2015-03-17

The Hasle-pilot project

Market based transmission capacity reservation 27th of October 2014 to 19th of December 2014

1 Executive summary

The purpose of the Hasle-pilot has been to evaluate market based transmission capacity reservation as a way to enable exchange of Automatic Frequency Restoration Reserve (FRR-A) capacity and achieve socio economic benefit. In the pilot, FRR-A capacity has been exchanged between Norway and Sweden. The Hasle-pilot has been run as a bilateral project between the Norwegian Transmission System Operator (TSO), Statnett, and the Swedish TSO, Svenska kraftnät.

The Hasle-pilot was run for the eight weeks between 20th of October and 19th of December 2014. This report presents operational and economical experiences from the pilot as well as impact assessments of alternative reservation methods and market design changes. The experiences shall contribute to the development of a Nordic market for FRR-A capacity.

The FRR-A capacity exchange and corresponding reserved Cross-Zonal Capacity (CZC) have been calculated weekly for the upcoming week. Exchange has been decided for three different time blocks per week. The exchange volume was determined according to a predefined method based on public prices. The method was made public before the pilot started.

The method compares the marginal value of using CZC for FRR-A exchange to the marginal value of using CZC for the Day Ahead Market (DAM). The marginal value of the FRR-A exchange is derived from the Norwegian and Swedish FRR-A bidding curves, while the marginal value of the DAM is derived from the DAM price difference of the procurement week. In addition, a set of criteria linked to transmission capacity and price level in the DAM is needed to be fulfilled to carry out the reservation.

The socio economic optimum of the reservation would be reached if CZC where reserved so that the marginal value of using CZC for FRR-A exchange would equal the marginal value of using CZC in the DAM. The applied method is however not designed to reach optimum reservation, but was conservative in the sense that it is designed to reduce the risk of over-reservation.

The result of the pilot is in overall to contentment. The exchange has been carried out according to plan and has not led to any significant difficulties during operation. It was however experienced that the exchange of FRR-A capacity involves additional tasks that to some extent complicates the daily routine in the control centers. In case of a permanent exchange, IT system development is required.

The total socio-economic net result is positive and summarizes to 62 000 €. Due to extraordinary market situation in the beginning of the pilot period with flood in Southern-Norway, the average economical gain in the pilot period is below what the average gain would have been if the pilot was run all autumn. The Swedish marginal FRR-A price has on average decreased with 4.0 EUR/MWh while the Norwegian marginal FRR-A price has on average increased with 0.9 EUR/MWh.

A comparison of the exchange of FRR-A capacities carried out and the optimal exchange of FRR-A capacity given the actual DAM prices, shows that the number of blocks with too much reserved capacity was limited, and the influence on the total economical outcome was negligible. For most blocks it would instead have been beneficial to reserve more capacity than what was carried out. The total socio-economic benefit of the pilot amounts to approximately 50 percent of what would have been the result given perfect DAM forecast (actual DAM prices).

Assessments based on market data of the full year of 2014 indicate a potential for extracting more socio-economic value from the exchange. The assessment indicates that it is possible to increase beneficial reservations without a corresponding increase in non-beneficial reservations. Two improvements of the weekly procurement that have been considered are: 1) to replace maximum price difference of the procurement week as input parameter defining the value of CZC for energy trade with the average price difference and 2) let the method include prices of financial contracts. However, more analyses are necessary before any firm conclusions could be drawn.

In line with the target model agreed by the Nordic TSOs it is recommended to change from weekly to daily procurement and reservation of CZC. The main benefit of changing to daily procurement is expected to be that the providers can offer FRR-A capacity to a reduced cost. That is however not addressed in this report. The socio economic benefit that is presented in this report is instead the potential increase of the value of exchanging FRR-A capacity between Norway and Sweden, assuming the same FRR-A bids as with weekly procurement. For the eight week pilot period the value is calculated to be more than 20 000 € higher with daily procurement compared to weekly.

A more thoroughly assessment of the DAM price impact have been done based on the bidding curves of the DAM and the alternative DAM results as it would have been without any reservation. The simulations have been performed by Nord Pool Spot (NPS). For the pilot period reservations, the NPS data indicates limited spot price impact due to the reservations. However, further analyses are necessary to draw sound conclusions.

One alternative to market based transmission capacity reservation is to use counter trade to release the congestions that are expected to occur due to exchange of FRR-A capacity. However, due to challenges both from an operational perspective and a market perspective, it is not recommended to apply this methodology to enable exchange of FRR-A capacity between Norway and Sweden.

The pilot has provided an opportunity to assess market impact as well as operational experiences. It has shown that it is possible to perform market based reservation of CZC, but it has also shown a need for several IT tools to be implemented in order to make the processes more efficient and secure. As the pilot was run for a limited period with unusual market conditions, it is recommended to run a second phase of the pilot.

2 Introduction

Automatic Frequency Restoration Reserve (FRR-A) was introduced in the Nordic synchronous power system in 2013 in order to improve the development of the frequency quality. The impact of the FRR-A on the frequency has been positive but the development of market solutions has proven demanding as the ability of market players to provide FRR-A varies between the Nordic countries. Exchange of FRR-A capacity is expected to be beneficial both regarding economics and security of supply; as such exchange can increase the volumes of FRR-A available in the Nordic region.

To enable exchange of FRR-A capacity between Norway and Sweden, without reducing security of supply, it is necessary to ensure availability of transmission capacity. Exchange of FRR-A is however complex to perform, both from an economical and an operational point of view. The Hasle pilot period was created in order to get small scale experience of transmission capacity reservation.

The method applied in the pilot is conservative. That is, the method is designed to minimize the risk of distortions in operations and spot market rather than maximize the value of capacity. Further, the method is in accordance with the market based reservation described in Network Code for Electricity Balancing (version submitted from Entso-E to ACER by 16th of September 2014).

The report starts with a brief description of the Hasle pilot, Chapter 3. The following chapters describe experiences from the pilot, operational experiences in Chapter 4 and economical experiences in Chapter 5. Chapter 6 provides an analysis of how different adjustments of the method would influence the result and Chapter 7 provides an analysis of the available Nord Pool Spot (NPS) simulations. In Chapter 8 the benefits of changing the procurement frequency from weekly to daily is analysed, while in Chapter 9 counter trade as an alternative method to reservation of transmission capacity is analysed. In Chapter 10 the total experiences and analyses are summarised.

3 Description of Hasle pilot[1]

The Hasle pilot is a bilateral project run by the Norwegian Transmission System Operator (TSO) Statnett and the Swedish TSO Svenska kraftnät.

The pilot period lasted from 20th of October until 19th of December 2014. Before the exchange of FRR-A capacity was started, Svenska kraftnät and Statnett informed relevant customer boards as well as National regulators and Nord Pool Spot about the exchange. The Norwegian Water Resources and Energy Directorate approved the Statnett participation. In addition, 14 days before the first reservation was performed, the start of the Hasle pilot was announced in an urgent market message at NPS.

3.1 The procurement and reservation process

The reservation of transmission capacity has been carried out as part of a co-ordinated procurement process between Statnett and Svenska kraftnät.

Immediately after gate closure time (h10 at Thursdays) Svenska kraftnät and Statnett have generated comparable national FRR-A bid curves. These bid curves and Day Ahead Market (DAM) forecasts have been used to calculate the exchange and corresponding transmission capacity reservation.

After calculating the exchange, Svenska kraftnät and Statnett have completed the national procurements, with adjusted volumes. Reserved capacity has been reflected in the Net Transfer Capacity (NTC) values defined for the spot market.

3.2 The exchange and reservation method

The method used to determine the exchanged FFR-A capacity consists of two steps:

1 Comparison of the marginal value of FFR-A capacity and the expected marginal value of Cross-Zonal Capacity (CZC) in the DAM

2 Verification that predefined criteria for reserving CZC are fulfilled

The first step determines the exchange volume that is socio-economically beneficial, given the expected marginal value of CZC in the DAM.

