	Report
	Title **Report to ACM, DERA and NVE on the NTCs on NorNed and Skagerrak**

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Summary:

The regulators (NRAs) in Denmark, The Netherlands and Norway have asked Energinet.dk, TenneT and Statnett to provide an updated report on the expected need for limitations on NorNed and Skagerrak, and the measures to reduce the impact of the grid restrictions

Based on the analysis in the area study of Southern part of Norway, Statnett expects to that the export has to be reduced due to congestions in the grid approximately 20% of the hours in an average year. The sum of reductions in trading capacity is expected to be up to 400 MW in total on NorNed and Skagerrak. In addition, on the Skagerrak interconnector 100 MW will be reserved for selling reserves. This means that the total export capacity available for the market will be between 1900 and 2300 MW in periods with no outages in the grid.

A number of measures to reduce the need for NTC restrictions are presented in this report, and some are already implemented.

Energinet.dk, Statnett and TenneT will undertake further joint qualitative and quantitative assessment of the potential measures in relation to their cost-effectiveness and impact on the internal market.

Signatures:

Energinet.dk *Statnett* *TenneT*

Audit	Date	Audit description	Contributors	Controlled	Approved

Statnett

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1. Introduction

1.1. Background

The regulators (NRAs) in Denmark, The Netherlands and Norway; Danish Energy Regulatory Authority (DERA), Netherlands Authority for Consumers and Markets (ACM) and Norges Vassdrags- og energidirektorat (NVE), has sent a similar letter to their respective TSO. In the letter the NRAs inform about their intention to investigate whether the congestion management in Norway and the calculation and allocation of NTCs on the NorNed and Skagerrak interconnectors are in line with applicable EU and national regulation. The three TSOs; Energinet.dk, TenneT and Statnett, are asked to provide a report on the expected need for limitations of the capacity on the above mentioned interconnectors.

Statnett finds it important to underline that no decisions are taken concerning the actual need for limitation in capacity on the NorNed and Skagerrak. The actual capacity given to the market (NTC) each day and hour are decided the day before the operating day (D-1) and provided to the market according to the procedures established through the North West Europe (NWE) market coupling. These capacities are based on the expected production, consumption and situation in the Norwegian grid for the following day.

It should also be noted that "The exchange information" sent to the market plays an important role in providing information to market participants. This information is particular important for producers in the south of Norway in order to plan the use of water over time. As these production resources are part of the n-1 consideration performed by Statnett each day they are critical for the ability to up hold a high capacity in the south of Norway as possible over time.

Statnett is through its public service obligation, given by the Norwegian Ministry for Petroleum and Energy obliged to take decisions during operation and investment based on socioeconomic optimisation. Statnetts annual income is regulated through an income cap covering operational cost, capital cost and system operations cost. The congestion rents connected to the interconnectors are used to reduce the tariffs paid by Norwegian consumers. This implies that marginal cost of investments and operation in the grid over all has the same effect as a marginal reduction in congestion rents due to limitations.

The report explains the challenges in the operation of the grid in the southern part of Norway. It is important to note that there are two main types of situations that my lead to a situation where Statnett has to reduce the capacity on the interconnectors in order to maintain security of supply.

One situation is when there are no outages in the grid (intact grid) but where there is a high demand for export over the NorNed and Skagerrak interconnectors. These situations and the consequences are explained in the market message from May 2013.

The other type of situations that may lead to congestions are when there are outages due to maintenance and reinforcements in the grid. Statnett would like to underline that the maintenance and reinforcement work both in 2014 and the coming years are of the utmost importance to relieve

the long term changeling connected to the terminal congestions in the Western Corridor.
Information about the expected outages and NTCs in 2014 was communicated to the market in February. For each outage a more precise information is given in urgent market messages (UMMs).

1.2. Plans for grid investments in Norway

Statnett is actively working to reinforce the Norwegian transmission grid, with the investments most important to NorNed and Skagerrak scheduled to be completed by 2019. The planned grid investments, which will see the main parts of the transmission system upgraded to 420 kV (from 300 kV) in addition to new lines being built, are detailed in the Grid Development Plan from 2013. The main drivers identified in the plan are:

- The large share of the grid constructed in the '60s and '70s are approaching the end of their life span and need to be reinvestments to maintain a satisfactory operational reliability
- Increased expectations for security of supply (N-1 criterion)
- Population growth in urban areas
- Increased share of intermittent renewable generation
- Demand for increased transmission capacity to other countries, and more challenging system operations due greater fluctuations and increased exchange with neighbouring power systems

The planned grid investments are described in more detail in chapter 3 and in annex 2, while the main challenges in Southern Norway are described in chapter 2.

The plans amount to expected grid investments of 0.6-0.9 billion euros every year for the next ten years.

1.3. Legal frame work

Statnett is a state owned company that owns 90 pct. of the Norwegian central grid. It holds the license as system operator for the Norwegian power system and also one license for the cross border power exchange on the connections towards the other Nordic countries and another license for the exchange of power with the Netherlands over NorNed cable.

The roles and responsibilities as system operator are given by the Norwegian energy act, the regulation to the energy act, the system operation regulation and the license regarding system operation. The Norwegian Energy Act and regulations are adapted to Regulation (EC) 1228/2003.

Socio-economic efficiency is the guiding principle that follows from the rules and regulations. Congestion management and capacity calculation is regulated in the Norwegian system operation regulation paragraph 5, where it is stated that significant and long lasting congestions shall be handled by defining appropriate price areas. How Statnett has included these principles in its daily operations are subject to supervision by the Norwegian NRA, NVE.

In Norway there is an on-going process to ratify Regulation (EC) 714/2009 as part of EEA agreement and to adapt Norwegian Energy law accordingly. As part of this process a public hearing on the necessary changes in the Norwegian Energy Act has been presented. No changes in the principals for congestion management and capacity regulation have so far been foreseen.

Further to Regulation (EC) 714/2009 provisions 1.3 to 1.6 inn Annex 1, it follows that the method for congestions management should provide network operational security, costs efficiency and give efficient economic signals to market participants and TSOs.

Based this Statnett does not see any obstacles to comply with the transparency requirements set forth in Regulation (EC) 714/2009, provision 1.7 Annex 1, even if this EU regulation is not valid for SN until now

1.4. Criteria for the selection of appropriate measures

It is important to recognize that security of supply in a hydrological based system, like the Norwegian, has two dimensions. The short term availability of peak capacity both in production and in the grid and the long term energy supply connected to the hydrological balance. In congestion management both these factors have to be taken inn to account. This implies that in cases where over time the expected available resources for regulation of the power system are limited due to the hydrological situation, necessary precautions has to be taken in order to maintain a sufficient level on security of supply, both in the short and the long run.

In cases where, in order to maintain security of supply, congestions inside a price area has an effect on the available transmission capacity on a bidding zone border there may be an adverse effect on the energy markets. The effect will depend on the market demand for transmission capacity on the given border. However, it should also be mentioned that water not being used due to congestions will be stored in the reservoirs and used for production at a later point in time. The value of this production should also be accounted for.

Furthermore when evaluating the effect of a particular measures to reduce a congestion the effect on total power system need to be taken into account. This means that relieving congestion in one part of the grid may lead to a need for larger reductions in other parts of the grid, which again may effect security of supply or give a larger negative impact on the market.

This implies that when evaluating a particular measure to avoid congested lines, key criteria should be:

- security of supply
- the impact on socio-economic welfare
- the cost-effectiveness of the measures
- other impacts on the internal market

The typical types of measures to relieve congestion are.

- Introduction or adjustment of price areas
- Grid investments to eliminate or reduce the congestions
- Market intervention or curative measures applied during operation, such as DC loop (rerouting), re-dispatch, counter trade etc. The availability of measures and resources during operation will affect the capacities given in the planning phase

Typically there will be more than one option to deal with the identified congestions and in many cases investment in new lines or increased capacity is the only real long term option. In these cases there will be a trade-off between short term and long term solutions. Short term solution should only be introduced if it can be demonstrated that they also have a positive effect in the long run, in particular that they do not interfere with the planning and possibility of finalizing the permanent solutions.

It should be noted that in relation to expected internal congestions in the grid in the southern part of Norway Statnett has not ruled out any investment measure based on cost alone. The planned grid investments to reduce or relieve congestions impacting NorNed and Skagerrak are presented later in the report.

During planning and operation the guiding principle for selecting which measures to use is to take in to account the expected cost of regulation toward the excepted benefits for the energy markets. The hydrological situation in Norway will influence the availability of regulation resources that can be used to relive the congestions in the south of Norway.

Estimating the day ahead prices in the spot market during operational planning, can be challenging. The expected day ahead prices (particular in Denmark) are in certain situations sensitive to the capacity given on all borders which make it more challenging to make a good prognosis. This implies that better forecast of prices used in the planning phase will possibly lead to better capacity utilization. The TSOs have identified this as an area for further cooperation and improvements.

2. State of the transmission grid in southern part of Norway

This chapter presents the findings the latest study of the transmission grid in Southern Norway (the Area Study of Southern Norway), and the main challenges in the region as described in the latest Grid Development Plan.

2.1. The Grid Development Plan

The Grid Development Plan from 2013 gave an overview of main challenges for the grid in the South of Norway. These challenges are repeated below.

The power flow in the southern part of Norway is dominated by transmission to and from the HVDC-cables to Denmark and the Netherlands. Stronger integration with the Continent has increased the daily fluctuations in production in Norway, with higher production when we are exporting and lower production when we are importing. With one new 700 MW cable to Denmark (Skagerrak 4) in 2014 as well as plans for a new 1400 MW interconnector to Germany in 2020 and a new 1400 MW interconnector to England scheduled for 2020, the daily flow pattern will grow even stronger. Hence, The Grid Development Plan for 2013 see a need for increased north-south capacity in Southern Norway.

Security of supply in the Stavanger-area is strained. The area has a significant electricity deficit with a major need for power to be transmitted into the area. The area receives power through two 300 kV lines with limited capacity, and the grid is at times operated without an instantaneous reserve.

Licences for around 600 MW wind power have been granted in this region over the last few years, but there is great uncertainty as to how many of these projects will be realised. Most of the projects are so large that new transformation to the main grid will be required.

The planned grid investments are described in Chapter 3 and in annex 2.

2.2. The Area Study of Southern Norway

In the Area Study of the Southern part of Norway from September 2011, challenges in the operation of the grid due to changes in production- and load-flow patterns where analyzed both in the short and long term.

The main conclusion was that the only permanent solution to relive the congestions is to upgrade most of the grid in the Western corridor from 300 to 420 kV. As a consequence Statnett has taken every step to provide the necessary reinforcements as soon as possible, with as little effect on the market as possible. The main features of the plan and the strategy to finalize it is presented in chapter 3.

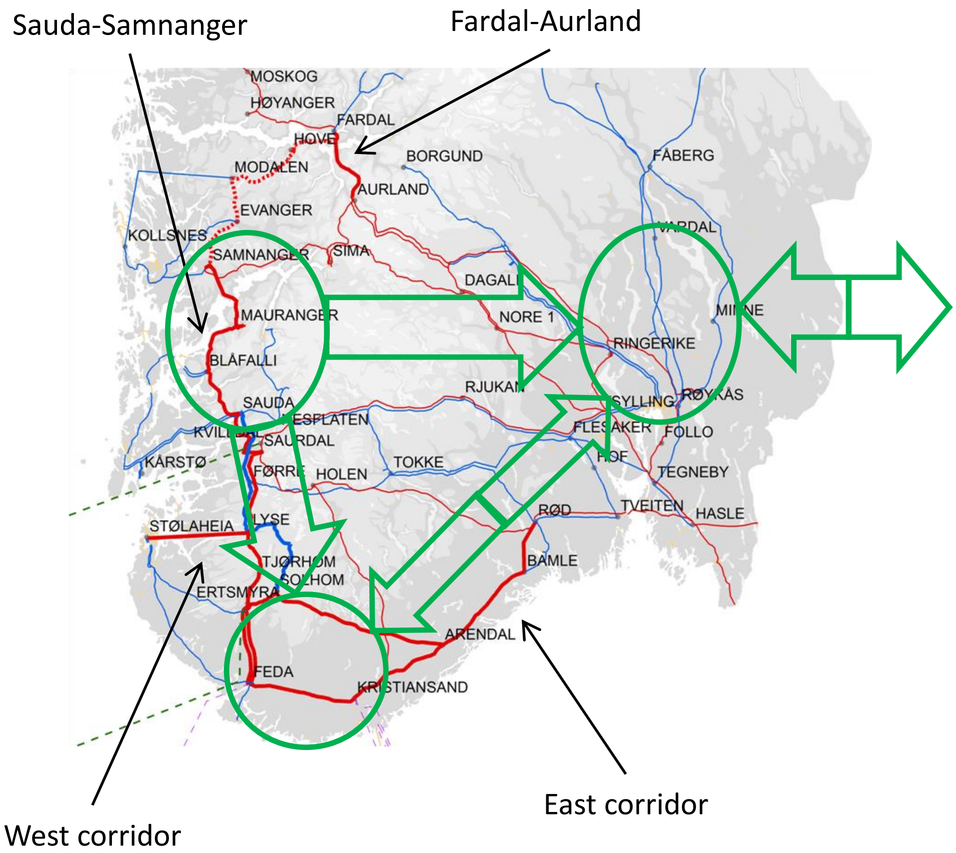
Until the necessary upgrades are completed, the analysis showed that in certain situations, limitations on export capacity is the only available measure to maintain the security of supply in operation. It was estimated that limitations on export capacity can be necessary in 10-20 % of the year, even if measures such as system protection or special regulation are used.

