IMPACT ON ELECTRICITY PRICES OF ADDED GENERATION IN SOUTHERN SWEDEN

–A COUNTERFACTUAL ANALYSIS OF THE AUTUMN 2021

RAPPORT 2022:845




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Impact on electricity prices of added generation in southern Sweden

- a counterfactual analysis of the autumn 2021

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ISBN 978-91-7673-845-0 | © Energiforsk februari 2022
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Summary

Objectives and methodology

The analysis aims to:

- Quantify what impact additional electricity generation would have had on electricity prices in Sweden in the period September - November of 2021
- Identify actions and choices going forward

The analysis focused on several specific cases:

- The importance of different price drivers in the autumn of 2021
- Actual prices in September – November 2021 compared to a hypothetical case with the Ringhals 1 and 2 reactors added to the system
- Actual prices in September – November 2021 compared to a hypothetical case with 3.5 GW of off shore wind capacity added to the system
- Comparing modelled prices for a ’normal’ year with a hypothetical case with Ringhals 1 and 2 reactors added to the system
- The study was done in collaboration with Ea Energianalyse, and the quantitative analysis was done using the power market model Balmorel

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Key findings – price impacts [1]

- Greater capacity to produce electricity in southern Sweden would likely have reduced prices significantly during the autumn of 2021
- If, hypothetically, Ringhals 1 and 2 had been operating, prices in SE3 and SE4 during Sept.-Nov. 2021 could have been 30-45% lower than observed
- Similarly, with an additional 3.5 GW of offshore wind capacity in SE4, prices in SE3 and SE4 during Sept.-Nov 2021 could have been 35-50% lower than observed.
- Replacing Ringhals 1 and 2 with offshore wind can yield same average price decrease, but greater variations within the period
- Grid bottlenecks are the main reason for the large price reduction in southern Sweden – most of any additional power generation would have been ’trapped’ in southern Sweden.

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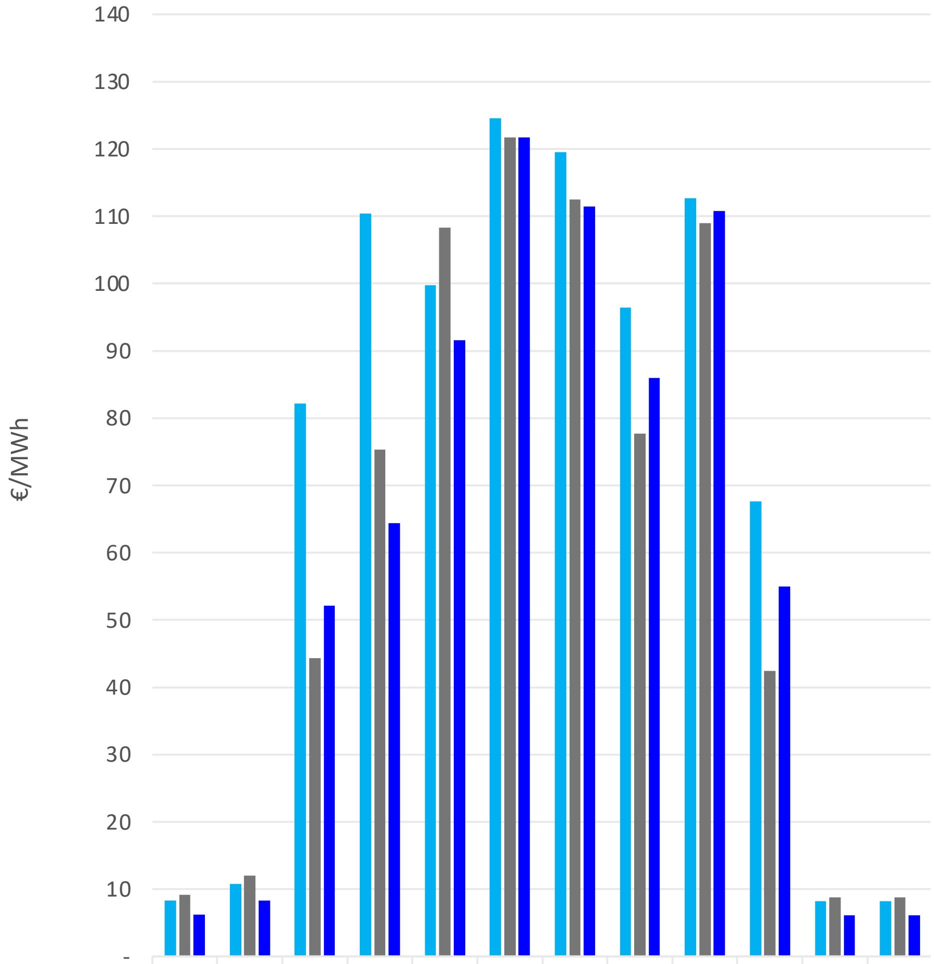
Key findings – price impacts [2]