1 More detailed explanation of the process and the method can be found in the memo "Method and parameters for determining capacity reservation" and the memo "Process description", both available on the websites: www.statnett.no/Drift-og-marked/Markedsinformasjon/sekundarreserver/Hasle-piloten/

The second step is to verify that additional criteria for reservation are fulfilled. These criteria shall identify market situations in which the risk of underestimating the marginal value of CZC in the DAM is high. Thereby the criteria reduce the risk of significant impact on the DAM. In the pilot, the amount of transmission capacity allocated to the exchange of FRR-A was restricted to exchange a maximum of 50 MW of FRR-A, or 5% of the forecasted Net Transfer Capacity (NTC), whichever was the lowest.

To enable exchange of FRR-A capacity from Norway to Sweden, cross zonal capacity between south-western (NO2+NO5) and eastern part of Norway (NO1) has been reserved in addition to the reservation of CZC between Norway (NO1) and Sweden (SE3). This is due to that most Norwegian FRR-A resources are located in the south-western part of Norway.

4 Operational experiences

One of the aspects evaluated in the Hasle pilot is the *Operational experiences*. *Operational experiences* cover a broad range of issues. Some of these were identified in the project planning phase while others were revealed in the implementation or operational phase.

The operational experience from the Hasle pilot is valid for limited exchanged volumes. In case of larger volumes, the influence of exchange on the power system will increase, which implies additional importance of system monitoring. In addition, a more comprehensive implementation would involve several cross zonal connections and as such a more challenging operational situation.

4.1 Weekly procurement

The weekly procurement of FRR-A has been carried out according to plan. The market model for FRR-A differs between Sweden and Norway and conversion of the bids is therefore required in order to compare the Swedish and Norwegian bidding curves and to find the optimum exchange.

The conversion of bidding curves has been carried out by use of Excel tools. The Excel tools have proven functional and the exchange calculated correctly and on time during the entire pilot period.

The weekly procurement process, with use of Excel tools and e-mail, has worked smoothly in the pilot period. However, the process has been time consuming and taken focus off other matters in the control center. In order to become more efficient, and to reduce the risk of failure, these manual tools should be phased out and integrated in the ordinary IT systems.

To enable a permanent solution, the market design should be aligned between countries and the functionality for creating and exchanging bidding curves should be part of the IT system.

The Hasle pilot has been run in parallel with a FRR-A exchange between Sweden and Finland. The exchange between Sweden and Finland is based on a probabilistic method, an alternative congestion management method to marked based reservation. At Svenska kraftnät, the parallel exchange with Norway and Finland has created some additional complexity. The results of both exchanges have been available in mail and

Excel files. It would however simplify the operation if the information was instead available in the trading system, accessible for all operational personnel.

4.2 Transmission capacity given to energy markets

Reservation on the NO1-NO5, NO1-NO2 and NO1-SE3 borders has been carried out for all exchanged capacity. The reservations have been included correctly in transmission capacity values defined for the energy markets.

In order to ensure that the reservations are considered in the calculations of ATC values for DAM, the reservations have been exported to the Nois IT-system by a semi-manual procedure. Even though it has been done correctly, it should be remembered that it is an additional task that to some extent complicates the daily routine in the control center. In case of a permanent exchange, IT system development is required.

An additional experience made during the pilot is that it is important to ensure that information on reserved values is sent to Nord Pool Spot (NPS) weekly. This can be solved by automatically generated e-mails. The reason being that NPS needs to know what the reserved volumes are in order to be able to cancel the reservations in case of a situation without cleared spot prices.

4.3 System overview

The exchange has worked according to plan and has not led to any significant difficulties during operation. It has however become clear that one major challenge in case of exchange of automatic reserves is the system overview.

Statnett monitor the flow in Hasle with the help of defined "cuts" in the SCADA-system. In order to exchange larger volumes, implementation of the effect of the changing limits due to activated FRR-A is necessary. The fact that the distribution of FRR-A capacity can change between hours and days also contributes to the need for a monitoring tool of distribution of balancing capacity. The example below explains in more detail why exchange of automatic reserves creates this monitoring need.

Detailed explanation to justify the need for monitoring of distribution and activation of automatic reserves:

- The exchange of secondary reserves influences the power flow between NO1 and SE3.
- With the normal TRM (Transmission Reserve Margin) of 150 MW, the maximum NTC from NO1 to SE3 is 2145 MW, which means a TTC of 2295 MW.
- Due to more volumes of primary reserves in Southern-Norway compared to defined sharing key, the flow will increase if the frequency dips below 50.00 Hz. To make sure that the power exchange do not exceed the TTC at a frequency of 49,90 Hz, the flow has to be kept equal to or lower than 2145 MW at 50.00 Hz.
- To ensure acceptable reliability of supply, the amount of exchanged FRR-A capacity and the resulting TRM has to be considered. If the FRR-A exchange from Norway to Sweden is 50 MW FRR-A, the TRM is 200 MW, but the optimal flow that the operators should try to maintain at full export or import is a bit more complex.
- If there are no FRR-A regulation in the system and the frequency is 50.00 Hz operation can aim at 2095 MW at full export.
- The complications arise whenever there is activated FRR-A. In a situation where the FRR-A is fully down regulated and the frequency is 50.00 Hz, 50 of the 200 MW TRM from SE3>NO1 has been used. The result is that operation have to aim at 2045 MW at 50.00 Hz, hence the limit for the power flow between NO1 and SE3 is dependent of both frequency and activated FRR-A.

One concern prior to the pilot was the Swedish «Västkustsnittet». Due to the market situation with high water levels in Southern-Norway, it has however not been an issue. With a more comprehensive scope of FRR-A exchange and reservation, this might need to be reconsidered. The Hasle experience shows that not only network constraints between Norwegian and Swedish areas, but also constraints within areas are of concern.

4.4 Transmission Capacity Forecasts

The forecasted available transmission capacities are important inputs to decide the exchanged capacity. The forecasted transmission capacities have been based on the

UMMs on available transmission capacities. A semi-automatic routine has been used to compile UMM and calculate available capacity. However, experience show that it is sometimes challenging to transform the UMM information into transmission capacities that can be used for the socio-economic calculation tool.

4.5 Canceling of reservation

It has not been necessary to cancel any reservation during the pilot period. A need to clarify the routines for cancelling of reservations and exchange has however been identified.

Cancelation of exchange will lead to a reduced volume of FRR-A in the system. The routines shall be designed so that the numbers of hours with reduced FRR-A can be kept to a minimum. One issue that needs to be clarified is therefore for what duration a cancelation is valid. The agreement has been that a cancellation shall be valid for the remainder of the week. However, this should not be necessary since the evaluation is carried out daily.

4.6 Settlement

The settlement practicalities went according to plan. The settlement agreement will be assessed and possibly changed in case of a permanent implementation.

5 Economical experiences

One main purpose of the Hasle pilot project has been to evaluate economical experiences of market based capacity reservation. In order to assess the capacity reservation method applied in the pilot, a socio-economic cost benefit analysis has been carried out.

The total socio-economic benefit of the FRR-A exchange and transmission capacity reservation between Norway and Sweden is for the eight week pilot period approximately EUR 62 000, in average just below EUR 8 000 per week.

The socio-economic benefit has been calculated as

- the value of exchanged FRR-A derived from the national bid curves and
- the cost of reservation in the DAM, approximated as the actual price difference between the relevant price areas, multiplied with the reserved volume.

Analysis of the DAM price impacts is covered in Chapter 6 *Impacts of reservations on spot prices*.

Prior to the actual pilot period, Statnett and Svenska kraftnät carried out a nine week test period. During the test period, FRR-A bids in Norway and Sweden were compared and the exchange calculated according to the pilot method. No actual exchange or reservation was however carried out. The result from the test period is included in some of the assessments presented below.

5.1 Main economic results

All the FRR-A exchange in the Hasle pilot has been in direction from Norway to Sweden. The Swedish marginal FRR-A price has on average decreased with EUR 4.0 while the Norwegian marginal price has on average increased with EUR 0.9, considering the blocks where FRR-A has been exchanged.