Those findings in this report were the background for the Exchange information on the future NTCs on the Skagerrak and NorNed interconnectors, published on 30.05.2013.

2.2.1. Main findings of the study

Distribution of production, consumption and export/import in the south of Norway

In southern Norway, most of the production capacity is in the western part while the load-centre is in the eastern part of the country. The result is that power predominantly flows from the west to the east. The Eastern flow will follow both the lines directly from the west to the east, and on the lines through the most southern part of the country. This means that the flow to the east will go south in the Western Corridor that is closely connected to the production in the west, and north through the Eastern Corridor that is more closely connected to the load-centre in the east.



Export on the interconnectors to Denmark and the Netherlands will increase the southbound flow in the Western Corridor since the corridor connects the interconnectors with the production along the West Coast.

With import from Denmark and the Netherlands the power from the interconnectors will flow towards the load-center in the east, mainly using the Eastern Corridor

This means that it will not be possible to achieve an even distribution of load between the lines in the southern part of Norway, a fact that need to be taken into account in analysis of the capacity in the south of Norway.

The importance of variations in the hydrological situation

The hydrological variation from one year to another and from one season to the next has a large influence on the production and flow pattern.

The hydrological situation is there for an important factor in determining the need for capacity in the grid both in the long and the short term. It is also important to acknowledge that within Norway the hydrological situation may also vary significantly from one local area to another. In particular the export and import capacities are sensitive to the amount of water in the North-West compared to the amount of water available for the production units closest to the interconnectors.

Together with the increase in production from renewables following from the introduction of the green certificate market, this is expected to have a significant effect on the production and flow patterns. In combination with the commissioning of Skagerrak 4 it is expected that the power transfer for export through the western corridor will increase further.

The analysis shows that there will be an increased amount of hours during a year that the transfer capacity in the western corridor is insufficient to handle this increased potential for export. This is the main findings in the area study of southern Norway and of the most important basis for the investments planned for the western corridor.

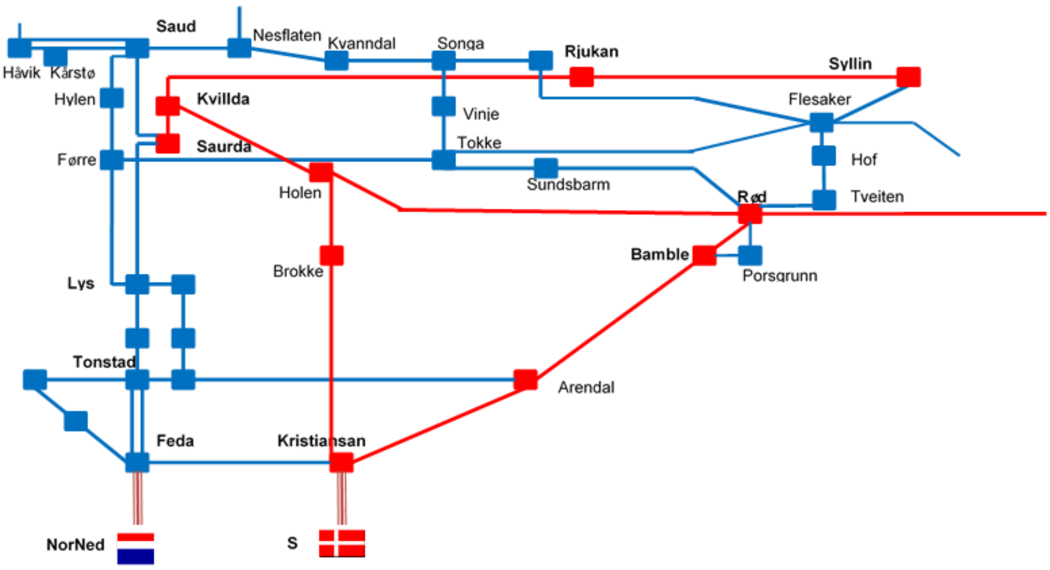
The main sources of congestions in export situations

The high export from the West to the South with the current grid in the Western corridor will lead to voltage stability issues and more importantly thermal congestion on several lines in the area. In the picture in paragraph 2.2 above, the eastern corridor is drawn as red as 420 kV line. These lines are in operation December 2014. With the eastern corridor upgraded to 420 kV, there is no need for restrictions on import over the interconnector from NL and DK as long as the grid is intact.

The thermal limitations in export situations will mainly be connected to the lines between Lyse and Tonstad in the map above. As there are only a few production unites available south of this congestion there may be a lack of regulation resources during operation. This lack of regulation resources can be even more unbalanced in a situation where the hydrological situation is dry in the South West and at the same time there is an excess of water in the North-West. This will be explained in more detail below.

The situation in the grid in import situations

As stated above, with import from Denmark and the Netherlands the power from the interconnectors will flow towards the load-centers, mainly using the Eastern Corridor, but spreading sufficient to all lines to avoid n-1 violations. This implies that than when the Eastern corridor is upgraded to 420 kV and there are no outages in the grid it is not expected to be congestion during import.



2.2.2. Measures considered to relieve congestions

Statnett has performed sensitivity studies in their market simulations tool to get a best estimate on the duration of the bottlenecks. These market simulations are done for 47 different hydrological inflow years, to represent the historical span of situations.

In order to identify and quantify the different bottlenecks, simulations have been performed for thermal capacity (N-1/N-1-1), voltage stability, transient stability and short circuit levels. To account for large number of relevant hydrological and seasonal variations in load, production, import and export situations have been checked. This has provided the best possible estimate for transmission capacities in different situations. Situations that lead to bottlenecks, both short-term measures and how the grid reinforcements could be in place to relieve the restrictions as early as possible have been considered.

Special System protection schemes (SPS)

System protection is already widely used in the Norwegian power system (see chapter 5.1 for more details). The mandate for the study said that we should not plan for increased use of system protection. However, the study still pointed out the possibility to use system protection for voltage stability issues, by including lines in the Eastern corridor in system protection schemes in the same way as Holen-Kristiansand is today. For thermal limitations system protection wouldn't improve the situation, as the thermal capacity restrictions in the western corridor were found also for intact grid conditions.

Series compensation or phase shifting transformers

The study looked into several ways to lighten the pressure on the 300 kV lines in the Western corridor. Series reactors in the Western corridor, Series capacitors on Holen-Kristiansand and lines in the Eastern corridor, phase shifting transformers and synchronous condensers were all looked into in the study.

Series reactors could be used to increase the impedance in the Western corridor, and hereby decrease the flow in the corridor. However, it would move the restrictions to the lines between Western and Middle corridor. This would not lead to any significant net capacity increase. In addition, this would worsen the voltage stability problems caused by high export.

Series capacitors in the Middle and Eastern corridors could be used to achieve the same result. However, we saw that it would result in the same restrictions due to lines between Western and Middle corridor. The voltage stability would be slightly improved due to lower impedances. Since there are practical limitations on the size of the capacitors on the lines in question the analysis showed that we couldn't achieve any significant improvements.

Phase shifting transformers (PST) is in principle a controllable series reactor, and would be used in the same way and hereby give the same new restrictions and the same decrease in voltage stability, as the impedance increases. The flexibility achieved from the controllability is difficult to utilize in the Norwegian system, since the PST must be tuned for the worst fault at all times. With the high variations in flow and generation between day/night and even within the hour, it would be extremely complicated even to tune one PST in this system. If there should be more of them in the existing system topology we don't see a robust method to utilize them without jeopardizing system security.

In addition, PSTs with limitation in MVA size. If installed on duplex EHV lines, they would limit the thermal capacity. This would make the capacity problems even larger.

Synchronous condensers

For voltage stability problems would synchronous condensers be a relevant measure. They could support local voltage, and provide Short Circuit Capacity. Statnett has performed a lot of simulations with different amount of new condensers in the system to see what impact it would have. The conclusion was that without upgrades in the Western corridor, at least 600 MVA of condensers would be needed to avoid voltage stability problems. The need would increase further with more HVDC links.

Condensers will not solve the thermal capacity issues, so they would only be part of a solution. In addition, we would need several units in stations with little spare areas to place them – and a future upgrade to 420 kV would probably make them obsolete.

3. Investment and outage planning in Norway

3.1. Planned grid investments

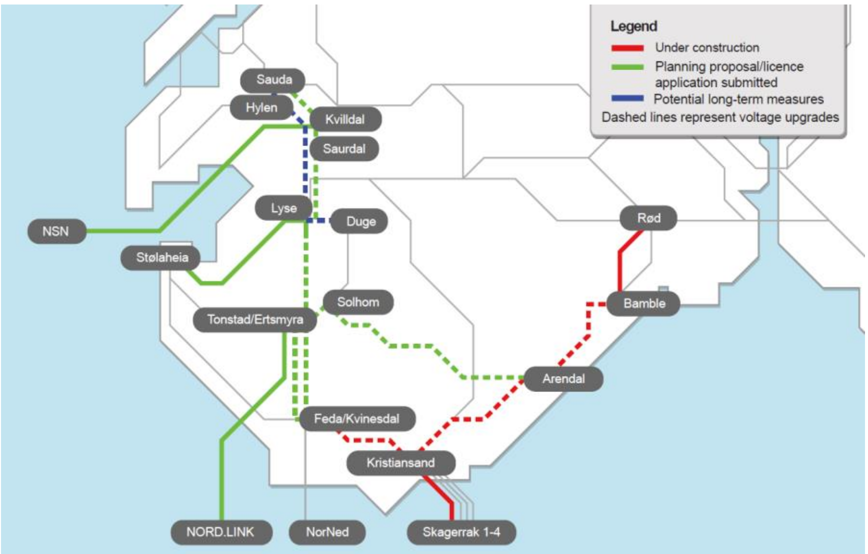
The AC grid in southern Norway needs reinforcements due to aging installations, to connect the planned renewable production and to secure acceptable capacity to existing and new interconnections. Upgrading the existing 300 kV lines to 420 kV is a long term strategy, starting in the South. Upgrading the voltage imply long lasting outages in the transmission system.

When considering investments a three-step approach is taken. First all investments deemed necessary to maintain an appropriate level on security for supply must be carried out. Second, the effect on total power system (that is the effect on the total capacity in the grid and the ability to relieve the congestion in question) should be positive. Third the investment and operation cost should be lower than the total benefit expected due to higher transmission capacity.

The Grid Development Plan for 2013 (see also chapter 2) gives a thorough description of the planned grid reinforcements in Norway. The report describes three main set of investments that are relevant for NorNed and Skagerrak in the coming years:

- The Eastern Corridor project, necessary (but not sufficient) for utilisation of Skagerrak 4, comprises a voltage upgrade of a 140 km interconnector between Kristiansand and Bamble, plus a new 45 km power line between Bamble and Rød.
- To establish two independent AC interconnectors to Stavanger city, with a new 420 kV interconnector between Lyse and Støleheia.
- The Western Corridor a complex project consisting of a step-wise power line upgrade to 420 kV from Kristiansand via Feda in the south to Sauda further north, is required to achieve a high utilisation of Skagerrak 4 and the new high capacity international interconnectors.

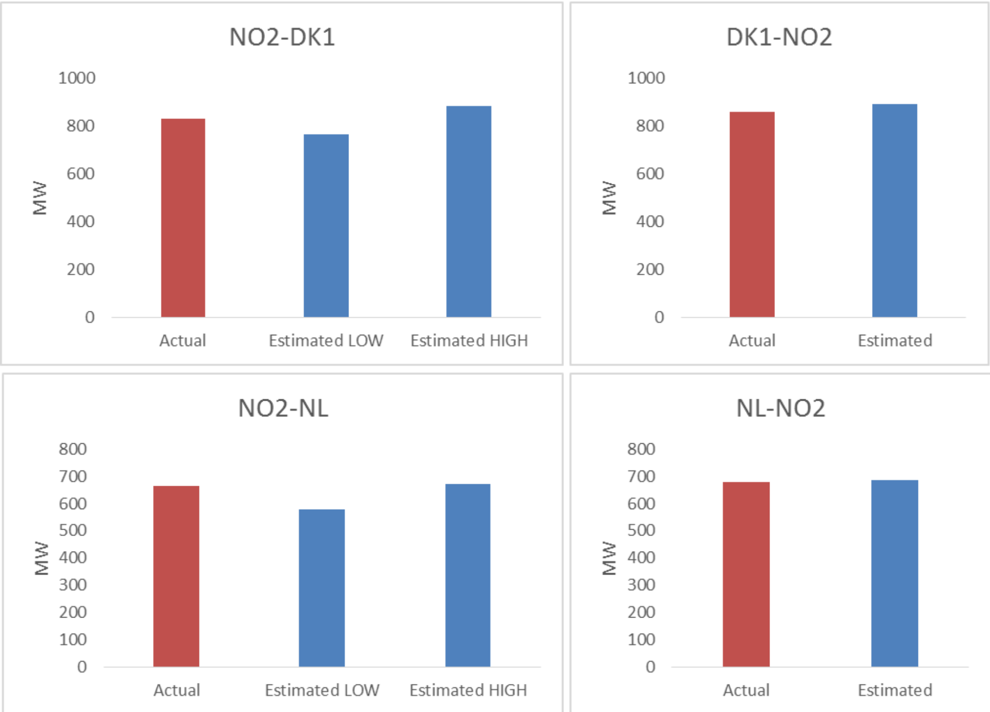
An overview of the eastern and western corridor projects is provided in annex 2. The projects are illustrated in the figure below.



