconnectors with highest value for the power market are least restricted.	less (see Figure 1). Nevertheless, the TSOs agree that implementing a combined ramping restriction for all or a subset of the interconnectors may be useful and will propose an amendment to this methodology including a combined Nordic ramping restriction by the introduction of an ISP of 15 minutes in 2023 (see section 6).
7	Statkraft Energi AS	• Even if we favour a sum restriction for NO2 rather than 3 individual restrictions (for Skagerak, NorNed and NordLink) of 600 MW/h we cannot see that a sum restriction on minimum 1200 MW/h is a better solution. We therefor ask the TSO to consider a higher minimum sum restriction for NO2 than 1200 MW/h if a sum restriction is to be implemented.	Comment acknowledged and did not result in a change of the Methodology. The TSOs aim for keeping the maximum combined ramping limits on NO2 as high as possible, but need to take the impact on the system security into account..
8	Statkraft Energi AS	• If aggregated ramping rate restrictions are considered to be impossible for other bidding zones, and individual ramping rate restrictions are unavoidable, then we question the application of the same value (600 MW/h) on each interconnector independent of the capacity of the interconnector. For us a more logical approach would be that the ramping restriction is made also dependent on the interconnector capacity, thus a higher value in MW/h as ramping rate restriction should be applied for an interconnector capacity of 1400 MW than for an interconnector of 600 MW.	Comment acknowledged and did not result in a change of the Methodology. The TSOs acknowledge the logic in the proposal by the respondent. However, the assessment results (as presented in section 4.4) show that the socio-economic cost of ramping restrictions is limited and consequently also the room for optimisation will be small. The TSOs also would like to add that the potential increase in individual ramping limits within a combined ramping limit will meet this proposed principle where applicable.
9	Statkraft Energi AS	• Currently ramping is maximum done for 20 minutes (+/- 10 min at hour shift). To be able to swing from full export to full (or vice versa) faster we ask the Nordic TSO to use the full hour for ramping (+/- 30 minutes at hour shift). Or, after introduction of a MTU of 15 minutes, a ramping period of 15 minutes (+/- 7.5 minutes at quarter of hour shift).	Comment acknowledged and did not result in a change of the Methodology. The TSOs note that changing the ramping period will have an effect on either the maximum gradient for change (in MW per minute) or on the changes to the trading plans from one hour to the next (in MW per hour). The latter one may be most important to the market. However, increasing the ramping limits will also increase the production steps and consequently increase the momentary mismatch production and consumption/export in the Nordic synchronous area which affects both the FRCE quality of the Nordic LFC block and the frequency quality of the synchronous area. The TSOs also refer to that these issues will be discussed further in the next update of the

			methodology. Ramping period will probably have to be standardised between synchronous areas to reduce deterministic imbalances.
10	Norsk Hydro	Our feedback concerns the proposed changes to new ramping restrictions on the HVDC connections Skagerak, NorNed and Nordlink, with the total transmission capacity of 3900 MW The proposal will implement a new combined ramping restriction on Skagerak, NorNed and NordLink. The maximum ramping rate for these connections is proposed to be 1200 MW from one hour to the next. In addition, it is proposed to allow for an increased individual ramping rate for these connections. The document does not offer details on how the increased individual ramping rate may be used. We assume however- based on a target to facilitate an efficient power exchange and utilization of the connections - that one way of utilizing this opportunity could be to allow the total 1200 MW ramping rate allocated to the Skagerak, NordNed and NordLink connections, fully to the one connection with the highest price difference first and then to the connection with the second highest price difference, and so on.	Comment acknowledged and did not result in a change of the Methodology. The TSOs elaborate that the combined maximum ramping restriction on bidding zone NO2 (article 3.3 of the Methodology) limits the flow change from one hour to the next on the sum of the Skagerrak, NorNed and NordLink interconnectors. The allocation to the individual interconnectors will be optimised by the Euphemia algorithm[5] within the individual maximum ramping restrictions of each interconnector. Since the Euphemia optimisation covers the entire internal electricity market and more consecutive hours, the assumption of the respondent is in principle correct, but not necessarily exactly true.