	During pilot period (w 44 to w 51)	Including test period (w 35 to w 51)
Average price increase of FRR-A in NO	0.9 EUR/MWh	1.0 EUR/MWh
Average price decrease of FRR-A in SE	4.0 EUR/MWh	3.4 EUR/MWh
Total socio-economic benefit	EUR 7 700 per week	EUR 9 200 per week

5.2 Weekly costs and benefits of the FRR-A exchange

Figure 5.1 shows the weekly costs and benefits of the FRR-A exchange. The figure includes the actual pilot period as well as the test period.

As the test period ended and the actual pilot started, the market situation changed considerably. An increased inflow to hydro reservoirs caused the DAM prices to drop in Southern-Norway and thereby the DAM price difference between Norway and Sweden to increase. This means the DAM price difference of week 44 increased considerably compared to the DAM price difference of week 43, on which the exchange was based. The DAM cost of the reservation was thereby underestimated. The actual cost of reservation during week 44 exceeded the value of the capacity on the FRR-A up-regulation market and the reservation was thereby non-beneficial. This was the only week with non-beneficial reservation.

Due to the large difference in DAM prices there were no reservation of capacity from Norway to Sweden during week 45 and 46. In addition, the cost of Norwegian FRR-A increased and converged to Swedish cost levels, this was most evident for down-regulation. This can be explained by high inflow volumes that resulted in run of river production and made down-regulation more costly for the Norwegian hydro producers. In some exchange blocks the Norwegian prices of down-regulating FRR-A were higher than the Swedish and would have led to exchange in the flow direction if the reservation criteria such as maximum DAM prices would have allowed.

As colder weather and a decrease in inflow normalized the market conditions in week 47, the exchange results returned to levels more in line with that of the testing period. The reservation and exchange of up-regulating FRR-A peaked in week 51, the last week of the pilot period. During week 51, the DAM price difference between Norway and Sweden was small for the relevant hours.

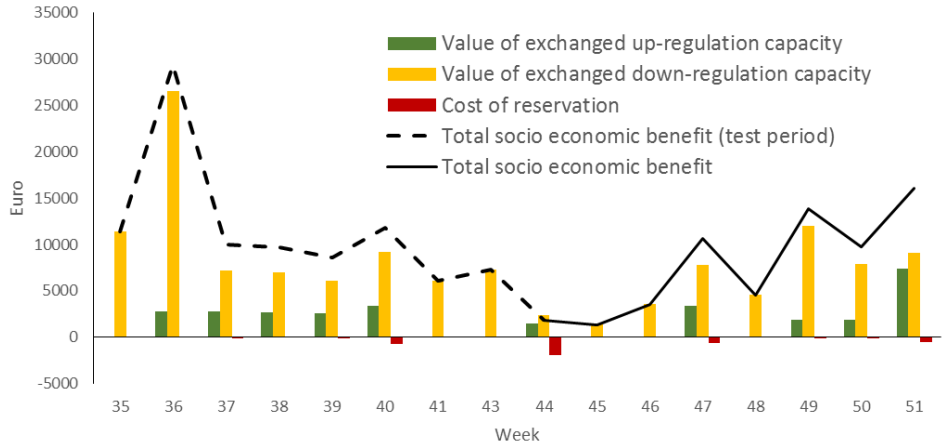

Figure 5.1. Weekly costs and benefits of FRR-A exchange in the test period and the actual pilot period

5.3 Conservative approach to reservation

The intention of the pilot project has been to use a conservative approach to reservation. This is to limit the risk to reserve too much transmission capacity and by that suffer injustifible costs in the DAM, i.e. cost that can not be motivated by equal or exedingly beneficial FRR-A exchange.

Figure 5.2, 5.3 and 5.4 show the actual reservation of transmission capacity towards SE (up-regulating FRR-A) and towards NO (down-regulating FRR-A) for each block respectively, compared to what would have been optimal reservation, given perfect DAM price forecast.

The assessment shows that the only time the reservation exceeded what would have been the optimum reservation was during block 2 and 3 of week 44. For remaining weeks the reservation is instead in level with or below the optimum reservation. The comparison between actual results and the result based on perfect price forecast indicates that the intention of using a conservative aproach has been met.

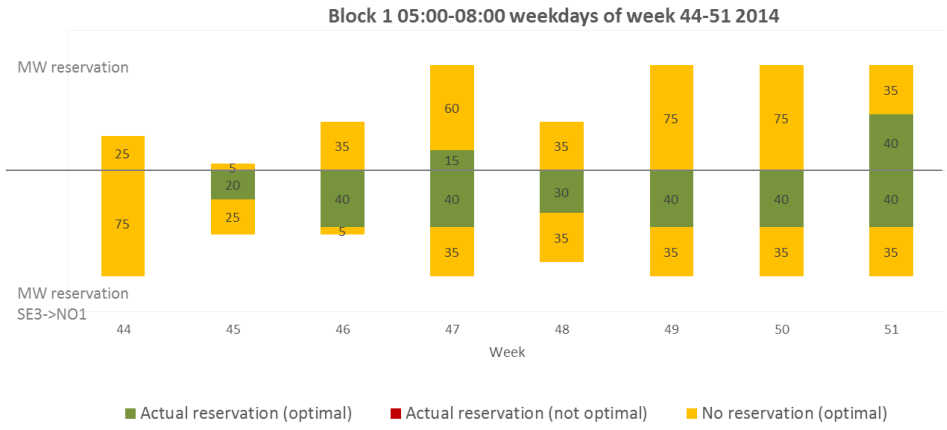

Figure 5.1. Actual reservation of transmission capacity towards SE and towards NO for block 1 compared to optimal reservation given perfect DAM price forecast

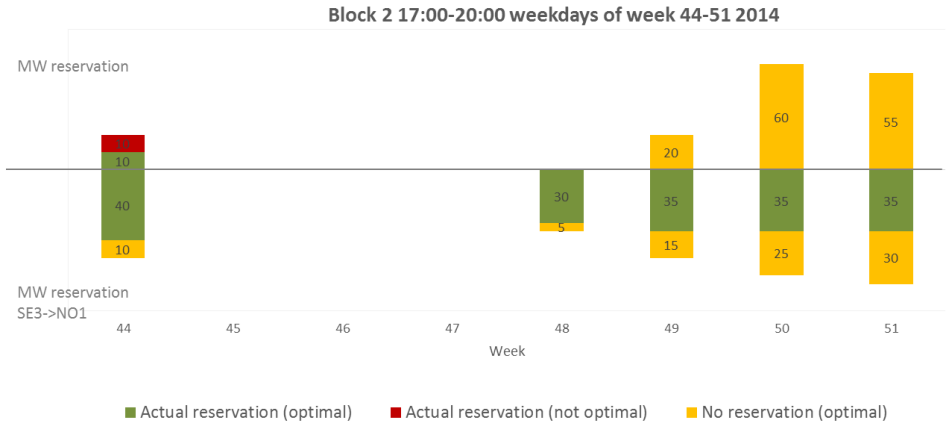

Figure 5.2. Actual reservation of transmission capacity towards SE and towards NO for block 2 compared to optimal reservation given perfect DAM price forecast

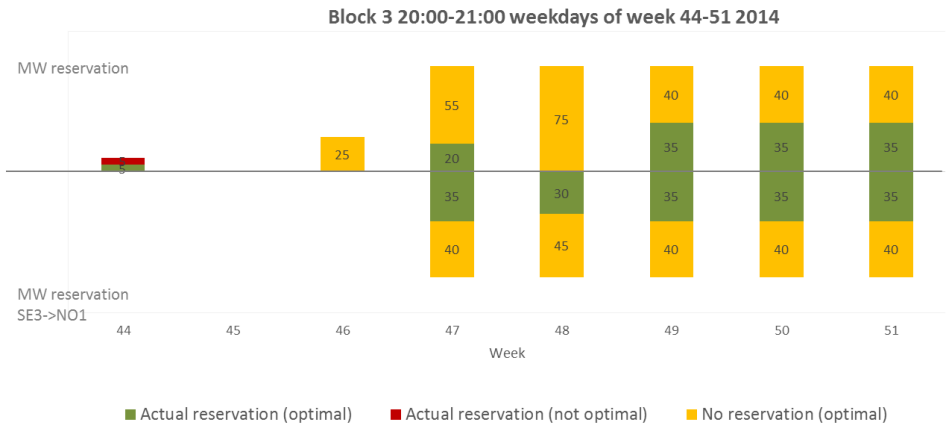

Figure 5.3. Actual reservation of transmission capacity towards SE and towards NO for block 3 compared to optimal reservati9on given perfect DAM price forecast

Figure 5.5 shows the additional value that could have been realized if perfect DAM price forecasts were available. The conservative method realized nearly half of the potential maximum benefit with perfect DAM price forecast.