The investment plans for the western corridor are to be carried out during the period from 2014 to 2020, with the main bulk of the project finished in Q2 2019. The Eastern corridor is finalized in 2014. As stated in the Exchange information published on 30.05.13 limitations of export and import capacities, due to maintenance and reinforcements, is not taken in to account.

Statnett put every consideration into planning these projects in order to minimize the amount of outages. The figures below compares the average estimated (as published in UMM by Statnett in

February 2014) and realized NTC capacity on NorNed and Skagerrak in 2014, while further details are provided in annex 2. Note that NTC restrictions due to reasons other than planned outages in the Norwegian AC grid is also present in the numbers for actual available capacity.



3.2. Measures to minimize the need for restrictions

The main goal when coordinating planned outages is always to minimize the impact on the security of supply and the trading capacity. The current process and foreseen developments are presented in this chapter.

Current process for handling planned outages

By implementing system protection schemes and utilizing the short term transmission capacity of the grid components Statnett to a great extent has managed to retain the transmission capacity during outages and grid reinforcements. To reduce outage time the transmission owners are instructed to use live-work when possible and by-passing sub stations during construction work within the station area. The projects are pushed to reduce the outage periods. Although the most important projects are coordinated through the yearly process there might occur changes in the projects and in the power situation influencing the outages and their impact on the power system. The power situation and electricity production capability in Norway is closely connected to the inflow of the reservoirs. The consumption of electricity is very temperature dependent. Major deviations in weather conditions compared to prognosis and changes the time schedule of the project may imply changes in announced transmission and trading capacities. The total investment plan in this area contains of many small pieces that have to fit together and small changes in the plan due to failures, bad planning or other not planned events can have consequences for the overall outage plans and estimated NTCs.

The prognosis on NTCs are based on estimation on actual and available production in the area south of the congested corridors/lines and also the average flow in the corridors. What the actual NTCs will be becomes more and more certain closer to the day of operations. In the Norwegian grid the need for reductions can vary a lot from one year to the next, even if it is the same outages, load and total production capacity.

Foreseen improvements to the process

Statnett will keep on improving the planning processes for outage planning to be in line with the coming code for operational planning and scheduling. This implies that outage plans for production and grid owner has to be done earlier and the future NTCs can be published at an earlier stage than today.

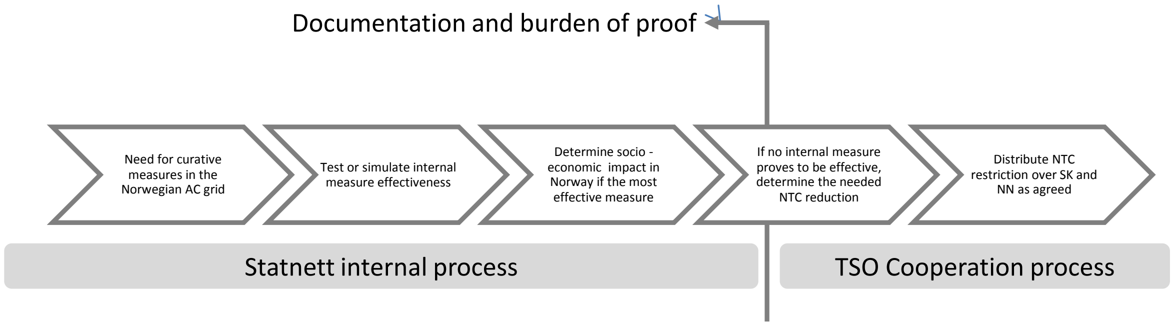
Coordination between TSOs are an area of big importance and more important in the coming years. The communications between the TSOs both in an early stage before the outages are decided and also during the year when the plans are changed is important both for security reasons and to maximize the NTCs. Statnett has already established groups with TenneT and Energinet where these discussions will take place and the necessary information exchanged. In addition the routines between the control centres and the operational planning units have to be flawless.

Statnett needs good forecasts on the flows for the next day when NTCs are calculated each morning. It would be beneficial for Statnett to have more information delivered by ENDK and TenneT before NTCs are made official. The flows on the DC-connections are indirectly dependent on the production from wind and solar power on the continent, because the availability of renewable feed-in determines the price difference. A procedure to exchange relevant data is being developed, and the first results are expected in 2015.

4. NTCs on NorNed and Skagerrak

4.1. Introduction

The process of determining NTC reductions as last resort is best visualized below. It is important to note that the measures described in this report are curative measures to restore system stability and secure N-1 security of supply in the Norwegian AC grid. The measure are not meant to serve as continuous system optimization with a permanent character.



The TSO's would appreciate guidance from the regulators in determining the boundaries and definitions when Norwegian internal measures qualify as cost efficient or having a positive socio-economic value in relation to NTC reduction. This would secure clear and auditable decisions on when NTC should be used as curative measure over other internal measure.

4.2. Calculation of NTCs D-1

NTCs on Skagerrak and NorNed are only restricted if considered as necessary to maintain security of supply. The capacities for the next day are determined every day at 08:30. At that time, no production or transfer plans are available for the TSO's. The total capacity on the HVDC-connections are thus based on a prognosis/assumption of: flow pattern, consumption, production, production capacity and re-dispatch possibilities.

Determining the flow pattern is the most challenging assumption when determining the capacities. The NTCs on NorNed and Skagerrak are influenced by the production and power flow in the whole of Southern Norway, including Western part of Norway, and exchange with Sweden. In general, the most restricting congestions concerning NorNed and Skagerrak is in the western corridor. High flow in the Western corridor and low flow in the Middle and Eastern corridor results in the lowest NTC's. This situation usually occurs when power production in Western Norway and export to Sweden is high. The exchange with Sweden has small consequences for the NTC's on NorNed and Skagerrak. Due to its low efficiency, a restriction in export capacity to Sweden is not an adequate measure to minimize the restrictions on NorNed and Skagerrak. However, the influence on NorNed and Skagerrak is still substantial since the exchange with Sweden may vary between +/-2000 MW.

The assumed flow pattern leads to an estimate of what congestions/grid elements that will be dimensioning for the total NTC. Short term capacity on single lines (15 minutes values) and the capacity increase due to system protection schemes on Skagerrak and NorNed are 100 % included in the capacity/limit on each cut, and thus also in the total NTC. An example of the calculation of total capacity is given in Appendix.

The potential for re-dispatch is also included when determining the NTC, but only to a limited degree. The reasons for this are:

- Re-dispatch is assessed against cost-effectiveness and impact on the internal market.

- Re-dispatch, up-regulation in Southern Norway, causes imbalances in the system that must be handled by down-regulation resources. Usually these resources are available, but if there are other congestions in the grid, for instance on the border to Sweden, the down-regulation resources must be available on the right side of the congestion.
- Re-dispatch requires available installed capacity in specific power stations in southern Norway, and some production capacity has to be kept for unforeseen operational events.
- Hydro power plants have limited energy, dependent on the inflow. The biggest power station, Tonstad, could in a normal year produce at an average of 42 % of the installed capacity. This means that re-dispatch over a long period could lead to a lack of energy in the area, which may have negative effects on NTCs and operational security.

4.3. Operational measures used to relieve congestions

The NTCs on Skagerrak and NorNed are only limited if it is considered necessary to maintain security of supply. Congestions may still occur in the operational phase, and it is crucial that necessary measures to handle these congestions are available for the operators.

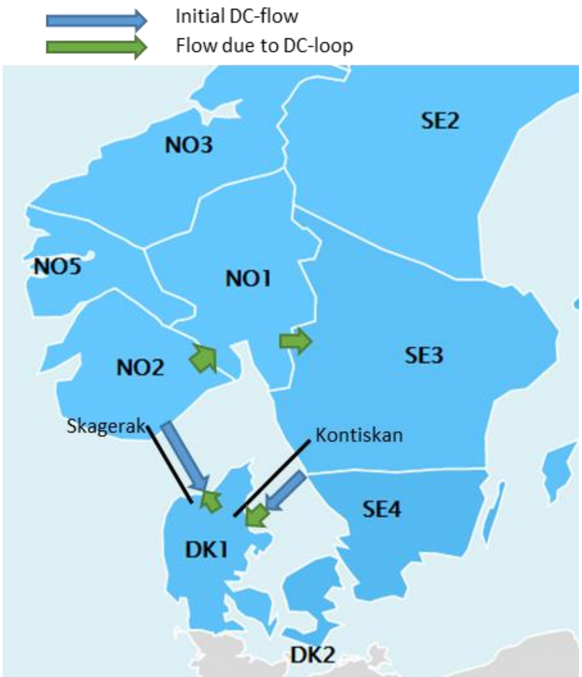
This chapter presents the available operational measures for congestion management in Southern Norway. These three most important measures are DC-loop, re-dispatch and countertrade, while switching may be an option of the other measures are unavailable.

Which measure is used depends on availability and cost.

4.3.1. DC-loop

Unlike an AC-connection, the HVDC-technology offers the possibility of exactly controlling the powerflow on a DC-connection. A DC-loop is when one, or more, HVDC-connections are used to exchange equal sized volumes between systems in order to relieve heavily loaded congestions, lines or cables. Since the exchanged volumes are equal, the balance of each system remain unaffected. It is cost-free and does not affect any production units or grid configuration. This makes DC-loop the preferred method for congestion handling. However, there must be available capacity in the powersystems to handle the change in power flow caused by the loop.

There are two DC-loops available in the Nordic system to relieve the Skagerrak connection: KontiSkan-loop and Storebält-loop. The following figure shows the principle of reducing a southward flow on Skagerrak using the KontiSkan DC-connection. The same principle applies when using Storebält, only involving more elspot areas.



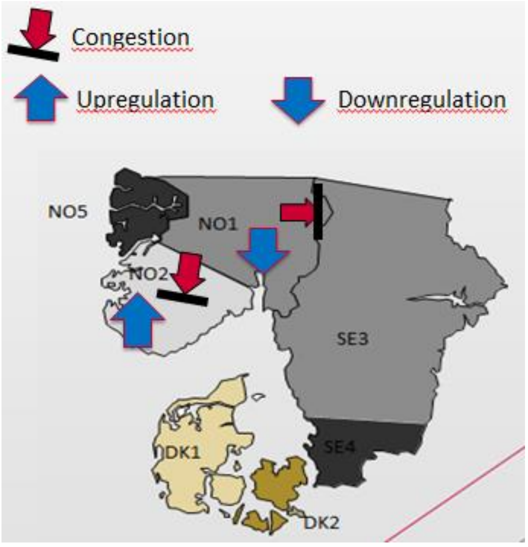
For example, if it is necessary to reduce the flow from NO2 to DK1 with 100MW due to congestion in NO2 the DC-loop will work as follows.

1. The plan on Skagerrak is changed with 100 MW going from DK1 to NO2. Similarly the plan on KontiSkan is changed with 100 MW going from SE3 to DK1. The balance in DK1 and the Nordic synchronous system is unaffected.
2. The loop has shifted the powerflow with 100 MW going from DK1->NO2->NO1->SE3->DK1. Hence, this loop is only possible if there is available capacity in all corridors between NO2 and DK1 in the clockwise direction.

4.3.2. Re-dispatch

Re-dispatch is when the TSO order a power plant to increase or decrease the power production level in order to change the power flow in the system. For Statnett, it is the most common way of relieving a congestion in the operational phase. The TSO must pay the producer for the cost related to the re-dispatch. The re-dispatch also causes an imbalance in the system that normally must be handled by in-/decreasing the production level in other parts of the system that does not affect the congestion.

The following figure will explain the principle of re-dispatch.



1. A congestion in NO2 requires reduced southward flow. There is also a congestion on the cross-border connection, NO1-SE3.
2. A power plant south of the congestion is ordered to increase power production by 200 MW. The southward flow through NO2 is now acceptable.
3. However, there is an imbalance of + 200MW in the system and requires 200MW to be downregulated somewhere else. Since there is a congestion between NO1 and SE3, this imbalance must be downregulated in the area between the congestion and SE3.

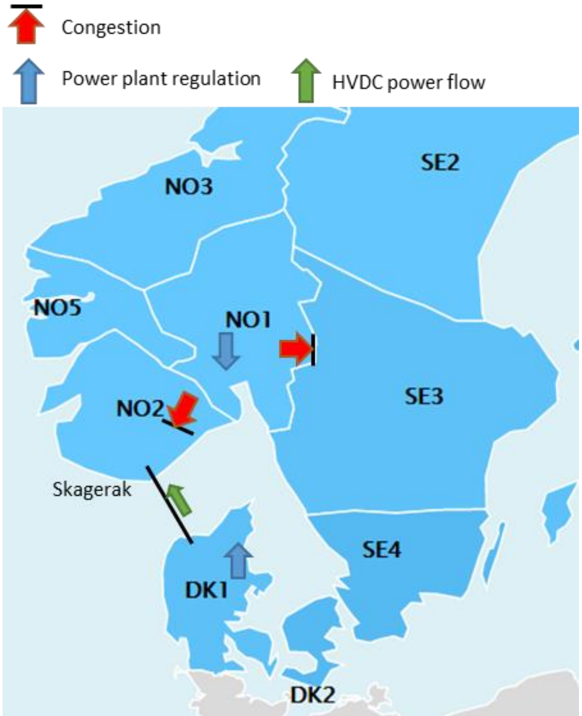
The capacity increase due to system protection schemes on Skagerrak and NorNed are 100 % included in the capacity/limit on each cut, and thus also in the total NTC. If a failure occurs the system protection will immediately reduce the export with a predefined volume. In advance of putting SK4 into operation, the system protection scheme on Skagerrak was increased from 400 MW to 600 MW. This increases the capacity on certain cuts/corridors, but not on the single lines. Statnett policy says if the capacity of a line is more than 70 % utilized, the short term capacity (normally 120 % of the nominal capacity) could not be used. Since the grid is heavy loaded, this is the case for most cuts in Southern Norway after SK4 was put into operation. Thus the power flow on these lines are equal to the nominal capacity after system protection is activated. This has reduced, but not removed the need for reserves. Statnett consider that countertrade on NorNed and Skagerrak cannot be executed fast enough or with the sufficient reliability after a failure. Statnett considers that there is still a need for reserves placed in Norwegian power stations, even if the volume is smaller than before the change in system protection volume on Skagerrak.