11	Norsk Hydro	1. A combined ramping on Skagerak, NorNed and NordLink of 1200 MW is lower than what has been practiced for new HVDC connections in current ramping regulation and reduces bottleneck revenues The proposal to implement a combined ramping restriction on Skagerak, NorNed and NordLink at 1200 MW is 600 MW lower than how the ramping regime has been practiced since 2007. This will increase the time to turn the flow on the HVDC connections by more than 2 hours and consequently reduce the bottleneck revenues. It also increases the risk of having flows in the wrong direction (from high price to low price area) just to ensure that the flow changes direction in time. This is an unfortunate development and was not communicated when the investment decision was taken on any of the connections. We encourage the TSO's to find ways to increase the efficiency and the ramping on these cables.	Comment acknowledged and resulted in a change of the Explanatory document. The TSOs acknowledge that the combined maximum ramping restriction on the Skagerrak, NorNed and NordLink interconnectors may increase the time for ramping. However, the TSOs also note that the impact on the Nordic socio-economic welfare is limited (see the response to comment no. 5) and very limited compared to the benefits of the NordLink and NSL cables, which is shown in the newly added Figure 4 and Figure 5.
12	Norsk Hydro	2. Increased individual ramping rate on the Skagerak, NorNed and NordLink is positive but should be extended to all HVDC connections	Comment acknowledged and did not result in a change of the Methodology. The TSOs acknowledge the respondent's support and ensure that the work on optimising the ramping restrictions continues.

[5] See http://www.nemo-committee.eu/assets/files/190410_Euphemia%20Public%20Description%20version %20NEMO%20Committee.pdf

		The proposal to allow for increased individual ramping rates partly meets our feedback given to the TSO consultation on the same matter in Q3 2020. Thus, we welcome the proposal. However, it can be argued that allocating a higher individual ramping rate on all HVDC connections from the synchronous Nordic area will increase the total bottleneck revenues. Since this probably would lead to changed bottleneck revenues for the different TSO's, such change would require an agreement between the TSO's on how the increased total revenues are to be distributed. Thus, we encourage the TSO's to continue the positive work on optimizing the utilization of the HVDC connections.	
13	Norsk Hydro	3. Situations when not all HVDC connections change flow simultaneously should be utilized to increase ramping on those who do With new HVDC connections from the Nordic power system to even more countries (bidding zones) it can be expected that not all HVDC interconnections will change directions at the same time. In such situations it should be considered to allow for a faster ramping on those HVDC connections that do change flow to optimize the bottleneck revenues and the utilization of the resources.	Comment acknowledged and did not result in a change of the Methodology. The TSOs note that in practice not all HVDC interconnectors ramp at the same time and that in practice the maximum step is less than theoretically total maximum step of 6000 MW/h is (see Figure 1). The Methodology takes this into account.
14	Norsk Hydro	Finally, we would also welcome an initiative from the TSO's to start calculate the increased bottleneck revenues from the optimal model and make them transparent for market players and users of the transmission system	Comment acknowledged and did not result in a change of the Methodology. The TSOs refer to the assessment report (of which a summary is presented in section 4.4) in which the impact on bottleneck revenues (congestion rent) has been discussed.
15	Fortum	Fortum's comments on Nordic TSOs' proposal on ramping restrictions Fortum appreciates the possibility to give our view on Nordic TSOs' proposal on ramping restrictions. Fortum is a true regional energy company with presence in electricity production and/or consumption in all Nordic and Baltic bidding zones. Our regional presence allows us to witness every day the value that the regional resource optimization creates to our societies in increased welfare. We strongly believe that a stronger regional co-operation is beneficial and necessary for all our societies alike.	Comment acknowledged and did not result in a change of the Methodology.
16	Fortum	Fortum's comments on the proposal: • We consider that Nordic TSOs should start using group/combined ramping restrictions for all interconnectors going out from the Nordic synchronous system as soon as possible. Reasons for this are following: o Increased efficiency in terms of socio-economic welfare as ramping would be restricted where is causes the least harm for the market.	Comment acknowledged and did not result in a change of the Methodology. The TSOs refer to the response to comment no.2.