- Reference case
  - The model calibrated to actual conditions to replicate observed prices as far as possible. Note that modelled prices still deviate somewhat from observed; most in SE1 and SE2, less in SE3 and S4
- Ringhals + transmission case
  - Including Ringhals reactors 1 and 2, i.e., 1 785 MW capacity, 86% average capacity available
  - Increased transmission capacity internally in Sweden: +500 MW from SE2 to SE3 and +900 MW from SE3 to SE4
  - Total additional nuclear generation 3.7 TWh in the period: 3.3 TWh from Ringhals, 0.4 TWh from other reactors due to higher transmission capacity
- Offshore case
  - Including 3.5 GW offshore wind in SE4
  - Modelled capacity factor: 49%
  - Total generation 3.7 TWh in the period



	SE1	SE2	SE3	SE4	FI	DK1	DK2	NO1	NO2	NO5	NO3	NO4
Reference	8	11	82	110	100	125	120	96	113	68	8	8
Ringhals+transmission	9	12	44	75	108	122	113	78	109	42	9	9
Offshore	6	8	52	64	92	122	111	86	111	55	6	6

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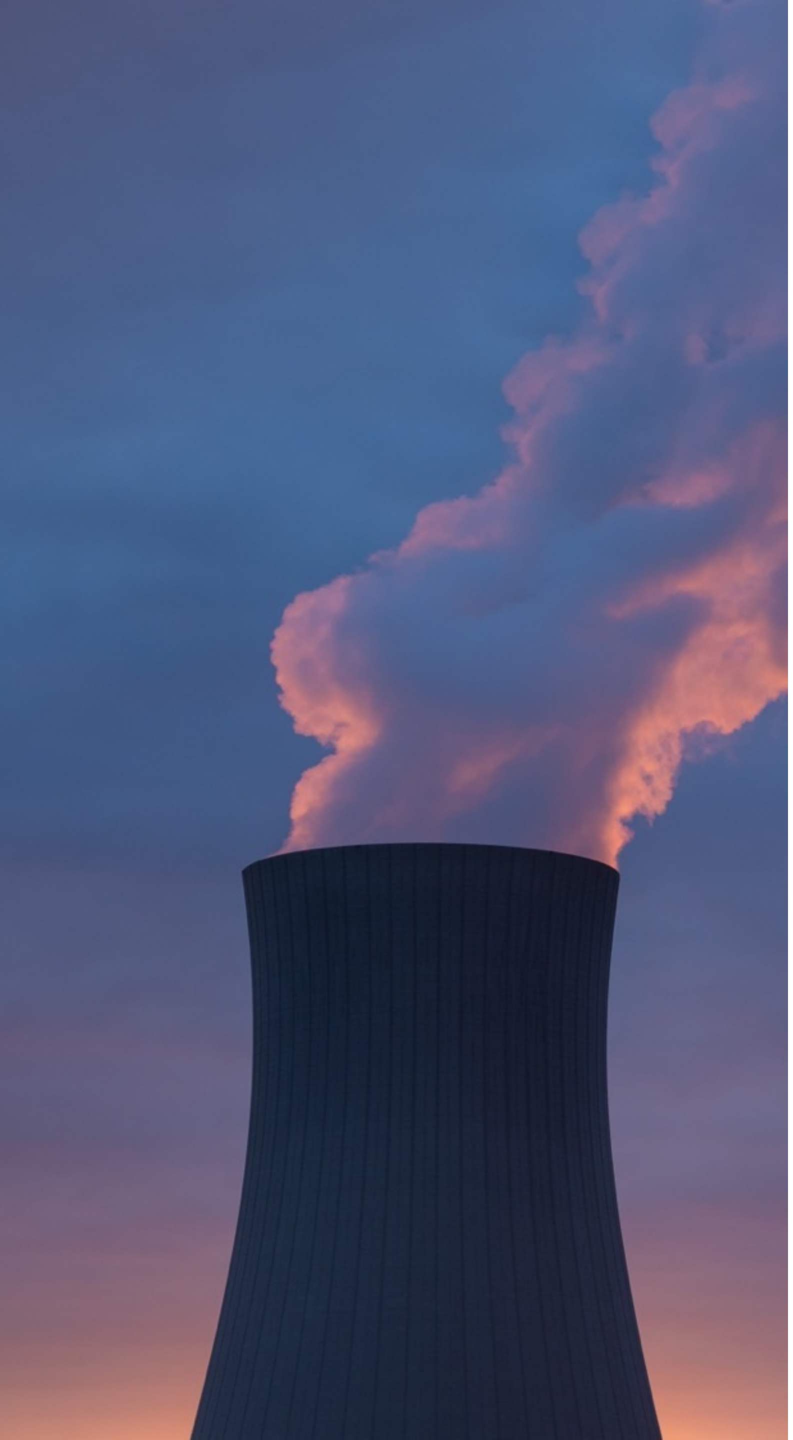