The already reduced power flow on Skagerrak and/or NorNed due to system protection schemes, must most likely be kept until the day ahead capacity is reduced. A new failure in the Norwegian grid in this period could lead to manual disconnection of load in the southern part of Norway.

4.3.3. Countertrade in the operational phase

Instead of using re-dispatch on Norwegian power plants, power plants in Denmark may also be used for the same purpose. Through the Nordic System Operation Agreement and the Nordic Regulation Power Market, all available market based bids for up- or down-regulation is known for all Nordic TSOs. The volume and cost of these bids are shown in the common Nordic Operational Information System, NOIS, and the least expensive resources to relieve any congestion is always used, regardless of where the resources are placed. As with regular re-dispatch, the TSO that request the regulation must pay for the cost and the imbalances must be handled by counter regulation in other parts of the system.

The following figure will explain the principle of countertrade.



1. A congestion in NO2 requires reduced southward flow. There is also a congestion on the cross-border connection, NO1-SE3.
2. Statnett asks ENDK to order increased power production in DK1, 200 MW.
3. The 200 MW surplus in DK1 is sent to NO2 via Skagerrak cable. DK1 is in balance.
4. The 200 MW from DK1 reduce the southward flow in NO2 to an acceptable level.
5. However, there is an imbalance of + 200MW in the system and requires 200MW to be down-regulated somewhere else. Since there is a congestion between NO1 and SE3, this imbalance must be down-regulated in the area between the congestion and SE3 (north of the congestion in NO2, in NO5 or in NO1).

4.3.4. Switching to increase capacity

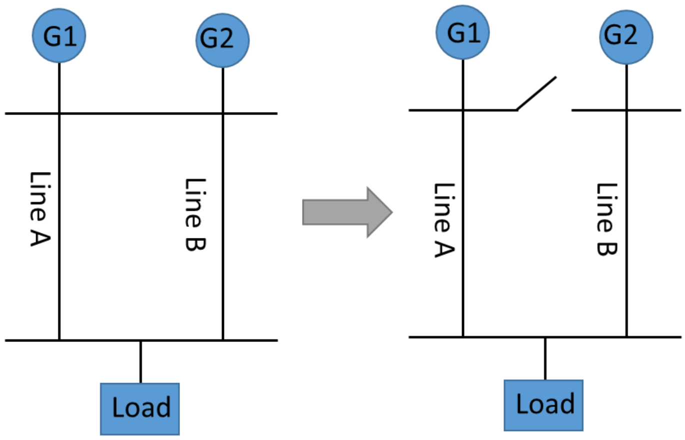
If the possibilities to use DC-loop re-dispatch or countertrade is unavailable, or limited, it may be possible to use switching as a mean to increase the cross-border capacity. This means that the TSO orders switching of circuit breakers in order to reconfigure the grid and optimize the grid capacity by changing the power flow before and after a potential fault. There are, however, several downsides to consider when applying this method:

- When operating the grid in a meshed configuration, other lines or cables have spare capacity to handle the flow when a fault occurs
- Reconfiguring the grid may increase capacity in one part of the system, but reduce capacity on other parts
- The risk for losing consumption, production or DC-connections increases.

- Switching requires careful analysis. The premises for one suitable grid configuration may change quickly
- In general, voltage stability is reduced

In some parts of Norway, switching has been applied with good effect. In Southern Norway, this has only been done occasionally, and in general this is not a feasible measure in this area because it reduces the security of supply in Stavanger and/or other regions in southern Norway. If switching turns out to increase capacity without jeopardizing security of supply, it will be used.

The following figure illustrates, very simplified, how a reconfiguration of the grid may increase the transfer capacity.



1. A load is supplied by two generators and two lines, each line with a nominal capacity (and short-term capacity) of 400MW.
2. When operated in parallel the two lines may never transfer more than totally 400 MW (+ 20 % short-term overload capacity) since any of the two lines must be able to transfer the total load if the other line is disconnected due to a fault.
3. If the load exceeds 400 MW the system no longer meets the N-1 criteria. If one line is disconnected the other line is immediately overloaded and will eventually be disconnected manually or by protection schemes. The system is in total blackout and one line may be permanently damaged due to the overload.
4. However, if the system is split into two radials, the two lines may in total transfer 800MW. When the lines are operated in two radials, one line will never be overloaded if the other one is disconnected. The system will still have blackout if one line is faulty, but there will not be any damage due to overload.

4.4. Distribution of NTC restrictions between NorNed and Skagerrak

Below follows a statement on how Statnett will distribute NTC restrictions between NorNed and Skagerrak interconnectors. The available export capacity for the DC-connections determined in the planning phase is allocated based on expected price differences and the congestion in the inertial grid expected to be most limiting in the hour of operation.

The principles are specified by ENTSO-E (last updated December 2nd 2013) and described in "Principles for determining the transfer capacities in the Nordic power market" on Nordpoolspot.com, Paragraph 5.2.1.

To determine the capacity reduction, the expected price differences between NO2 and the Netherlands, and NO2 and DK1 will be analysed. In addition, the effect of a capacity reduction on each of the two HVDC-cables will vary depending on the bottleneck in question, and will therefore be taken into consideration in combination with expected price differences.

The decisions on the capacity on each interconnector have to be taken as part of the daily operation and will be subject to time pressure. Within the Nordic area, the total import and export capacity between all price areas has to be sent to Nordpool before 9.30 D-1. According to the local Nordic procedures, the capacity data need to be sent to NOIS (Nordic Operational Information System) before 08:30. Before Statnett can provide the Capacities on NorNed through NOIS the Import and Export capacities needs to be aligned between Statnett and TenneT.

In order to assist the decision making by the control centre Statnett has developed a spread sheet that calculate the socioeconomic cost of placing the restriction on one or the other of the interconnectors. However, in cases where the calculations provide a small difference in socioeconomic cost between the two cables a threshold is introduced on which a pro-rate distribution will be performed. The threshold is applied to account for uncertainties in the price prognosis.

The calculations are based on the following data:

- The expected overload on the internal congestions (IC) per cut based on expected power flow, consumption and production capacity. (Denomination: MW). In other words; the need for unloading (relieve of congestion)
- The expected, absolute, price differences (EPD) between NO2 and DK1 and between NO2 and NL. The current process use historical prices (D-1), Denomination of €/MWh/h.
    - Statnett is looking into the possibility of using prices based on marked analysis.
    - The TSO will discuss if there is a possibility of involvement and improvement of these prognosis.
- Pre-determined effectiveness, in %, per cut (EIC): That is the relative reduction effect on the congestion when each interconnector (SK 1 to 4 and NorNed) is by a certain amount.
    - Load flow analysis performed by Statnett, give a factor for the effect of a restriction from a particular cable on a particular line. By combining these factors per line using redistribution factors, the total effect per cut is calculated
    - Outages and reinforcements will lead to changes in these factors.
- The reduction (in MW) will be IC/EIC

The socioeconomic cost (SC) of placing a restriction on a given interconnector is found by taking the product of the excepted price differences and the needed capacity reduction on the interconnector in order to relieve the congestion:.

SC_{NN} € = $EPD_{NO2/NL}$€/MW* (IC /EIC_{NN}%) MW

SC_{SK} € = $EPD_{NO2/DK1}$€/MW* (IC / EIC_{SK}%) MW

As a rule of thumb, the restrictions will be assigned to the interconnector with the lowest socioeconomic cost.

It is however important to acknowledge that the price differences will be influenced by the distribution. In order to take account of uncertainty when deviations in the expected prices differences are small the following threshold are applied.

$\lvert SC_{NN}/IC - SC_{SK}/IC - \rvert < 5$ €/MW

If the threshold apply the restrictions will be allocated based on a "pro rata", but taking into account the effectives of the individual interconnectors have on the cut.

The capacity on NorNed is 700 and the capacity on SK1-4 is 1700. The pro rata distribution will then be:

For SK: IC/EIC_{SK}* Installed capacity SK/ total installed capacity (NN + SK) = IC/EIC_{SK} * 17/24

For NN: IC/EIC_{SK}* Installed capacity NN/ total installed capacity (NN + SK) = IC/EIC_{NN} * 7/24

5. Measures to relieve congestions before the operational phase

5.1. Special System protection Scheme to increase capacity

System protection schemes are widely used in the Norwegian grid, and are installed on both interconnectors to Denmark and the Netherlands. The use of system protection is included in the communicated prognosis on reductions in NTCs. Several overload situations and faults in the grid close to the DC-connections will result in a quick reduction of the actual export/import on Skagerrak. The system protection on NorNed is more limited and only used in a few operational situations.

Statnett and ENDK changed the system protection response on Skagerrak from 400 to 600 MW in the end of 2014. This gave an increased NTC on Skagerrak and NorNed with more than 100 MW in total. In periods with outages in the Southern grid, the increase can be higher.

Statnett has also asked TenneT to change the system protection on NorNed to have similar possibilities as on Skagerrak. It is more beneficial to have system protection on NorNed than Skagerrak in some operational situations due to better efficiency on congested lines/corridors.

The mandate for the area study of Southern Norway pointed out the possibility to use system protection for voltage stability issues. The study looked at including lines in the Eastern Corridor in system protection schemes in the same way as Holen-Kristiansand. For thermal limitations, system protection would not improve the situation, as the thermal capacity restrictions in the Western Corridor also were found for intact grid conditions. This protection scheme in the Eastern Corridor is installed and ready to be used March 2015.

5.2. Planned counter trade

Counter trade is the cross zonal exchange initiated by system operators between two bidding zones to relieve physical congestion. The counter trade is considered to be *planned* when the TSO increase the available NTC provided to the market beyond what is expected to be physically feasible. The TSO then expects to initiate counter trade either before or during the operational phase to relieve the overloads that may result from energy trade across the border.

Counter trade may be initiated during the operational phase by activating balancing reserves, or before the operational phase by either bilateral agreements with producers and consumers, or by TSO participation in the energy markets.

5.2.1. Theoretical considerations on countertrade

In the day ahead and intraday markets the total energy consumption and use of energy production resources are optimized. One of the prerequisites for a correct optimization is that correct cross-zonal capacities are used. If more cross-zonal capacity is provided to the market than is expected to be available, the optimization in the spot market will not be based on correct information regarding what the scarcity of cross-zonal capacity actually is. This incorrect information would lead to an inefficient dispatch of generation and consumption compared to a situation of NTC restrictions. It may nonetheless be situations in which the use of planned counter trade can be expected to provide additional socio-economic surplus compared to NTC restrictions. It could be due to for example one of the following conditions:

1. Stability of NTCs is a net benefit for the producers and consumers (even when it doesn't reflect the physical availability)

2. 1 MWh of counter trade allows for more than 1 MWh of additional NTC capacity, which means it may be efficient to use counter trade even if the marginal costs of counter trade are higher than the marginal benefit of NTC capacity for some individual hours

   a. This could be if the power plants used for counter trade has a higher positive impact on the congestion than the negative impact by the border flows
   b. It may also happen if the need for countertrade only occurs in parts of the hour, so the energy requirement is lower than the HVDC flows that are made possible
   c. It may also happen if the actual need for counter trade is somewhat uncertain at the point in time when the NTCs are determined, so that reductions in NTC may sometimes turn out to have been unnecessary

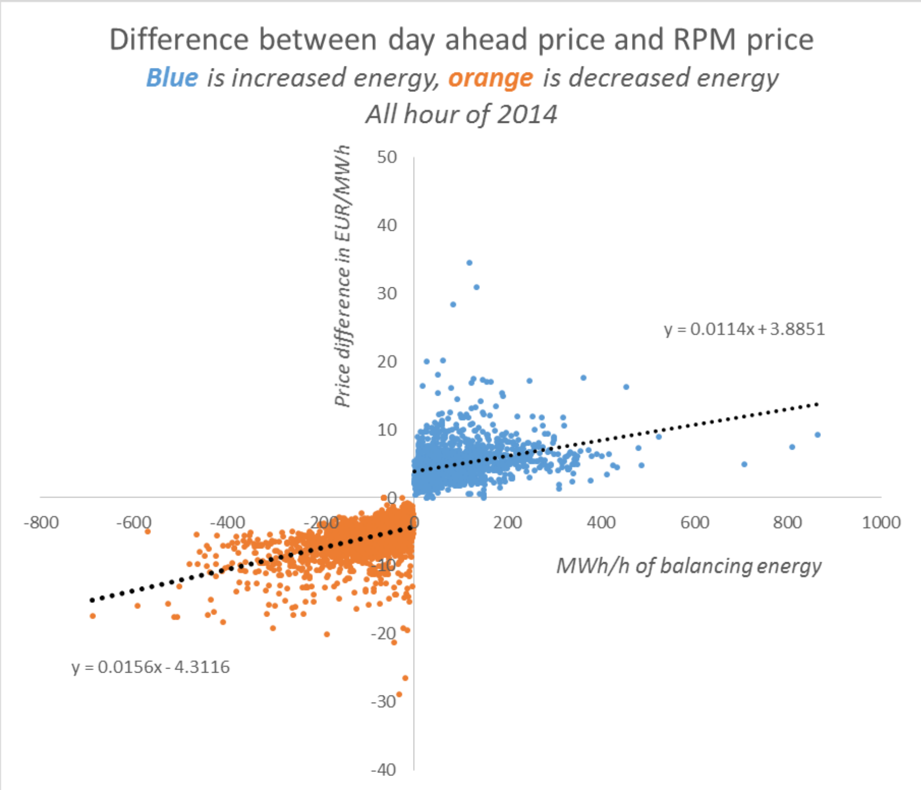
3. Producers or consumers that are not present in the energy market, and that have lower costs than the prices in the long-term, day ahead or intraday markets can provide the energy required for counter trade.