		○ As described by the TSOs, the need for ramping restrictions originates from system level limitations that are needed for operational security and fulfilling frequency quality target. This means that restrictions per interconnector are artificial and support introducing group ramping. ○ SDAC and SIDC are already now able to handle group ramping ○ In the proposal TSOs state: "In response to the public consultation of previous ramping restriction proposal, many stakeholders suggested the implementation of combined ramping restrictions instead of the individual ramping restrictions. This will be investigated further towards new restrictions after mACE and 15 minutes Imbalance Settlement Period." We question why this is not done immediately, as group ramping as such is not connected to mACE or 15 minutes in any way.	
17	Fortum	Article 3(4) states: "The TSOs may increase the maximum ramping speed from 30 MW/minute in paragraph 1 and individual ramping rates in paragraph 2 from 600 MW/hour if the following conditions apply:…" • This indicates that the default values proposed by the TSOs are very conservative as it is possible to increase ramping speed. • Fortum considers that TSOs should restrict ramping as little as possible and only if needed from operational security reasons • Socio-economic welfare impact of ramping restrictions and applying group ramping should be studied.	Comment acknowledged and resulted in a change of the Explanatory document. The TSOs do not agree with the respondents' statement that Article 3.4 indicates that the 'values proposed by the TSOs are conservative'. As stated in the remainder of Article 3.4, the 'default values' can only be increased if a number of conditions are fulfilled, including the implementation of a combined ramping restriction. This combined ramping restriction ensures that the additional flexibility given to the market by increasing the ramping restrictions does not result in breaching the security limits. The TSOs agree with the respondent that the ramping restriction shall restrict as little as possible and only needed from operational security reasons. The TSOs performed additional market analysis and the results included in section 5.4 of the explanatory document reconfirm that the addition of the new ramping restrictions and combined ramping restrictions has very limited impact on both the Nordic and the European socio-economic welfare.

18	Fortum	• Proposal seems to only focus on hourly resolution in ramping. Fortum would also like to understand how introducing 15 minute resolution in the markets and in balance settlement impacts ramping restrictions. • TSOs should also ensure that MARI, PICASSO, NBM and FBMC in the Nordics support the use of group ramping.	Comment acknowledged and did not result in a change of the Methodology. The TSOs acknowledge that the Methodology only focuses on an hourly resolution. The TSOs will propose an amendment to this methodology by the introduction of an ISP of 15 minutes in 2023 (see section 6). The TSOs plan taking also into account in that amendment the impact of the mACE concept and other results of the NBM project. The TSOs confirm that FBMC takes account of the ramping restrictions.
19	EFET	The European Federation of Energy Traders (EFET*) welcomes the opportunity to provide comments on the Nordic TSOs' proposal on ramping restrictions. In general, we question the necessity to impose ramping rate restrictions. Ramping rate restrictions: an unnecessary and unjustified measure The TSOs explain that the first objective of the ramping rate restrictions, is to balance the Nordic system (generation, consumption and exchange over the HVDC interconnectors). However, that objective does not justify the application of ramping rate restrictions. If such restrictions would not be applied, the market outcome could indeed result in a huge change for the Nordic system, for example from full import to full export within one hour. However, such market outcome is backed up by commitments from Nordic BRPs, so there is no reason to assume that these commitments could not be fulfilled. Reference is made to the GB system: The GB synchronous system is of similar size as the Nordic synchronous system and has several DC-interconnectors. However, the GB system operator does not impose any ramping rate restrictions. It is understood that a large change could result in temporary imbalances if the ramping period and ramping speed is not coordinated. Therefore, EFET does understand and accept ramping period restrictions and ramping speed requirements for HVDC interconnectors – but not ramping rate restrictions.	Comment acknowledged and did not result in a change of the Methodology. The Nordic TSOs refer for the justification of the ramping restriction to the Assessment report from July 2020 that is summarised in section 4.4 of this report. The TSOs do not understand how 'the commitments from Nordic BRPs' which are on an hourly basis could prevent for the large momentary imbalances on a minute-by-minute basis. The TSOs refer to the response to comment no.4 for a response to the comparison with the GB system.