Understanding the results

- The high electricity prices in 2021/22 are driven primarily by high fossil fuel prices, in particular very high natural gas prices.
- With more ’normal’ historic prices for gas, coal and CO2 allowances, electricity prices would have been around half of those observed in September- November 2021, *without* any additional production capacity
    - With 2010-2020 average natural gas coal prices , and a moderate cost of CO2 allowances (40 €/ton), electricity prices in SE3 and SE4 would have been around 35 and 55 €/MWh, respectively.
- Looking ahead, added capacity in a ’normal year’ would still lower prices by about a third, but as prices are expected to be lower the absolute effect would be much less than in 2021.
    - Using 2010-2020 average natural gas and coal prices and 70€ton CO2 price, Ringhals 1 and 2 would lower prices in SE3 and SE4 by 25-35 %. The same would likely be true for added wind generation although that case has not been quantified.
- Adding international grid connections would make the Nordic electricity system more robust in the long run, but would also increase the sensitivity to electricity prices in the rest of the EU.
- Thus the price impact of adding new electricity production in southern Sweden will decrease as the domestic and international grid is strengthened, since this will make the total market bigger.

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The way forward [1]

- Adding gigawatt-scale new electricity production capacity in southern Sweden would lower prices to consumers significantly, at least in the short term.
- This is true for both nuclear and wind power, and likely also for biomass generation although that was not analysed in this study.
- Most low-carbon scenarios include a highly integrated European electricity market. This improves overall efficiency and makes the electricity system more robust, but reduces the impact of any added generation in southern Sweden.
- Decreased reliance on natural gas in continental Europe will reduce the likelihood of similar price spikes in the future.

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The way forward [2]

- The way forward will entail choices around added production capacity, improved flexibility including stronger domestic grid capacity, European integration and policies addressing distributional economic effects.
- In exaggeration, one can see two distinct pathways, neither of which seems attractive:
  - Isolation. Slow expansion of international integration to decrease exposure to developments in continental Europe. Good for Swedish consumers at least in the short term, bad for producers, bad for EU climate goals and integration. Added generation in Sweden would further strengthen the trends.
  - Reliance on EU integration. More interconnector capacity but deployment of new generation lags behind. Could lead to high prices - continental style - occasionally very high. Tough on consumers but good for remaining generators.

Instead, a three pronged strategy seems most appropriate:

- Facilitate an accelerated and proactive deployment of new generation capacity in southern Sweden.
- Further strengthen domestic grid capacity and international connections to make the system more robust, in particular over the long term.
- Develop policy measures that address legitimate concerns of short term economic impacts of occasionally high prices, while keeping incentives for investments and other actions to improve flexibility and energy efficiency.

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Limitations of the study

The analysis excludes some important questions, including:

- The effects of new generation capacity on long term average prices and total system costs.
  - Lower electricity prices in the autumn of 2021 do ***not*** necessarily mean lower average prices to consumers over a longer time period, nor that more generation would necessarily lower total societal costs.
- The costs associated with keeping or adding generation
- The profitability of potential investments in new capacity
- Impact of other potential options to mitigate electricity price increases
  - For example, we have not compared added generation in the south to a case with added transmission capacity coupled with added generation in the north of Sweden.