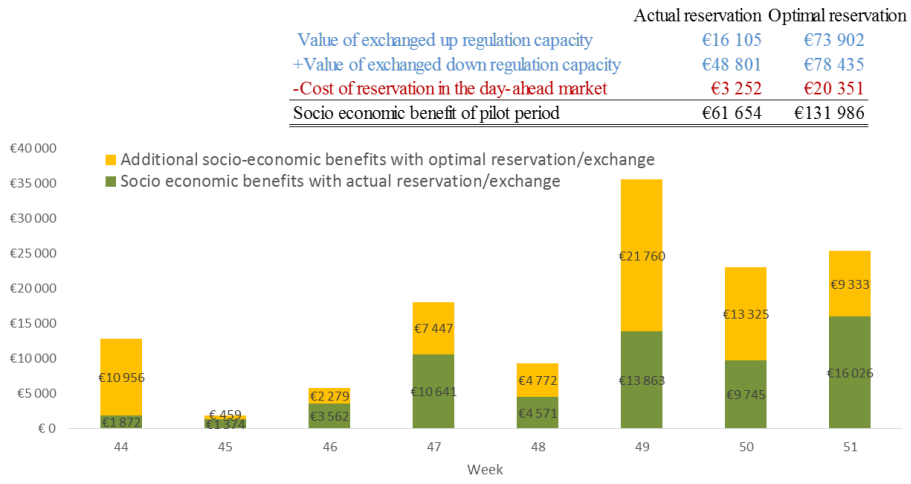

Figure 5.5. Additional socio-economic benefits if perfect DAM price forecasts were available

5.4 Exchange of FRR-A from Sweden to Finland

During the Hasle pilot period, Svenska kraftnät also exchanged FRR-A capacity with Fingrid. The exchanges between Norway and Sweden and between Sweden and Finland have been run as individual projects. However, there is a connection as the imported volumes from Norway have contributed to decrease the price on the exchanged volumes between Sweden and Finland.

6 Impact of reservation method

Given the uncertainty of the cost of reserving transmission capacity in the DAM at the time of FRR-A procurement, a set of criteria, or rules, have been defined to minimize reservations for which the cost of reservation in DAM exceeds the value of FRR-A exchange. However, the criteria still allow for the model to realize such as large proportion as possible of the potential efficiency gained from reservation. With the method used in the pilot, approximately 50 percent of the potential value of the exchange was realized, while only a small volume of the FRR-A exchange was non-beneficial.

The exchanged volume in each block was determined by the criteria summarized in Figure 6.1.

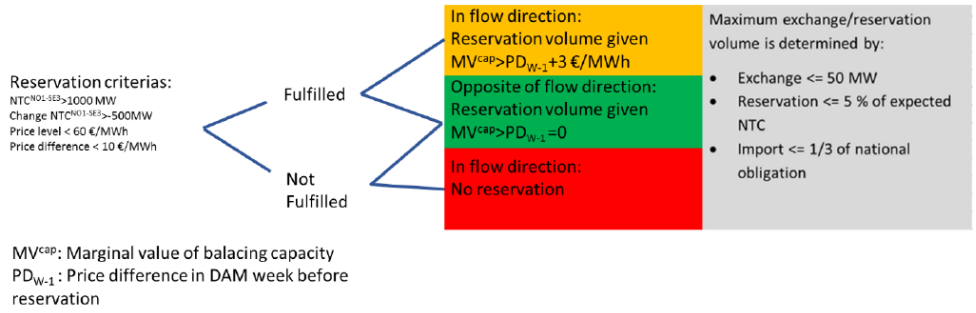

Figure 4.1. Criteria for FRR-A exchange

Due to the varying market conditions during the pilot period, several different criteria have served as the limiting factor for exchange. The eight week pilot period includes in total 24 blocks with possible FRR-A exchange. Figure 6.2 shows which criterion that has been the limiting factor for each of these blocks.

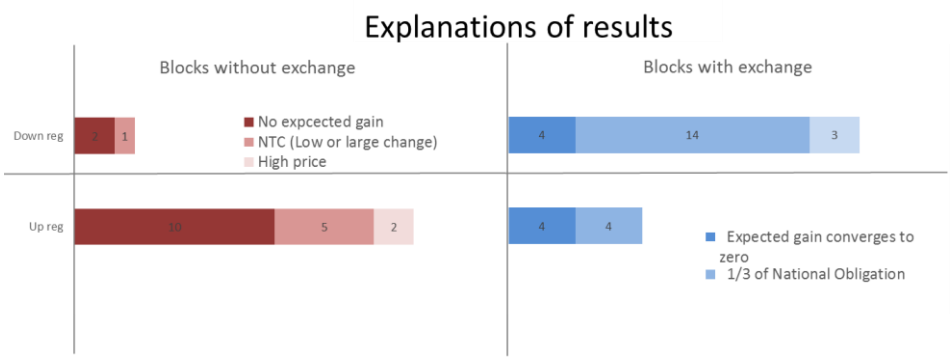

Figure 6.2. Limiting factors for FRR-A exchange

In blocks without exchange, the limiting factor is on most occasions due to *no expected gain*. That is, the expected marginal value of the capacity in the DAM is higher than the marginal value of exchanging FRR-A.

Expected NTC between NO1 and SE3 below 1000 MW or a decrease in expected transmission capacity exceeding 500 MW have prevented exchange in five blocks. The DAM price in SE3 exceeding EUR 60 has prevented exchange in two blocks.

The exchanged volumes depend on the expected flow direction, which is forecasted based on the flow direction of the week of procurement. It is worth noticing that during the pilot, the actual DAM flow direction never deviated from the expected direction. This indicates that the economic risk of exchanging down-regulating FRR-A from Norway to Sweden is small with a hydrological situation such as the one during the pilot.

On most occasions the exchanged volume has been restricted by the requirement to procure two thirds of the national obligation in the domestic market (18 blocks). Given the Swedish procurement volumes, it was never possible to reserve 50 MW, which is the overall limit of the pilot. The expected marginal value in DAM converging to the marginal value of FRR-A exchange, was the limiting factor in eight blocks.

7 Alternative reservation methods

The method used in the pilot period is based on the assumption that the DAM price differences in the procurement week will serve as a reasonable forecast of the price differences in the delivery week. The margin and criteria are defined with the purpose to avoid reservations in market situations where there is a substantial risk that the actual DAM price difference of the procurement week will exceed the forecasted value.

For each MW that can be reserved within the pilot restrictions there are four possible outcomes, shown in Figure 7.1. Based on the expectations at the procurement, it is decided whether to exchange FRR-A, and reserve the corresponding volumes of transmission capacity. Depending on the realized DAM prices in the week of exchange, the decision is *correct* if transmission capacity *is reserved* when the reservation turned out to be *beneficial* or if transmission capacity is *not reserved* when the reservation would have been *non-beneficial*.

In the project, it is considered more important to avoid non-beneficial reservations than to not reserve and exchange capacity when it would have been beneficial. In this sense, the strategy for handling uncertainty is risk averse.

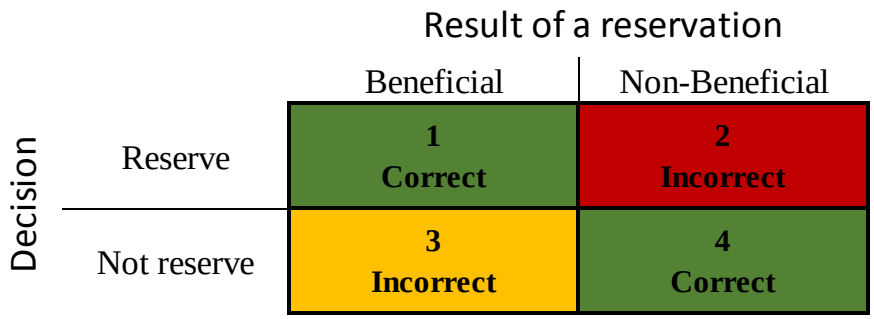

Figure 7.1. Four possible outcomes of the decision making process of the procurement week

Many possible changes in method could be explored in order to increase the number of correct outcomes and decrease the number of incorrect outcomes of the reservations.