Statnett consider the use of re-dispatch when the NTC is determined, as stated in chapter 4.1. The potential benefit to SEW from counter trade due to points 2a-c is therefore probably lower that would be expected if no other operational measures were considered.

Both planned counter trade and NTC restrictions may have significant (but different) effect on prices, and also on the distribution of welfare between the consumers and producers in all affected bidding areas. The impact on the internal market will therefore be different for each measure.

Parts of the potential benefit to socio-economic surplus of counter trade outlined in point 2c above could also be achieved by providing the intraday market with any additional capacity made available due to reduced uncertainty as the operational hour approaches.

Point 3 above seems rather unlikely as it assumes that producers or consumers that would profit from participation in the energy markets do not do this. This does not seem to be the case in Norway, judging by the prices in the Nordic regulating power market (RPM). The figure below shows the difference between the day ahead price and price of balancing power in Southern Norway. Notice that upward balancing power is usually more expensive than the spot price, while the price of downward balancing power is usually lower.



5.2.2. Technical restrictions on the use of counter trade

Counter trade, whether in the planning or operational phase, cannot be used in situations where it could jeopardize operational security. This would imply that counter trade cannot be used in cases where the availability of sufficient resources might not be available when needed.

An option to make counter trade feasible in such situations could be for the TSOs to contract the availability of resources. This would add to the costs of counter trade, and would affect the energy markets, as the contracted parties would not be free to participate in the markets as they otherwise would.

5.3. Principles for countertrade on the DK1-Germany interconnector – report by the University of Aachen

In the 2014 report by the University of Aachen referred to by the NRAs, the socio-economic feasibility of using countertrade to relieve congestion on the cross-border interconnector between Germany and Western Denmark has been investigated. The report was commissioned by TenneT GmbH and Energinet.dk.

The report considers three different approaches to increasing the available capacity on the DK1-DE interconnection: (1) setting a minimum value to the NTC, (2) increasing the NTC by a fixed amount, and (3) a combination of 1 and 2. All of these could possibly be applied to NorNed and Skagerrak, as long as operational security is maintained, but the conclusion on SEW cannot be directly transferred, as it is only applies to the analysed case.

The report assumes that the intra-day market would be used for countertrade, which could differ from the potential countertrade on the Skagerrak and NorNed interconnector. The report is based on coupled market and grid simulations. The assumption that the intraday market would be used is based on the fact that the intraday market is often used for balancing purposes in Germany, which is not the case in the Nordic region.

The main finding of the report is that the isolated effect of using countertrade on the DK1-DE border is negative for Germany and Denmark, but has a positive regional SEW effect. The main benefits from the use of countertrade on the DK1-Germany border were found in the other parts of the Nordic region and Italy.

5.4. Price areas

According to the System operation regulation issued by NVE, Statnett as system operator shall define bidding areas to handle major and long lasting congestions in the grid. The size and duration of the congestions in the area close to the DC-connection is within what Statnett consider as major and long lasting. It was evaluated some years ago if a new area division could handle these congestions and this was rejected at the time. The main reasons were:

- The bottlenecks vary with production distribution both inside and outside of the area and with the HVDC distribution, and this could vary from hour to hour
- The price signals in import could lead to unwanted import restrictions due to stop in local generation (and hereby less voltage support and short circuit capacity)
- Local generation within the area would normally increase production before the HVDC export is reduced, and hereby reduce available reserves south of the physical bottleneck

6. Initial assessment of planned counter trade

In response to the letter of the NRAs, Energinet.dk has undertaken a pre-feasibility assessment of countertrade between DK1 and Norway using BID-modelling. The main findings are presented below.

6.1. What is at stake?

Preliminary assessment by Energinet.dk indicates that the volume of electricity that is affected if the reductions are 200 MW in 20% of hours is around 500 GWh over the next years. On the 02.03.15 Statnett issued a UMM to the effect that NTC restrictions would be up to 400 MW until mid-2019. These general assessments are for a hydrologically “normal year”. In so-called “wet years” the amount of electricity affected will roughly double.

The estimated socio-economic welfare loss for the internal market (DK, DE, NL, SE) of NTC restrictions are negative whereas Norway experience a net benefit. Conversely, if countertrade were applied by Norway the internal market (excluding Norway) would experience a reduced welfare loss.

The reference case for the numbers presented below is the situation without any need for counter trade or NTC restriction.

Energinet.dk’s initial BID simulation for 2018 (normal year) roughly indicates the distribution of socio-economic welfare:

M€/year	Norway	Region (minus Norway)
NTC restriction	9,0	-8,0
Countertrade in DK1	-4,1	+1,6

Methodologically, the SEW of countertrade has been estimated using the DK1- NO price differentials in the concerned hours of NTC-restriction. The results of the preliminary case-study show that even if realized countertrade cost were higher, the SEW of the region consisting of DK, DE, NL and SE would still be less badly affected compared to the situation of NTC-restriction.

It is emphasized that this is a preliminary assessment. However, it indicates that there seems to be grounds for detailed market and SEW study. For example, there will be value in having a joint detailed modelling of Norwegian hydro system. Statnett has suggested that more detailed modelling of the production behavior of Norwegian hydro-plants may alter the results.

The measures for reducing the impact of the internal congestion in Norway on the internal market should be evaluated jointly by the TSOs as foreseen in Regulation 714/2009.

6.2. Relevant European regulation

The European Regulation governing congestion management is Regulation 714/2009, and article 16 states:

> ***“General principles of congestion management****1.*
>
> *Network congestion problems shall be addressed with non-discriminatory market-based solutions which give efficient economic signals to the market participants and transmission system operators involved.(…)”*

It is therefore Energinet.dk’s understanding that the measures used to relieve the internal congestion in Norway should to the highest degree possible be market based, taking into account security of supply. A practice of moving internal congestion to cross-border connections is not considered as a market based measure to relieve congestion in the European regulation and will discriminate between market participants.

The value of the using countertrade is thus to ensure a well-functioning market by increasing the reliability of the capacity on the cross-border connections. The cross-border exchange is a key part of a well-functioning internal market in electricity.

6.3. Structural versus non-structural congestion

Statnett has announced multi-annual significant, predictable congestions in its grid reoccurring under normal power system conditions. The nature of these congestions fall within CACM's definition of "structural congestions" as defined in CACM (art. 2, point 19):

> *"19. 'structural congestion' means congestion in the transmission system that can be unambiguously defined, is predictable, is geographically stable over time and is frequently reoccurring under normal power system conditions; "*

However, in line with practice across Europe, capacity reduction resulting specifically from (efficiently executed) maintenance works or unpredictable technical outages should *not* be counted towards the "volume" of structural congestion. This means that maintenance and unplanned outages are not relevant for countertrade.

In conclusion, each congestion event in the Norwegian grid should be categorized as either structural and non-structural congestions. Second, to apply market-based instruments foreseen in European regulation and which are agreed between the TSOs to reduce the impact on the internal market of the *structural congestions* in the Norwegian grid.

Specifically, the CACM sets up requirements in article 71 for the TSOs in a coordinated capacity allocation region to define a framework for countertrading and re-dispatch. This framework should define cost-sharing principles. Article 34 requires a common methodology for countertrade to be developed by the TSOs in a coordinated capacity allocation region.

There is therefore little doubt, that European regulation regards countertrade as an important part of the toolkit in structural congestion situations.

It should be very clear that limitations on the cross-border interconnectors due to maintenance and outages, which are only temporary, is not within the scope of the measures.

6.4. Countertrade as a potential measure to relieve the impact of congestions in the Norwegian grid on the internal market

Countertrade refers to regulation of flexible generation or consumption requested by the TSO to *relieve existing or anticipated congestion in the transmission system.*

Cross-border counter trade on the Skagerrak-interconnector would mean that Statnett would purchase balancing south of the internal Norwegian congestion, either in Southern Norway, Western part of Denmark ("DK1") or in the Netherlands. This would be an alternative to moving the internal congestion to the cross-border interconnector to Denmark or the Netherlands.

A closer cooperation in the balancing of the national grids is also envisioned in the implementation of the Network Code on Electricity Balancing and a closer cooperation between the TSOs operating the interconnectors affected by the internal congestion in Norway would therefore be in line with the development initiated by the European Commission in the regulation of the internal market.

6.5. Feasibility of countertrade on Skagerrak and availability of capacity in DK1

Based on the above formal requirements, Energinet.dk finds that the TSOs are obligated to jointly determine whether available resources for countertrade could be made available in the relevant areas to reduce the impact on the internal market of the internal congestion in southern Norway.

From an economic perspective the impact of countertrade on the market is to fully/partially guarantee the availability of trading capacity on the cross-border interconnector. The market players would therefore experience less price risk in trading in individual price areas, since the TSOs would guarantee some capacity between borders.

There would also be distributional effects in using countertrade between market players in the high and low price areas compared to a situation where internal grid congestion is placed on the cross-border interconnectors.

The costs of using countertrade would be socialized through the tariffs by the TSOs and the economic efficiency would depend on the market, where the necessary resources would be procured and activated. Countertrade for internal congestion in Southern Norway affecting Skagerrak could be done using the Nordic regulation power market. To avoid that activation of countertrade will use the already limited regulating power resources for other purposes is it recommended that additional resources are procured.

Several reports have investigated the effect of using countertrade as a measure for congestion management in the internal energy market, among others Nordel[1] and ETSO[2].

The ETSO-report on preventive countertrade stated that preventive countertrade on a small scale can be a tool to ensure a well-functioning internal market and that the main effect was that the TSOs would bear price risks between price areas and not the market players.

The conclusion from the ETSO report was:

> "(…) *Overall conclusion is that preventive countertrade may be beneficial for the well-functioning of the market when employed in limited extent to guarantee a relatively constant virtual interconnector capacity to the market.(…)*"

Countertrade is therefore a feasible tool to ensure a well-functioning market and the use of countertrade should be seen as a tool to realizing and supporting the internal energy market.

6.6. Preliminary estimation of technical viability on the Danish side

As Denmark's TSO Energinet.dk obviously has knowledge of the current capacity situation in DK1 and its anticipated development for the range of years in which Statnett expects that Norwegian NTC-restrictions to Denmark may apply. Further, Energinet.dk considers it to be feasible that up to 200 MW of balancing resources, possibly more, would be available for countertrade, subject of course to terms offered.

6.7. How quickly can balancing reserves be activated in DK1?

This section estimates how quickly DK1 balancing reserves for countertrade can be activated by Statnett which could be a part of a possible countertrade framework.

Decision step	Description	Maximum Time without matching og schedules	Maximum Time with matching og schedules	Comment

[1] Nordel August 2004: Rules for congestion management – Evaluation of availability of capacity and possibilities for increased countertrade

[2] ETSO April 2005: An evaluation of preventive countertrade as a mean to guarantee firm transmission capacity.

Overload of network components		instantaneous	instantaneous	
Agree upon Countertrade between control centers		2 minutes	2 minutes	This involve a telephone contact between control centers
Make a schedule for regulation		2 minutes	2 minutes	
Send schedule and receive confirmation		0,5 minutes	7	Matching of schedules is a requirement from Statnett. If only energy shedules were matched the time constraint was reduced to 1-2 minutes. If the matching schedule only were for information the time constraint would be 0,5 minutes.
Activate bids		5 minutes	5 minutes	ENDK kan only activate bids pr. 5 minutes, meaning if we activate a bid xx:x0:30 the bid is considered as activated xx:x5:00
Start regulation		5 minutes	5 minutes	Time for BRP to activated the bid
Regulation executed		10 minutes	10 minutes	Time to be fully regulated.

Statnett and Energinet.dk has a long experience of exchanging balancing services on the Skagerrak-interconnector, and delivery of balancing resources for counter trade for reliving internal congestion in Southern Norway, should in Energinet.dk's view, be possible given that the time frames for activation of counter trade resources correspond to normal balancing services, but this would have to be evaluated by Statnett.

A system protection scheme was introduced on the Skagerrak-interconnector in October 2014, which allows for the instantaneous delivery of 600 MWh balancing energy from Western Denmark to Southern Norway using the Skagerrak-interconnector. The system protection scheme has already, in Energinet.dk's understanding, increased the available capacity on the Skagerrak-interconnector. This scheme could therefore be seen as a first step in the introduction of an increased cooperation in balancing between the TSOs affected by the internal congestion in Southern Norway.