20	EFET	The TSOs claim that the ramping rate restriction results in a socioeconomic welfare loss of 1 million Euro per year in the balancing market. This might be a relatively low figure. But even then, there is no reason to accept this welfare loss.	Comment acknowledged and resulted in a change of the Explanatory document: The TSOs have added Figure 4 and Figure 5 to this Explanatory document in which NordLink and NSL have been incorporated in

		More importantly, the analysis is based on historical grid situations and historical bids in January, March, June and October 2019. Therefore the analysis does not take the into account the commissioning of NordLink and Kriegers Flak or the upcoming commissioning of NSL.	the analysis on socio-economic welfare, based on the historical bids of four months in 2019. Again, the socioeconomic of ramping restrictions is low. The reason to accept this loss have been explained in comment no. 19.
21	EFET	Secondly, the analysis only covers the day-ahead time frame and ignores value gains coming from cross-border exchanges in the intraday and balancing time frame. The analysis also does not take into account future fundamental market developments were increasing price volatility in the continental and GB markets can be expected. Such volatility would normally increase the value of cross-border capacity from/to the Nordic market and thus ramping rate restrictions would cause higher value losses.	Comment acknowledged and resulted in a change of the Explanatory document: Figure 4 and Figure 5 have been added to the explanatory document and include NSL and the impact of the GB markets. The TSOs confirm that the analysis is based on day-ahead time frame. Considering the very small impact on the day ahead market, it is fair to assume that impact on the intraday market is limited as well.
22	EFET	Finally, EFET assumes that applying a ramping rate restriction will result in more temperature variants in the cable and will negatively impact the life time of the cable. Therefore EFET requests the Nordic TSOs to take these possible effects into consideration.	Comment acknowledged and did not result in a change of the Methodology. The TSOs acknowledge that the temperature variants has to be considered in the detailed scheduling of HVDC flows but considers this not to be directly connected to the ramping restrictions.
23	EFET	The second objective of the ramping rate restrictions is apparently related to avoiding congestions inside of the Norwegian grid. This in particular applies to the three interconnectors from/to the zone NO2 and a combined ramping restriction for NorNed, NordLink and Skagerrak of at least 1200 MW/h is proposed There is no detailed explanation of this aspect. However if the grid is able to be operated securely in case of a full export situation as well in a full import situation, there is no apparent reason to assume that a gradual shift from export to import (or vice versa) would cause flows that would violate security constraints. Therefore EFET rejects the proposal to impose a combined ramping rate restriction for the three interconnectors in addition to other ramping rate restrictions.	Comment acknowledged and resulted in a change of the Explanatory document: The TSOs have added information on the grid issues in NO2 in section 5.2 and Textbox 2: Increased ramping on HVDC interconnectors to NO2 affects AC gridTextbox 2. The TSOs further explain that – on a minute-by-minute- basis, the mismatch between e.g. production *increase* in NO2 and HVDC export + consumption *increase* will result in an unplanned flow over the AC lines within NO2 and the AC interconnectors towards NO2. Since the TRM on the AC import lines is 50-150 MW, a small mismatch will already result in overloading these lines.
24	EFET	Use of combined ramping rate restrictions instead of individual ramping rate restrictions If the abolishment of ramping rate restrictions cannot be accomplished, then EFET urges the Nordic TSOs to apply a combined ramping rate restriction for all DC interconnectors instead of ramping rate restrictions that apply to each interconnector individually.	Comment acknowledged and did not result in a change of the Methodology. The Nordic TSOs note that in practice not all HVDC interconnectors ramp at the same time and that a total of 6000 MW/h is only a theoretical maximum, in practice the maximum step is

		The idea is that if the Nordic synchronous power system can cope with ramping rate restrictions of 600 MW/h per interconnector for ten interconnectors, then it can cope with a total ramp of 10 x 600 = 6000 MW/h. Splitting this total system ramp over individual ramping rate restrictions is too conservative. The market will be less restricted if one combined ramping rate restriction is applied. If for example, the market does not result in a change of flow on one interconnector, then other interconnectors would be allowed to change their flow with a greater amplitude than 600 MW/h. Applying one combined ramping rate restriction will result in less restrictions for those interconnectors that generate more value. Applying a combined ramping rate restriction instead of an individual ramping rate restriction of 600 MW/h would especially be relevant for the new larger interconnectors like NordLink which has a capacity of 1400 MW. A ramping rate restriction of 600 MW/hr for would mean that NordLink could only swing from full import to full export in 5 hours. This could entail a major restriction of the market and result in considerable welfare losses.	less (see Figure 1). Nevertheless, the TSOs agree that implementing a combined ramping restriction for all or a subset of the interconnectors may be useful and will propose an amendment to this methodology including a combined Nordic ramping restriction by the introduction of an ISP of 15 minutes in 2023 (see section 6).