In this chapter an assessment of some alternative reservation methods is presented. It is however important to keep in mind that the analyses are carried out on a limited set of data and made with specific assumptions.

7.1 Reservation without margins and other criteria

The first alternative to be assessed is the same method as in the pilot project but without any margins or criteria.

Figure 7.2 shows the distribution of outcomes of the assessed method compared to the outcome of the method used in the pilot project. The four categories on which the outcomes are distributed correspond to those in 7. To be able to base the analysis on a larger set of data than available from the pilot period, the DAM data (prices, flows and capacities) from week 1 to 51 of 2014 has been used.

The same marginal value curve of exchanging FRR-A is used for all 50 weeks. The marginal value curve is based on the average value of each block in the Hasle period, which implies a maximum exchange of 40 MW.

The presented results affect the up-regulating FRR-A only, since the influence of the method on the exchange of down-regulating FRR-A is negligible for the period.

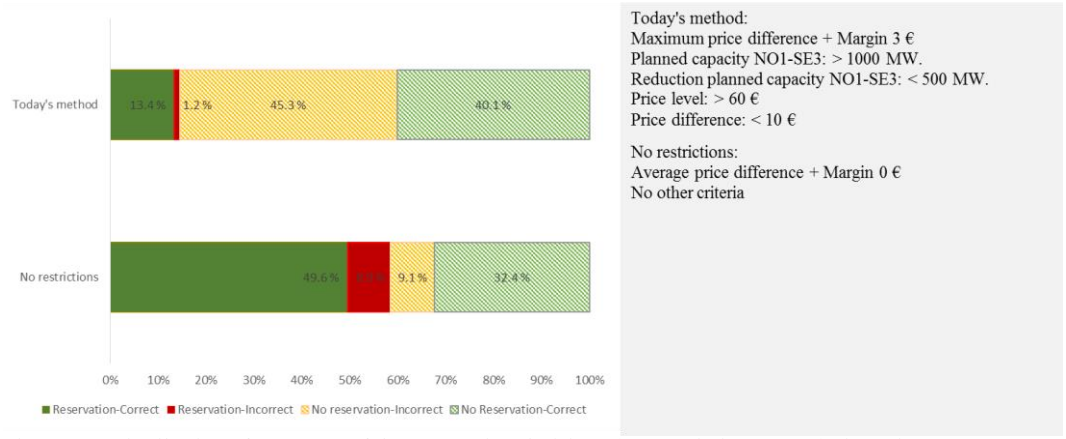

Figure 7.2. Distribution of outcomes of the reservation decisions (up-regulating FRR-A) given the method in the pilot project and a reservation method without margins and other criteria

The result presented in Figure 7.2 shows that the method applied without restrictions increases the share of beneficial reservations with 36 percentage points while the share of non-beneficial reservations is only increased with 8 percentage points. This indicates a clear potential for extracting more socio-economic value by increasing beneficial reservation without a corresponding increase of non-beneficial reservation.

7.2 Average and maximum DAM price difference

In the pilot project, the DAM price difference for each block has been forecasted as the *maximum* price difference between Southern-Norway (NO1, NO2 and NO5) and Sweden (SE3) of the procurement week, plus a margin of EUR 3.

This method makes the forecasted marginal value sensitive to large price differences that occur only in a single or very few hours in the procurement week. For example, if there would be a price difference of 9 EUR/MWh in hour 18 on Wednesday of the procurement week, but the price difference is lower than 3 EUR/MWh all other block hours, a marginal value of EUR 9 + EUR 3 =EUR 12 would still be used as forecast for *all* 15 block hours in the reservation week.

One alternative to the use of maximum price difference is to use average price difference. Methodologies based on average price difference have been assessed as part of the project. The results of two such assessments, one with EUR 3 margin as in the pilot project and one with EUR 5 margin, are shown in Figure 7.3.

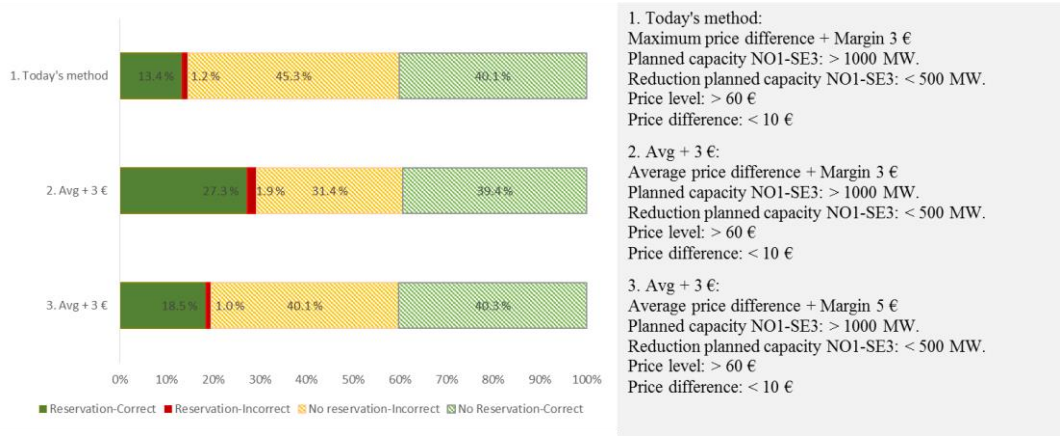

Figure 7.3. Distribution of outcomes of reservation decisions (up-regulation regulating FRR-A) given the reservation method used for reservation in the pilot project and reservation methodologies forecasting price differences as the average price difference

Figure 7.3 shows that the use of average price difference and a EUR 3 margin increases the share of beneficial reservations with 14 percentage points compared to the pilot method, while the non-beneficial reservations increase with less than one percentage point. Increasing the margin to EUR 5, increases the share of beneficial reservations with five percentage points compared to the pilot method, while the number of non-

beneficial reservations is marginally reduced. This indicates a clear potential for extracting more socio-economic value by increasing beneficial reservation without a corresponding increase in non-beneficial reservation.

7.3 Financial contract prices in the reservation method

When forecasting DAM price differences according to the methodology used in the pilot project, knowledge about potential changes in the DAM price differences is taken into consideration only to a very limited extent.

One way to improve the DAM forecast could be to analyse impacts of weather forecasts, market messages on outages and other variables considered relevant for the market development. To build, maintain and operate a comprehensive forecast model is however demanding. In addition, it is considered important to carry out reservations based on clear and transparent rules and it is not considered advisable to use commercially available forecasts.

Another way to improve the ability to capture upcoming changes, without using a forecast model, could be to include prices of financial contracts in the method. These prices reflect expectations and knowledge of a large number of market players and should therefore perform well when it comes to capturing changes that is important for the short-term price development. In addition, prices of financial contracts are publicly available data.

One way to make use of forwards or futures prices in the reservation method is to use the contract prices to adjust the DAM forecast. An alternative way is to use the change of the contract prices as a criterion to avoid reservation in case of substantially changed market conditions.

A challenge connected to the use of financial contracts is that the prices of the different financial contracts do not have an hourly resolution and does not reflect Elspot area prices. The futures and forwards prices which represent all hours of years, quarters, months and days can thereby not be used directly as a forecast for the DAM price of the FRR-A hours. This is mainly a concern if the contract prices are to be used for DAM forecast, i.e. the first of the above alternatives. The evaluation presented in this report however, focus on changes in the market, i.e. the second of the above alternatives.

In the assessment, quarterly forward contract (NASDAC Commodities) is used as an indicator of changes in the market. The method applied in the pilot project has been

compared with two alternative methods. For both alternatives, the criteria of the pilot method (transmission capacity, price level and price difference) are replaced with only one criterion that requires that the change in forward price from Monday to Thursday in the procurement week is limited to EUR 1 in order to reserve capacity.