Energinet.dk therefore considers it to be technically viable for DK1 to supply Norway with up to 200 MW balancing reserves, which could be used for countertrade. Considering that Statnett is likely to in most cases to offer advance notification of NTC-restrictions (or countertrade need), this relative predictability helps actors in Southern Norway, DK1 or the Netherlands to provide competitive prices for countertrade reserves within the relevant timeframes.

Energinet.dk and Statnett have not yet discussed the technical specifications and other requirements that could be applied in a possible bidding round for balancing reserves, but in Energinet.dk's opinion these discussions should start as soon as possible, and would be a logical first step in ensuring a well-functioning internal market.

6.8. How could countertrade be organized?

As Statnett's grid restrictions are planned according to construction schedules it is possible to provide suppliers of regulating capacity/electricity in DK1 with an "early warning" on a daily basis that now there is an enhanced probability of activating counter-trade. Issuing this information will help market actors provide best possible prices.

Norwegian countertrade in DK1 would mean *additional* contracted reserves to the reserves already purchased by Energinet.dk to cover its own obligations. This would ensure that the necessary resources are available during the operational hour, where countertrade is needed.

It may also be possible to purchase from Norwegian and Dutch suppliers though this is not covered in this note.

6.9. Conclusion on initial assessment

Cross-border countertrade with DK1 could be a feasible alternative to NTC-restrictions on the Skagerrak-interconnector and may if applied reduce the negative impact on the internal market for electricity. The measure should be continuously evaluated thoroughly by the TSOs concerned in compliance with the requirements of the Regulation to which the NRAs make reference.

7. Other factors that may affect the flow on the interconnectors

7.1. Loss factor on cables

Currently the only interconnector between the Nordic and the continental areas with a loss factor in the NWE market coupling algorithm is the Baltic cable. The effect is that when the market algorithm determines the flow more of the power is routed over the NorNed and Skagerrak interconnectors than over the Baltic cable if there are no congestions between the HVDCs limiting such a shift.

7.2. Flow based

The Nordic TSO are studying how flow based capacity allocation could be introduced in the Nordic area. The results so far show that this would be particular well suited to handle the type of congestion arising in the south of Norway. However, there are still quit some development to be done before this can be realised. The current project plan mentions 2018 as earliest date of implementing flow based in the Nordic region.

8. Conclusions and TSO cooperation

In the next years there will in some cases be reductions in NTCs on the Skagerrak and NorNed connection due to congestions in the Norwegian grid both in situation with a complete grid and in periods with outages in the grid due to construction and maintenance work.

Based on the analysis in the area study of Southern part of Norway Statnett expects to that the export has to be reduced due to congestions in the grid approximately 20% of the hours in an average year. The sum of reductions in trading capacity is expected to be up to 400 MW in total on NorNed and Skagerrak. In addition, on the Skagerrak interconnector 100 MW will be reserved for selling reserves. This means that the total export capacity available for the market will be between 1900 and 2300 MW in periods with no outages in the grid.

A number of measures to reduce the need for NTC restrictions are presented in this report, and a some are already implemented.

Energinet.dk, Statnett and TenneT will continue a joint assessment of the available measures presented in this report.

Annex 1 - Completed and planned investments

Completed reinforcements in 2014

The Eastern Corridor Project was necessary for utilization of the SK4 cable, although not sufficient for giving full capacity at all times. The project included a voltage upgrade of 140 km interconnector between Kristiansand and Bamble, and a new 45 km line between Bamble and Rød. The Eastern Corridor was in operation in middle of October before Skagerrak 4 was put in operation in December. A synchronous condenser was put in trial operation in Feda in November to increase the short circuit capacity.

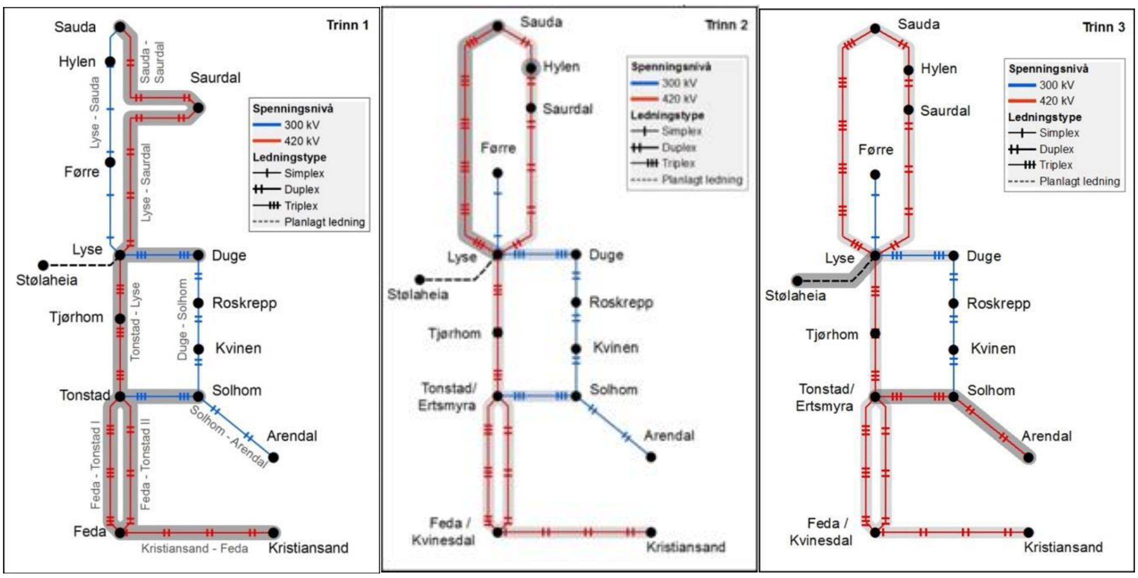
The Skagerrak 4 cable increased the total Net Transfer Capacity (NTC) between Norway and Denmark from 950 MW to 1632 MW. Based on the area study of Southern part of Norway, a reduction in export is required due to congestions in the grid approximately 20% of the hours in an average year. The sum of reductions in trading capacity is expected to be up to 400 MW in total on NorNed and Skagerrak with no outages in the grid. In addition, 100 MW on the Skagerrak interconnector will be reserved for selling reserves.

List of relevant investments completed by 1.12.204:

- 200 MVAr synchronous condensers in Feda
- Shunt capacitors in Kristiansand
- Adjustable shunt reactors in Flesaker, Arendal, Lyse, Hasle, Sylling and Frogner
- 420kV line Rød-Bamble(new)-Arendal and 420 kV cables Rød-Tveiten-Hasle
- A new 420 kV line for Sima-Samnanger was put in to operation in 2013
- A new 300 kV (built for 420kV) Sauda-Liastølen were put in to operation
- The line between Saurdal and Liastølen is connected to the new line Sauda-Liastølen, creating a permanent line from Sauda to Saurdal.

Investment plans for the Western Corridor

The Western Corridor is a complex project consisting of a step-wise power line upgrade to 420 kV from Kristiansand via Feda in the south to Sauda further north. This is required to achieve a high utilization of Skagerrak 4 and the new high capacity international interconnectors. The corridor will also provide increased operating margins and facilitate new renewable power production in south and Western Norway. The project consists of three stages as shown in the figures below.



Step 1 consists of voltage upgrade that gives a 420 kV line from Kristiansand, Feda to Sauda further north. The upgrade involves new construction of a 420 kV line from Lyse via Tonstad to Feda. The existing line will be removed.

Kristiansand-Feda, Feda-Tonstad 2 and Saurdal-Sauda will be upgraded from 300 to 420 kV on existing lines. The stations Saurdal, Lyse and Tjørhom will be upgraded. New stations will be established: Ertsmyra close to Tonstad and Kvinesdal close to Feda. Lyse-Duge and Tonstad (Ertsmyra)-Solhom will be upgraded to a triplex line and the old simplex line will be removed. Solhom-Arendal will be upgraded from 300 to 420 kV, but will be operated with 300 kV until step 3 is established.

Kristiansand-Kvinesdal-Saurdal will be in operation first for a faster expansion of capacity in the corridor. The current plan is to complete this part by second quarter of 2019. This will solve the problem of poor voltage stability and is necessary to solve the thermal congestions.

The expectation is that the finalization of step 1 will allow full utilization of the capacity on the interconnectors in situations with no outages in the grid and reduce the need for restrictions during maintenance.

The current plan is to complete this step by 2019. This is dependent on all concessions are given in time and that the actual commissioning and construction goes according to plan.

Step 2 consists of a new 420 kV duplex line from Sauda to Lyse that will increase thermal capacity south of Sauda. According to the analysis, the old simplex transmission line causes congestions approx. 30% of the year with a new interconnector, and more than 50% of the year with two new interconnectors. This implies that Step 2 should be sufficient for a cable to Great Britain (Kvilldal), but not quite sufficient for a cable to Germany (Ertsmyra). The old 300 kV line between Sauda and Førre will be removed, the 420 kV station in Sauda will be completed and the station in Hylen will be upgraded.

Step 3 consists of voltage upgrade from 300 to 420 kV on Ertsmyra-Solhom(Fjotland)-Arendal and establishment of a new station in Solhom(Fjotland). This will give almost full transmission capacity also during planned outages. Sufficient voltage stability is however also conditioned on the building of a new line from Lyse to Støleheia. This line is required for giving full capacity on NorNed with the grid intact.

At the moment, Statnett has received licences for upgrading the lines Lyse-Saurdal, Kristiansand-Feda, Tonstad-Øksendal-Feda, Solhom-Arendal and Sauda-Saurdal.

Applications for Tonstad(Ertsmyra)-Lyse and Tonstad(Ertsmyra)-Solhom are sent to OED for handling of complaints. Statnett submitted a planning proposal to NVE for Lyse-Duge last year, and are planning to send proposals for Sauda-Lyse and station Fjotland during spring 2015.

According to the investment plan, the lines and substations included in step 2 and 3 are to be set in operation in 2020 and 2019. There is a risk that step 2 can be delayed due to the concession process.

Investment plans for Lyse-Støleheia

To strengthen security of supply to South Rogaland and establish two independent interconnectors to Stavanger city, Lyse Sentralnett is seeking a licence for a new 420 kV interconnector between Lyse and Stølaheia. A final licensing decision is expected in 2016 and construction expected to take three to four years.

Annex 2 – Estimated and realized NTCs on Skagerrak and NorNed in 2014

Statnett published information about estimated capacities on NorNed and Skagerrak due to outages in the Norwegian grid February 2014, for the current year. This information is used in the tables and figured below for the estimated capacity. For each outage, more precise information was given in urgent market messages (UMMs). The figures below show the estimated and the actual given capacities. Note that NTC restrictions due to reasons other than planned outages in the Norwegian AC grid is also present in the numbers for actual available capacity.

The main changes in given capacities are due to unplanned outages, changes and cancellations of the outages and work in the Danish grid. In addition, there were some changes due production and consumption situations deviating from the estimate. The total given capacities were higher than expected due to high availability of production close to the DC-connections. For some periods, switching has been applied to create a grid configuration that increased the grid capacity. This change in grid configuration was not used in the work with estimating the capacity in the yearly planning.

Statnett gave high and low estimates for both interconnectors to indicate the possibility of reduction on either one or both cables. Most of the reductions in capacities were given on Skagerrak because of smaller price difference, and a lot of work in Kristiansand substation in relation with the Eastern Corridor and the SK4 project. Reductions in capacity to Denmark in the period from the middle of August to the middle of December were mainly due to connection and trial operation of SK4 and the Eastern Corridor.

Based on the area study of Southern part of Norway, Statnett noticed the need of reducing the export capacity on NorNed and Skagerrak up to 400 MW in total with SK4 in operation and the grid intact.

In periods with the grid intact, the reductions in given export capacities has varied between 0 and 350 MW since commercial operation date of SK4, 29.12.2014, and 11.03.2015. The reductions has been given on Skagerrak because of smaller price difference. In these periods with the grid intact, the average reduction has been approximately 150 MW on Skagerrak. In addition to this, 100 MW has been reserved for selling reserves (except the period 6. – 9.01.2015).