25	EFET	Preference for continuous ramping In order to minimise the possibility of deterministic frequency deviations, EFET proposes to apply smooth or continuous ramping on the DC interconnectors. This would mean that a full hour for ramping (+/- 30 minutes at the hour shift) is used at the moment, and that a ramping period of 15 minutes (+/- 7.5 minutes at the quarter of hour shift) can be used after the introduction of the 15-minute MTU in the Nordic system.	Comment acknowledged and did not result in a change of the Methodology. The TSOs refer to the response to comment no.9.
26	Nordenergi	Nordenergi – the joint collaboration between the Nordic associations for electricity producers, suppliers and distributors – appreciates the opportunity to comment on the Nordic TSOs' proposal for ramping restrictions. The Nordic TSOs argue that additional ramping restrictions are needed to take into account the new HVDC interconnectors in the Nordic system and ensure the balance of the Nordic system. They estimate that the proposed ramping restrictions will result in a socioeconomic welfare loss of 1 million EURO per year. Nordenergi, however, do not agree with this reasoning. Firstly, the balancing of the Nordic system should not be the reasoning for imposing ramping restrictions, as this is ensured by the commitments of the Nordic BRPs – a commitment that the Nordic TSOs seemingly assume will not be upheld. We do not see any reason that justifies assuming that the Nordic BRPs will not uphold their commitment.	Comment acknowledged and did not result in a change of the Methodology. Nordic BRPs are committed to keep their balance on an hourly basis at the moment. Consequently, (especially) production BRPs do not necessarily follow the ramp of consumption and HVDC interconnectors on a minute-by-minute basis. The objective of the proposed ramping restrictions is to keep the balance on a minute by minute basis which is not within the BRPs area of responsibility.
27	Nordenergi	Secondly, the estimated welfare seems very conservative, and cannot serve as a reference point. The reasoning is that the estimate is based on 2019 data, implying that	Comment acknowledged and resulted in a change of the Explanatory document.

		the new HVDC interconnectors are not included. Moreover, the estimate only considers the day-ahead timeframe, leaving out the value of cross border exchanges in the intra-day and balancing market. Additionally, the estimated well loss does not consider fundamental market changes, such as an increased price volatility in the Continental and GB markets, resulting in the value of cross border capacity to the Nordic being underestimated. Nordenergi requests that the TSOs further develop the effect on frequency quality from ramping restrictions and the analysis into effects on welfare from ramping restrictions.	The TSOs refer to the response to comment no. 20 and 21.
28	Nordenergi	The Nordic TSOs propose imposing combined ramping restrictions of a minimum of 1200 MW/h for the three interconnectors: NorNed, NordLink and Skagerrak. The reasoning seems unclear to Nordenergi. We request that the Nordic TSOs further explain why there is a need for these restrictions and what under what circumstances it could be increased to 1800 MW/h.	Comment acknowledged and resulted in a change of the Explanatory document. The TSOs refer to the response to comment no. 23.
29	Nordenergi	Finally, if ramping restrictions cannot be avoided, we suggest imposing combined ramping restrictions for all Nordic DC interconnectors. Combined ramping as opposed to individual ramping restrictions will result in a more efficient market. An example could be that if the market outcome leads to no change in the flow on one interconnector then other interconnectors would be able to change their flow passed the restrictions of 600 MW/h. This will result in less restrictions for the interconnectors, which creates the highest value.	Comment acknowledged and did not result in a change of the Methodology. The TSOs refer to the response to comment no. 24.
30	Nordenergi	Nevertheless, if the proposed method is approved, we expect that the ramping restrictions are evaluated annually after implementation in order to ensure efficient markets and system security.	Comment acknowledged and did not result in a change of the Methodology.