In one of the alternative methods assessed, the DAM price differences are forecasted by maximum price difference as in the pilot project method. In the other alternative method, the average DAM price difference is instead used. Figure 7.4 shows the result of the assessment.

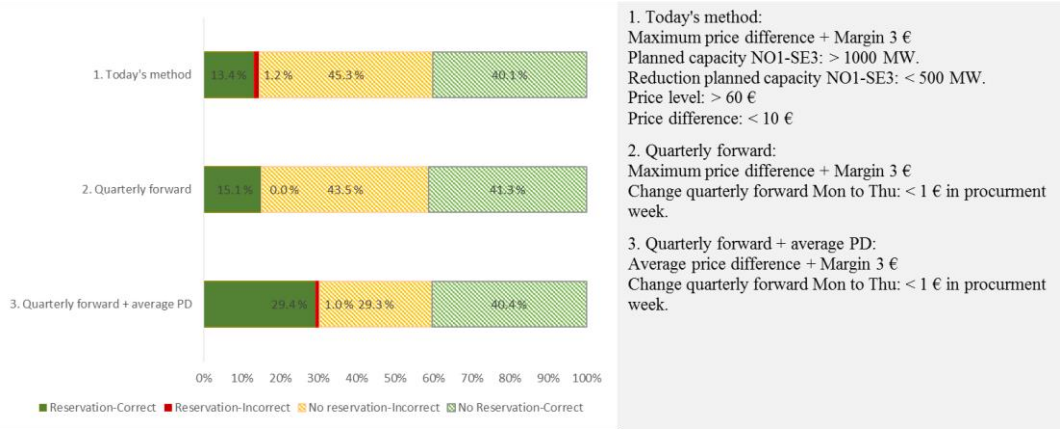

Figure 7.4. Distribution of outcomes of reservation decisions (up-regulating FRR-A) given the reservation method used for reservation in the pilot project and reservation methodologies using price change in Quarterly forward contracts

Figure 7.4 shows that that the forward contract increases the accuracy of capturing DAM changes compared to the pilot criteria. Given the data period and the assumptions made, all non-beneficial reservations are eliminated at the same time as the share of beneficial reservations increases. In addition, if the maximum price difference is replaced by the average as price difference forecast, the beneficial reservations are increased by 16 percentage points while the share of non-beneficial reservations are marginally reduced. This indicates a clear potential for extracting more socio-economic value by increasing beneficial reservation without a corresponding increase in non-beneficial reservation.

8 Assessment of changing from weekly to daily procurement

For the time being, FRR-A is procured weekly on Thursdays with h10 as Gate Closure Time (GCT). In this chapter weekly procurement of FRR-A is compared to daily before DAM gate closure procurement. Two benefits of changing from weekly to daily procurement are:

- With a GCT closer to operational hour the uncertainty and thus the risk that FRR-A providers are exposed to will be reduced. It is expected that this will contribute to reductions in the FRR-A prices.
- A GCT closer to real time will make it possible to increase the accuracy of the forecast of the value of transmission capacity in the DAM. This is both with regard to DAM prices and available transmission capacities.

The Nordic TSOs have agreed that the target is a daily, before DAM, market. An implementation of a daily market requires changes in IT-tools and routines both by the TSOs and by the FRR-A providers. For the time being the Nordic TSOs are analyzing in more detail how daily procurement can be introduced. This analysis is a part of the preparations of a Nordic FRR-A market

8.1 Benefits of daily procurement

It is difficult to estimate to what extent daily procurement will reduce the risk that the FRR-A providers are exposed to and hence the impact on the FRR-A price. Information regarding the cost structure and possible changes in bidding behavior of the providers is not available.

What is possible, however, is to assess the influence of daily procurement on the accuracy of the forecast of the DAM transmission capacity value. By using hourly data on the price difference between Norway and Sweden, the following forecast methods for each block has been compared:

- Weekly forecast (procurement on Thursday): Average price difference of block hours Monday to Thursday in procurement week (w-1) as forecast of block hours in reservation week (w)
- Daily forecast (procurement before day-ahead prices are published): Average price difference of block hours on procurement day (D-1) as forecast of block hours on

reservation day (D). For Monday, an average based on last Friday's block hours is used.

The block hours corresponds to the three blocks used in the Hasle pilot:

1 From 05:00 to 09:00

2 From 17:00 to 20:00

3 From 20:00 to 21:00

Figure 8.1 shows that the forecast errors of the daily forecasts are substantially lower than that of the weekly forecast. The share of hours with a forecast error in the range between EUR 3 and EUR -3 is more than 10 percentage points larger for the daily forecast compared to that of the weekly forecasts. There are also less hours with extreme errors. This is as expected with a more frequent procurement and forecasts that refers to shorter periods.

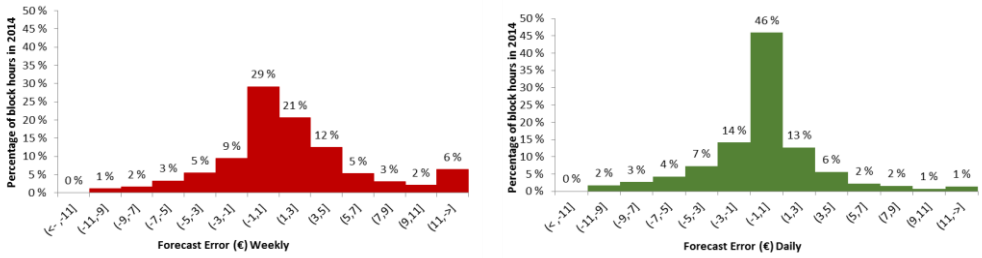

Figure 8.1. Forecast error with weekly and daily procurement

Figure 8.2 and 8.3 shows the reservation and the socio-economic benefit of the FRR-A exchange for daily procurement, compared to the actual Hasle pilot period results using weekly procurement. The same criteria is assumed for the daily procurement as used in the Hasle pilot but the values of the criteria decision parameters are based on the observed values for D-1 instead of W-1.

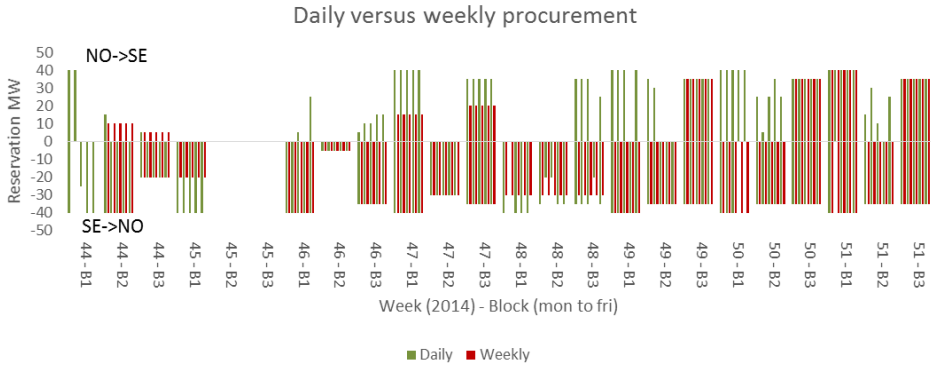

Figure 8.2. Reserved capacity for daily procurement compared to the actual Hasle pilot period with weekly procurement

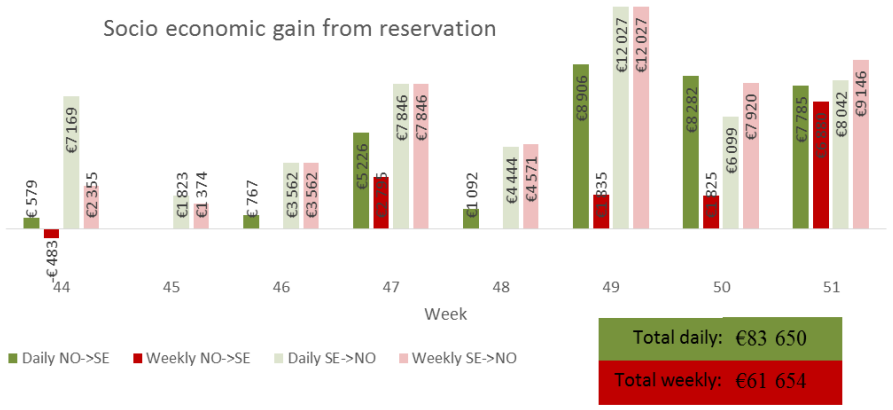

Figure 8.3. Socio-economic benefit of the FRR-A exchange for daily procurement compared to the actual Hasle pilot period with weekly procurement

The socio-economic benefits of the eight week pilot period is more than EUR 20 000 higher with daily procurement compared to weekly. That corresponds to more than EUR 2 500 per week. Given the assumption that the bidding curves will be the same for daily procurement as for weekly procurement, it is likely to be an under estimation of the true benefits. The effect of less uncertainty for providers and the ability to differentiate bids for the different weekdays have been neglected.