Average estimated and realized capacities on Skagerrak in 2014 (MW)		
	NO2-DK1	DK1-NO2
Actual	832	859
Estimated LOW	766	
Estimated		894
Estimated HIGH	884	

Average estimated and realized capacities on NorNed in 2014 (MW)		
	NO2-NL	NL-NO2
Actual	664	678
Estimated LOW	577	
Estimated		687
Estimated HIGH	673	

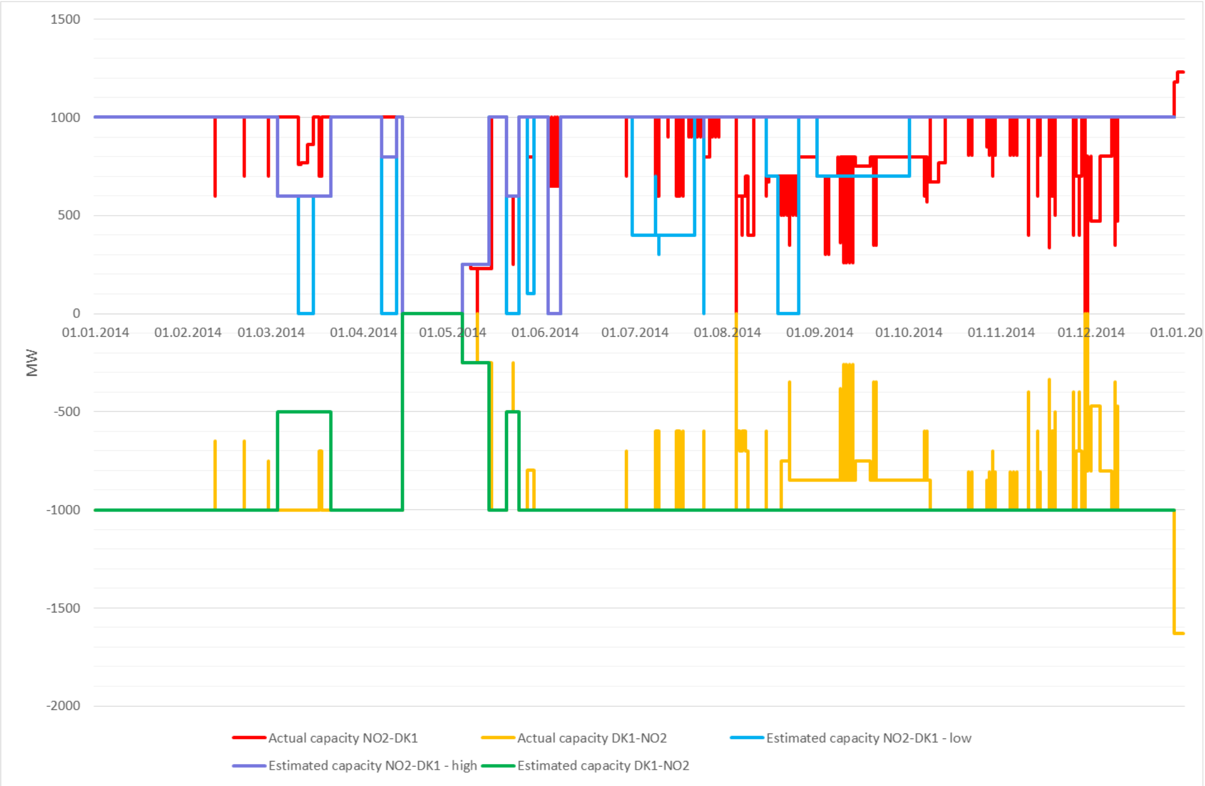


Figure 1 Actual versus estimated capacity in 2014 on Skagerrak due to outages in the Norwegian grid

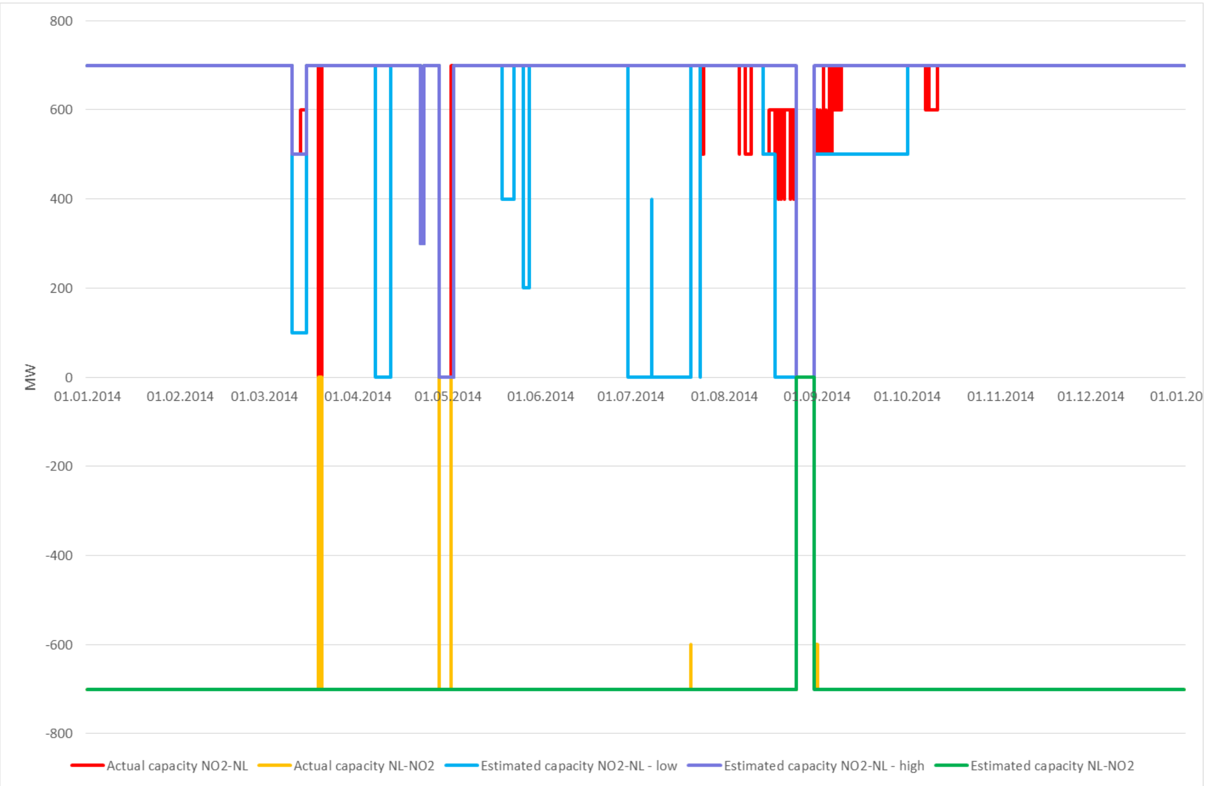


Figure 2 Actual versus estimated capacity in 2014 on NorNed due to outages in the Norwegian grid

Annex 3 - Estimated total capacities on NorNed and Skagerrak in 2015

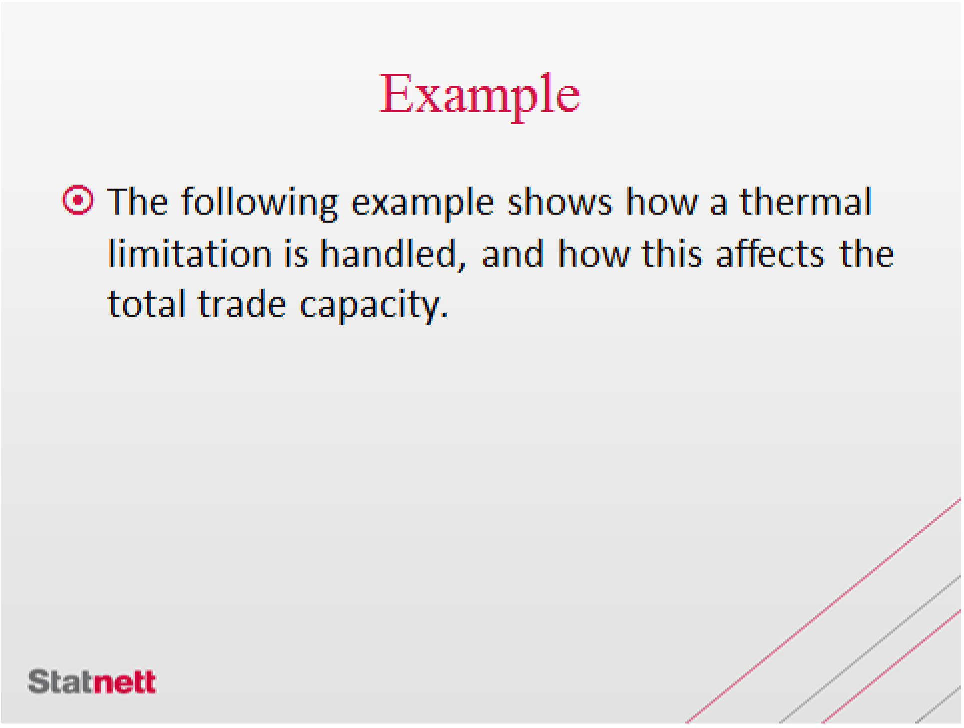
Statnett published information about the expected outages and NTCs in December 2014 for coming year. The prognosis on the NTCs are based on estimation on actual and available production in the area south of the congested corridors/lines and on the average flow in the corridors. The prognosis of NTCs will become more certain closer to the actual outage date.

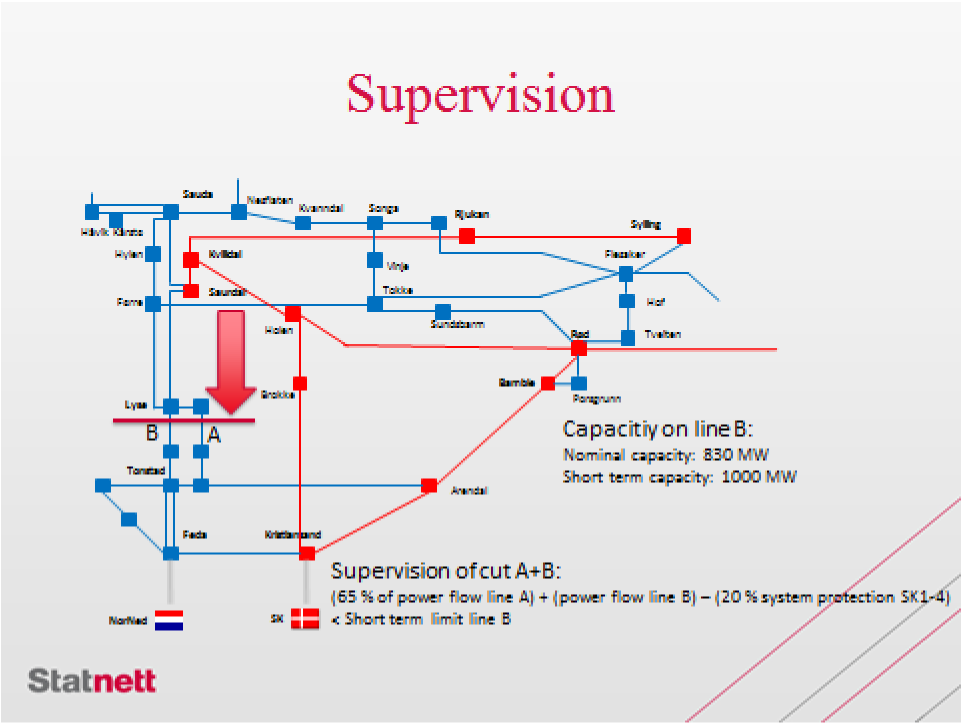
Most of the planned outages in South Norway 2015 are due to regular maintenance, reinvestments and outages due to preparations of reinforcements in the Western Corridor. There are already some changes in the estimated capacities due to unplanned outages, changes and cancellations, and different production situation than expected.

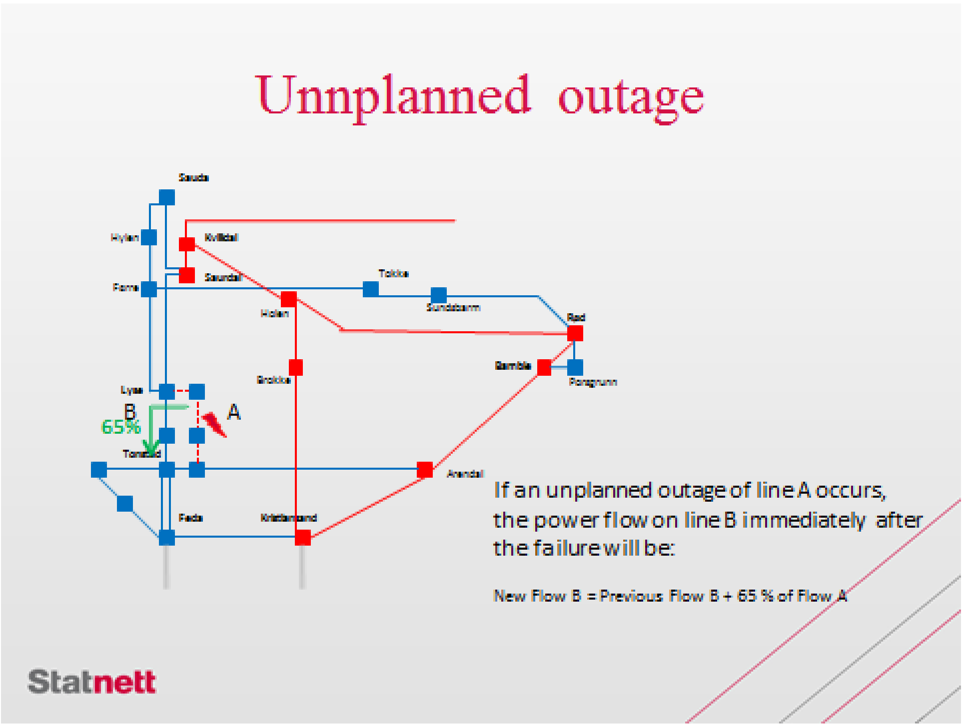
		Estimated capacity on Skagerrak 1-4, connection NO2-DK1.					Estimated capacity on NorNed, connection NO2-NL.				Estimated total capacity on NorNed and Skagerrak 1-4, connection NO2-NL and NO2-DK1.			
		Export from Norway [MW]		Import to Norway [MW]			Export from Norway [MW]		Import to Norway [MW]		Export from Norway [MW]		Import to Norway [MW]	
Weeks with reduction	Days	Max	Min	Max	Min	Days	Max	Min	Max	Min	Max	Min	Max	Min
ATC - Max		1532		1532			700		700		2232		2232	
ATC - Min		1132		1132			700		700		1832		1832	
10-11		1532	1532	1532	1532	12	600	600	700	700	2132	2132	2232	2232
12	3	1532	950	1532	1532	3	700	100	700	700	1650	1632	2232	2232
13		1532	1532	1532	1532	6	600	600	700	700	2132	2132	2232	2232
16a	1	1532	1050	1532	1532	1	700	450	700	700	1982	1750	2232	2232
16b	2	1532	750	1532	1532	2	700	200	700	700	1732	1450	2232	2232
17a	2	1050	1050	1532	1450		700	700	700	700	1750	1750	2150	2150
17b	5	500	500	1532	500		700	700	700	700	1200	1200	1200	1200
18a1	1,5	500	500	1532	500		700	700	700	700	1200	1200	1200	1200
18a2	2,5	500	500	1532	950		700	700	700	700	1200	1200	1650	1650
18b	3	1000	1000	1532	1000		700	700	700	700	1700	1700	1700	1700
19a	2,5	550	550	1532	1000		700	700	700	700	1250	1250	1700	1700
19b	2,5	1532	1450	1532	1532	2,5	700	600	700	700	2150	2132	2232	2232
21a	1	1532	450	1532	1532	1	700	300	700	700	1832	1150	2232	2232
21b	1	1532	450	1532	1532	1	700	300	700	700	1832	1150	2232	2232
27	5	1050	1050	1532	1150		700	700	700	700	1750	1750	1850	1850
28	1	1532	1350	1532	1532	1	700	300	700	700	2050	1832	2232	2232
36		1532	1532	1532	1532	7	0	0	0	0	1532	1532	1532	1532
37	6	1532	1250	1532	1532	6	700	550	700	700	2082	1950	2232	2232
38		1532	1532	1532	1532		700	700	700	700	2232	2232	2232	2232
39		1532	1532	1532	1532		700	700	700	700	2232	2232	2232	2232
41	4	1232	150	1532	1532	4	700	0	700	700	1232	850	2232	2232
42		1532	1532	1532	1532		700	700	700	700	2232	2232	2232	2232
46		1532	1532	1532	1532		700	700	700	700	2232	2232	2232	2232
	43					46,5								