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Annex: Quantitative analysis

The quantitative analysis was done in collaboration with Ea Energianalyse, using the Balmorel power market model.

Ea Energy Analyses

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Power price implications adding new generation capacity in Southern Sweden

January 23, 2022

Ea Energianalyse

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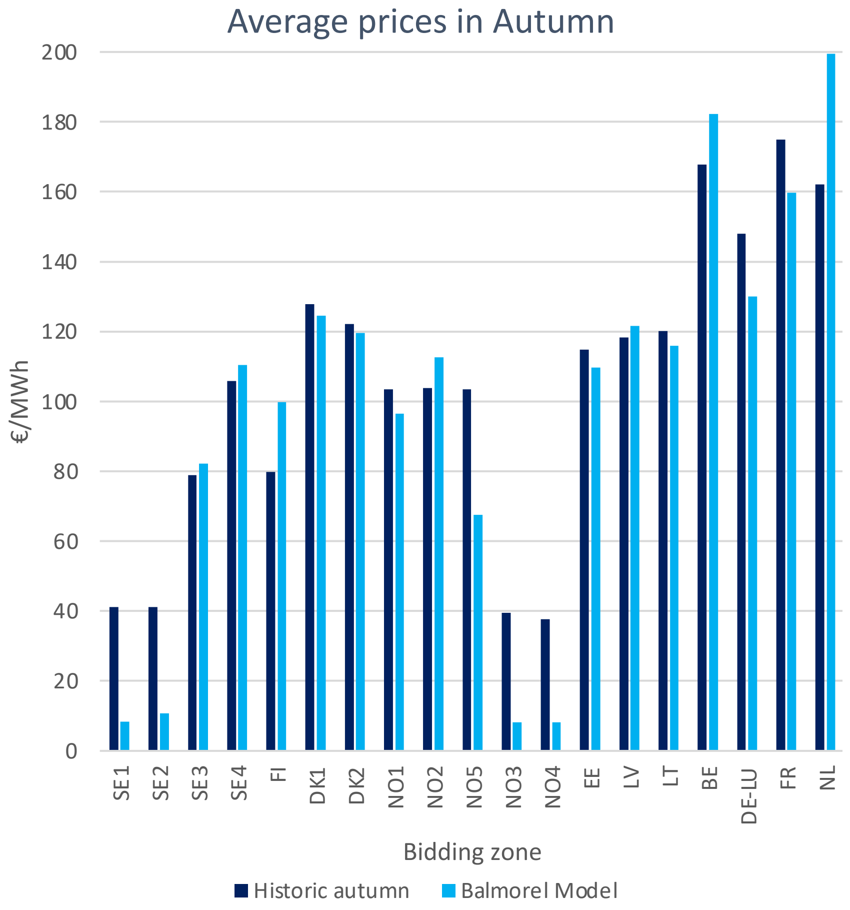
Summary (1/2)

- The autumn (Sep, Oct. Nov.) of 2021 showed unprecedently high electricity market prices across most of Europe, including in price areas Stockholm (SE3) and Malmö (SE4).
- In Sweden, this has stirred a contrafactual discussion focusing on the hypothetical impact on the electricity prices if all the reactors at Ringhals nuclear power plant were still running.
- The closedown of Ringhals 1 & Ringhals 2 reactors (R1R2 hereafter) not only reduced generation capacity but also implied a reduction grid capacity available for the spot market due to changes in the flows of Western Sweden
- The electricity market model Balmorel is applied to replicate electricity market prices in autumn 2021. This meant aligning fuel and CO_2 prices, availability of transmission capacity between bidding zones and wind power generation in some bidding zones.
- The simulations show a reasonable match between statistical average prices and modelled prices in most bidding zones (see graph to the right).
- Key limitations in the replication of historic prices
    - Balmorel applies average fuel price during autumn 2021. Fuel prices have in fact varied considerable on a daily level over the three months.
    - Hydro inflow is based on the model’s standard weather year. Nordic hydro reservoir were low at the beginning of autumn,. This will likely have affected the bidding and production strategy of the hydro generators and may explain why historic prices were higher in SE1, SE2, NO3 and NO4, than in the model.
    - However, a sensitivity analysis where hydro producers were assumed to submit bids in line with observed prices in SE1 and SE2 (aound 40€/MWh), yielded only slightly lower price reductions from additional production capacity than compared to the reference case. This suggests that the deviations between modelled reference case and historic prices are not critical for the conclusions of the study.