In addition to daily procurement, finer time resolution might further increase the value of the exchange.

9 Impacts of reservations on spot prices

Marked based capacity reservation reduces the transmission capacity available to the DAM.

Reduced DAM transmission capacity will influence the DAM prices and result in a socio-economic cost when the connection is congested. As long as the FRR-A price difference exceeds the DAM price difference, exchange of FRR-A is *on the margin* more valuable than the DAM cost of reservation. However, the DAM price difference does not give the exact *total* socio-economic value. A more precise number of the total socio-economic cost will be a valuable input in the process of developing the method for ex-ante determination of FRR-A exchange and corresponding reservation volumes.

Due to the small changes in volume, DAM price changes do primarily result in redistribution of economic surplus between producers and consumers. The redistribution as such might however be considered important, and it is therefore of interest to analyze what impact the capacity reservation has on DAM prices.

9.1 Assessment method of reservation cost

For a more precise assessment of the total DAM socio-economic costs of reservation the change in congestion rent and the surplus of producers and consumers can be used, see figure 9.1, 9.2 and 9.3, respectively.

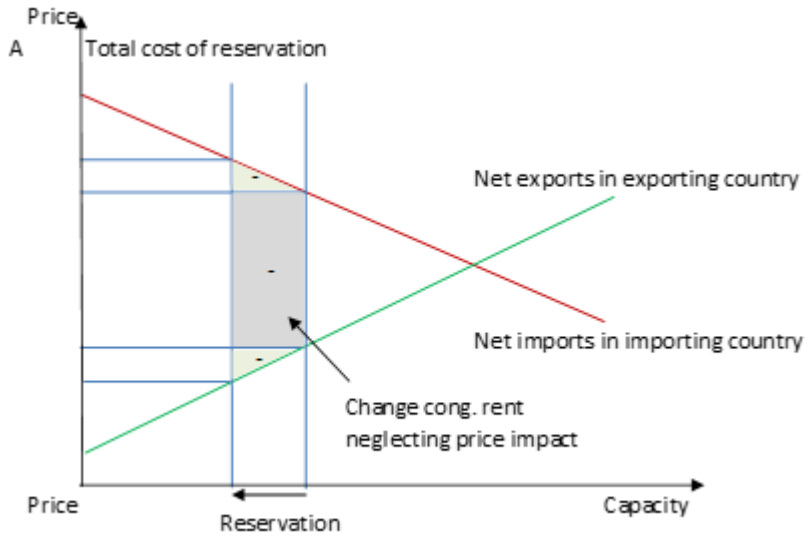

Figure 9.1. Total cost of reservation

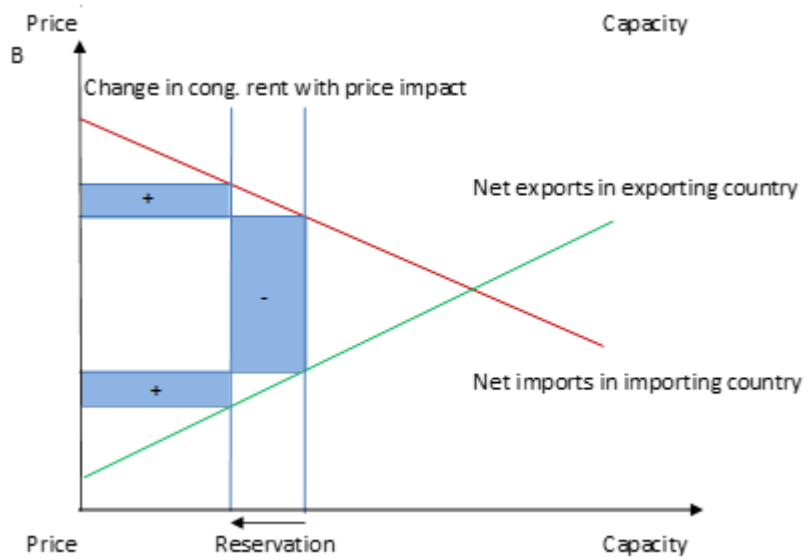

Figure 9.2. Change in congestion rent with price impact

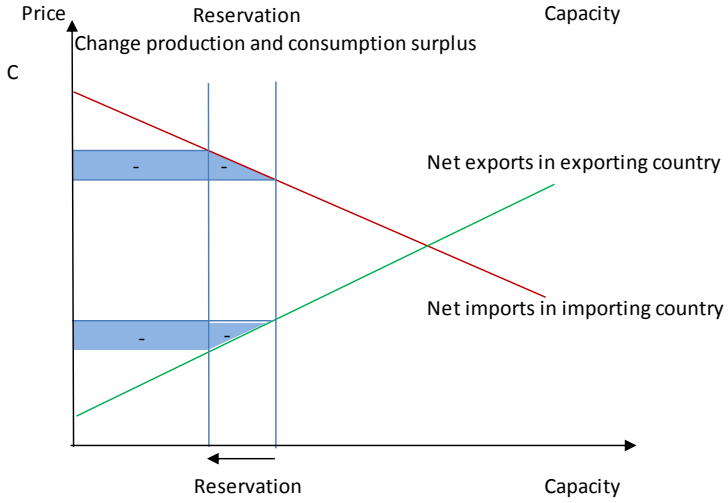

Figure 9.3. Change in production and consumption surplus

The assessment of the DAM socio-economic costs of reservation can be done based on the bidding curves of the DAM and the alternative DAM results as it would have been without any reservation.

NPS has delivered calculations according the above, for the eight-week pilot period. DAM prices of the Nordic Elspot areas, and Elspot flow between the areas as well as total welfare (congestion rent, and surplus of consumers and producer) for all Nordic and non-Nordic areas involved in the price optimization, have been calculated for the following scenarios.

- Historical: Actual market results given actual reservations in the pilot
- Scenario 1: No reservation in any hour
- Scenario 2: 25 MW reservation in both directions for all the hours of the eight weeks
- Scenario 3: 50 MW reservation in both directions for all the hours of the eight weeks
- Scenario 4: 100 MW reservation in both directions for all the hours of the eight weeks

The simulations have been performed by NPS. However, analysis has shown contra-intuitive results for some hours, which requires further investigation. Due to uncertainty regarding the correctness of the data it is decided to await the final conclusion of the investigation and a recalculation of the dates that are affected.

Revised data will be provided from NPS. Svenska kraftnät and Statnett will analyze these data. Nord Pool spot will be included in the quality check of the interpretation of the NPS simulations before these analyses are published.

9.2 Impact of reservation on price in NO1 and SE3

Figure shows the price difference between NO1 and SE3 and Figure shows the change in price difference due to different reservation volumes. The figure shows the impact per hour for hours with reservation towards Sweden (the congested direction) as well as the actual price level in the areas.

In the first week of the pilot period, the market situation was exceptional. An increased inflow to hydro reservoirs caused the DAM prices to drop in Southern-Norway. During these hours, an increase from actual reserved volume to 50 MW or 100 MW would have increased the price difference from below EUR 0.5 EUR/MWh to at most above 2 EUR/MWh.