Figure 3 Estimated capacities on NN and SK and on both cables in 2015 due to planned outages in the Norwegian grid, http://umm.nordpoolspot.com/messages/45224

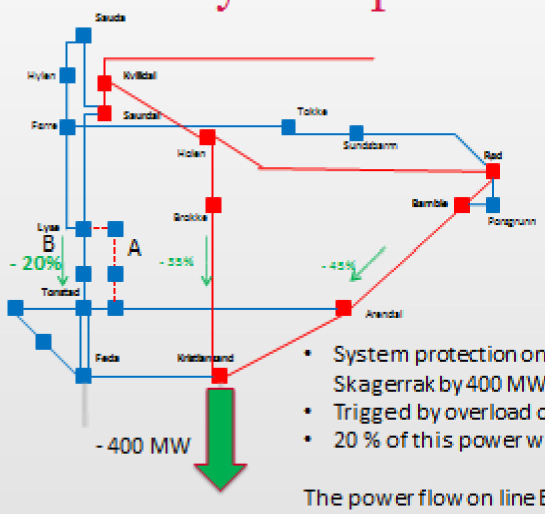
Annex 4 - Example on how the thermal limitation is handled




Supervision
Sauda
Nesflaten
Kvanndal
Songa
Rjukan
Sylling
Hylen
Kvilldal
Vinje
Flesaker
Saurdal
Tokke
Forre
Hof
Holen
Sundsbarm
Rød
Tveiten
Bamble
Porsgrunn
Lyse
Brokke
B
A
Tonstad
Arendal
Feda
Kristiansand
NorNed
SK
Capacitiy on line B:
Nominal capacity: 830 MW
Short term capacity: 1000 MW
Supervision of cut A+B:
(65 % of power flow line A) + (power flow line B) – (20 % system protection SK1-4)
< Short term limit line B
Statnett


Unnplanned outage
Sauda
Hylen
Kvilldal
Saurdal
Forre
Tokke
Holen
Sundsbarm
Rød
Brokke
Bamble
Porsgrunn
Lyse
B
65%
A
Tonstad
Arendal
Feda
Kristiansand
If an unplanned outage of line A occurs, the power flow on line B immediately after the failure will be:
New Flow B = Previous Flow B + 65 % of Flow A
Statnett

System protection

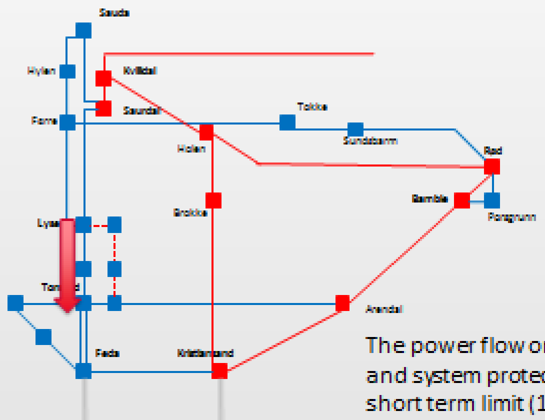


- System protection on SK1-4 will reduce export on Skagerrak by 400 MW.
- Trigged by overload on line B.
- 20 % of this power will reduce power flow on line B.

The power flow on line B will decrease by 80 MW
NB: The total trade capacity increase a lot more due to the system protection, because the lines in parallell will be higher loaded before the cut is full.

Statnett

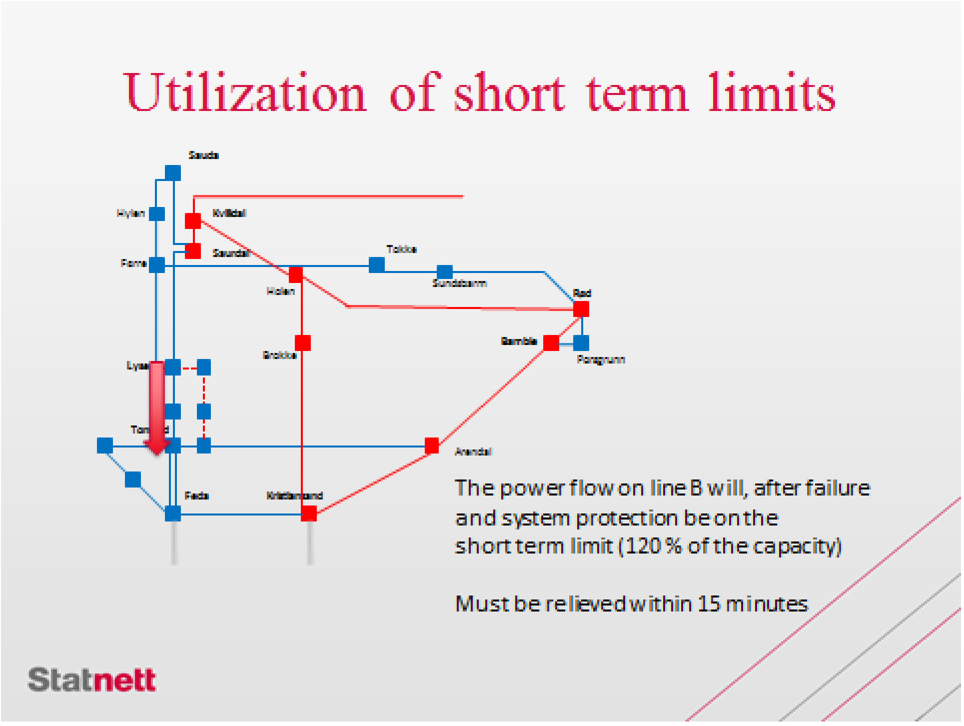
Utilization of short term limits

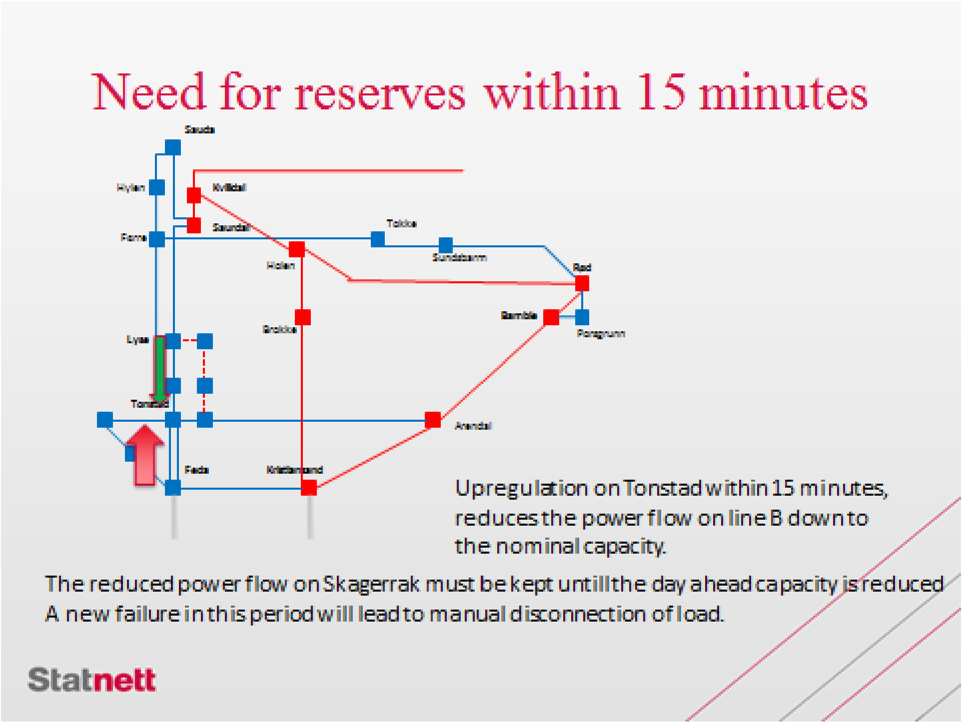


The power flow on line B will, after failure and system protection be on the short term limit (120 % of the capacity)

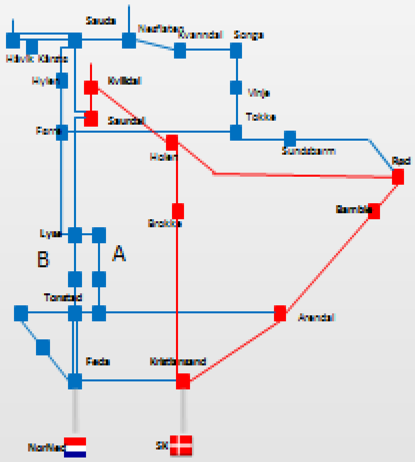
Must be relieved within 15 minutes

Statnett


Utilization of short term limits
The power flow on line B will, after failure and system protection be on the short term limit (120 % of the capacity)
Must be relieved within 15 minutes
Statnett


Need for reserves within 15 minutes
Upregulation on Tonstad within 15 minutes, reduces the power flow on line B down to the nominal capacity.
The reduced power flow on Skagerrak must be kept untill the day ahead capacity is reduced
A new failure in this period will lead to manual disconnection of load.
Statnett

Example



Line B:

- Nominal capacity: 830 MW
- Short term capacity: 1000 MW
- Efficiency of system protection: 20 % x 400 MW = 80 MW

Cut:

- 65 % line A + Line B – 80 MW < 1000 MW

Example of full utilization:

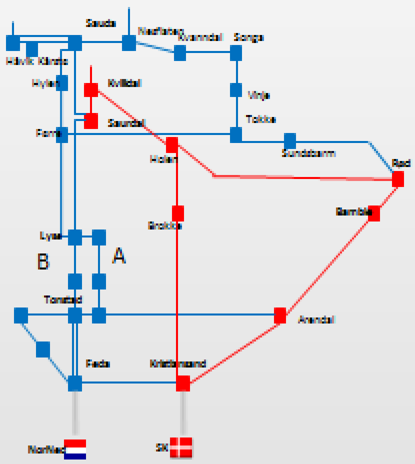
Line A: 650 MW

Line B: 650 MW

Cut: 65 % x 650 MW + 650 MW – 80 MW= 993 MW

Statnett

Countertrade and need for reserves



Upregulation to keep the cuts within the limits before failure:

- Could be done in Norway or Denmark, according to price.
- Nessecary reserves for fault handling could not be used before failure

Upregulation after trip of line A

- Resources to relieve the line from short-term limit to nominal capacity must be kept in Norway.
- Reserves for this purpose must be fully upregulated within 15 minutes.

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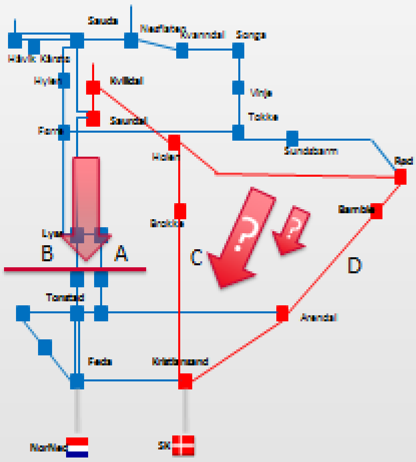
Trade capacity



- Full cut A+B: 1300 MW
- The total capacity depends on the power flow on the other lines when cut A+B is full.
- If line C or D are heavy loaded, other cuts could be dimensioning for the trade capacity.
- The total capacity on HVDC-connections are based on prognosis on flow distribution, consumption, and production capacity.

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