For the remaining of the pilot period, the impact of the actual reserved volumes was below 0.25 EUR/MWh. In a scenario with at most 100 MW reservation, the price difference would not increase more than 0.4 EUR/MWh for any hour except one. In that hour the increase would have been 0.72 EUR/MWh given the data received from NPS.

For the pilot period reservations, the NPS data indicates small spot price impact. The limited impact indicates that the Hasle pilot approximation of socio-economic surplus is sufficient. As there has been some challenges with other parts of the NPS results, the revised dataset from NPS is however important also in order to make a more firm conclusion regarding this issue.

Figure 9.4. Actual price level in NO1 and SE3 in block hours of the eight-week pilot period

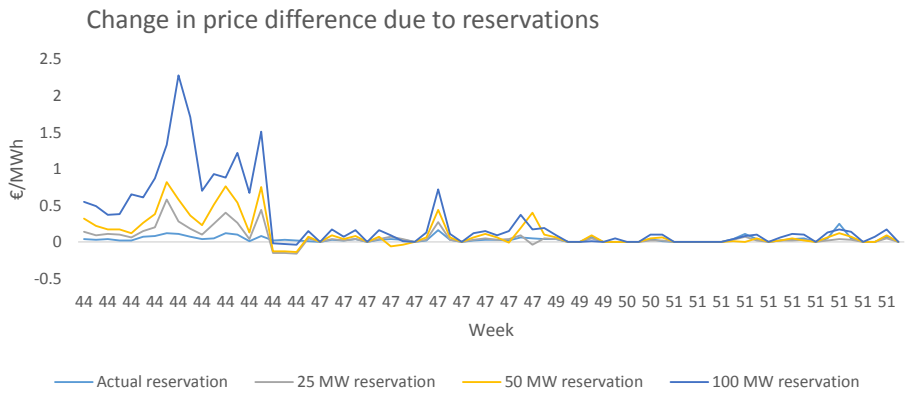

Figure 9.5. Change in price difference between NO1- and SE3 comparing the scenarios with reservation to the scenario without reservation.

10 Assessment of counter trade as alternative to reservation

An alternative to market based transmission capacity reservation is to plan for counter trade to release the congestions which could occur due to exchange of FRR-A capacity. During the pilot period, stakeholders have asked for calculations of what the costs of counter trade would have been if capacity reservation not had been carried out.

10.1 When does the choice of method matter?

The use of counter trade to release cross-zonal capacity used for exchange of FRR-A will imply costs. Provided that the selection of FRR-A bids is done to minimize total procurement costs, expected costs of counter trade should be considered when the FRR-A exchange is decided.

In situations when it is considered that the probability of free capacity in DAM and IDM is close to 100 %, the choice of methodology will not make a difference. FRR-A capacity will be exchanged and no counter trade is necessary.

In situations where the forecasted cost of reservation is higher than the expected value of exchanging FRR-A both methods should result in zero exchange of FRR-A. As the cost in a certain situation can be different in the two methods, choice of method can affect if this scenario is the case. It has not been analysed which method that normally will give highest costs.

The discussion of the two methodologies is based on situations in which exchange of FRR-A is expected to increase congestions, but still at a lower cost than the benefit of FRR-A exchange.

10.2 Operational considerations of counter trade

Countertrade is a tool used to handle problems during operation. If a fault on a connection during operation reduces the capacity, it is necessary to countertrade the difference between the capacity given to the market and the new operational capacity. There are several operational challenges connected to the use of countertrade as a method to enable FRR-A exchange:

1 If FRR-A capacity is exchanged without cross-zonal capacity reservation, TSOs are planning to countertrade. If strained operation occurs and there is need for further countertrade, it will be difficult for the operators to keep total system overview.

2 There is no easy way to figure out the total countertraded volume hour by hour, and it is impossible to predict day ahead. To get the correct volume of special regulation and countertrade it will need to be a thorough study of the actual power flow and activated regulation on both sides of the bottleneck. This is something the operators of both TSOs have to figure out and agree upon after finishing each hour.

3 The activations of bids in the Nordic system are, according to the merit order list of Regulation Power bids as long as there are no bottlenecks. Hence, the activation east of Hasle may be in another country than Sweden. With current RPM rules activation of regulating power for this purpose in another country than Sweden, would require a specific agreement between Svk and the relevant TSO. This implies increased administration.

All in all this implies that use of counter trade will be an operational challenge, both due to increased number of actions and increased complexity.

10.3 Market considerations of counter trade

Both reservation of CZC and use of counter trade may have impacts on the spot market.

As pointed out in chapter 8, reservation of CZC may affect spot area prices. Therefore it is not straightforward to calculate the exact cost of reduced exchange in the spot market. However, the comparison of prices still reflects when it is beneficial to reserve CZC on the margin.

In the spot market 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 it is given more cross-zonal capacity to the market than what 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.

In periods when there is a risk that not enough RPM volumes will be available, Statnett is procuring Regulating Power Capacity. Use of countertrade in order to release CZC that has been congested due to FRR-A capacity will increase volumes of RPM bids that need to be available.

Introduction of a new purpose for activation of RPM bids may as well challenge the transparency of use of RPM resources and how this affects the imbalance power prices. This is most probably possible to solve by marking of bids and volumes, but work needs to be put in to this.

10.4 Assessment of costs of counter trade

Despite the above discussion an assessment has been carried out on the cost of counter trade as an alternative method. It has been assumed that in case of congestions in DAM counter trade is necessary. The cost of the counter trade would have been the next available bid on the regulating power market. Actual bids have been used in the evaluation. With this approach the cost of counter trade for the Hasle pilot is approximately 6000 €, which is approximately twice the cost of exchange in DAM due to reservation of CZC. The cost of counter trade per week is shown in figure 10.1.

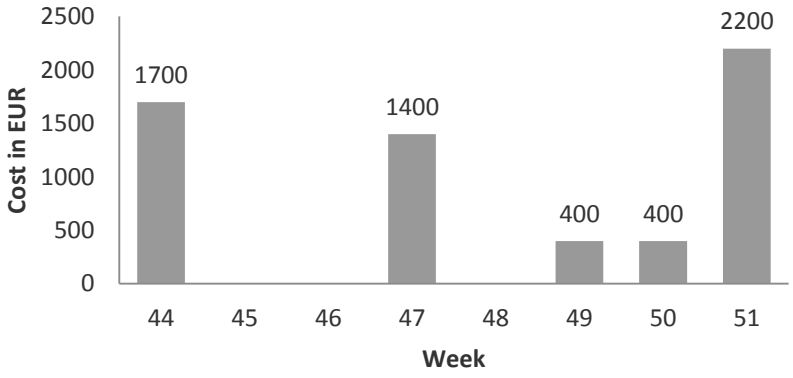

Figure 10.1. Cost of counter trade per week 44 to 51 during pilot period

11 Conclusions

The socio-economic gain of the eight week pilot period can be summarized to approximately EUR 62 000. The figure as such is however not the most importance outcome of the pilot. The most important outcome is that the Hasle pilot shows that market based capacity reservation is possible.

As mentioned above, the Hasle pilot results are valid for a limited exchange volume only. Larger volumes will increase the impact of the exchange, both the impact on the markets and on system operation. Apart from increasing the risk associated with capacity reservation it would also increase the potential benefits of the exchange. The results from the Hasle pilot period show that exchange between Norway and Sweden influence the gain of the exchange between Sweden and Finland. Part of the savings from the exchange between Sweden and Finland would not have been possible without the Hasle exchange.

There is a number of open issues that need to be addressed before a permanent solution for exchange and cross border capacity reservation can be considered. One is that the Hasle pilot ran for a limited time period. The result, both market influence and operational experiences, should be validated also during other power system conditions.

Other things that need to be considered by the Nordic TSOs, regardless of congestion management method, are IT needs such as on-line system monitoring and selection of bids. Further, the TSOs should continue to work towards market design alignment.

As for market based capacity reservation, one major challenge is how to improve the price prognosis. Daily procurement will improve the prognosis, but other measures should also be further analyzed.

As the pilot was run for a limited period, and as the market conditions where unusual for parts of the pilot period, it is considered to be useful to run a second phase of the pilot.