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Summary (2/2)

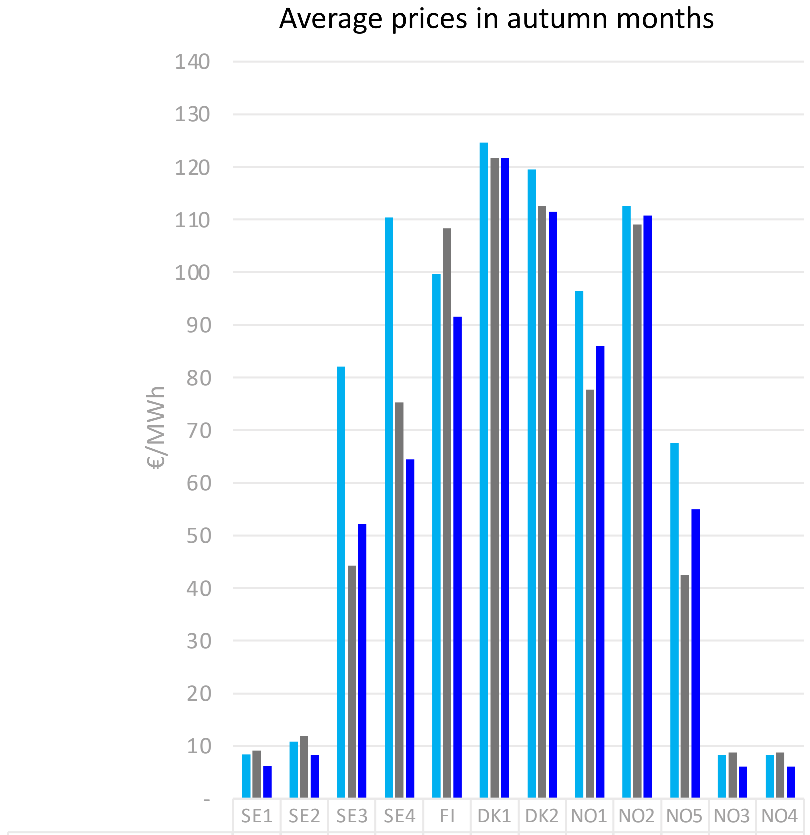
- We analyse two counterfactual scenarios to test the effect on average prices in autumn 2021:
  - Ringhals+transmission case
    - Including Ringhals reactors 1 and 2, i.e. 1,785 MW capacity
    - Increased transmission capacity internally in Sweden: +500 MW from SE2 to SE3 and +900 MW from SE3 to SE4.
  - Offshore case
    - Including 3.5 GW offshore wind in SE4

- The Ringhals + transmission case has a significant impact on the average price of SE3 (46 % decrease) and SE4 (32 % decrease), as bottlenecks on Snitt4 are moved further south to SE4's connections to DK, DE, PL and LT.

- The Offshore case has a strong effect on power prices in both SE4 (42 % decrease) and SE3 (37 % decrease). The location of the offshore wind in SE4 – south of the Snitt 4 bottleneck – is the reason for the strong price effects in both bidding zones even though the offshore cases does not imply additional transmission capacity between SE3 and SE4.

- Results should be interpreted with caution due to the particular conditions of the Autumn of 2021 with very strong price differences between Northern and Southern Sweden and the large variations in hydro reservoir levels making it difficult to model bidding strategies of hydro power plants.

- A sensitivity analysis shows that the absolute price effect (€/MWh) of adding more generation capacity is significantly lower in a year with "normal" fuel prices but relative changes (%) would still be significant (25-35%).



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Background and objectives

Background

- The autumn (Sep, Oct. Nov.) of 2021 showed unprecedently high electricity market prices across most of Europe, including in SE3 and SE4.
- In Sweden, this has stirred a contrafactual discussion focusing on the hypothetical impact on the electricity prices if all the reactors at Ringhals nuclear power plant were still running.
- The closedown of R1&2 not only reduced generation capacity but also implied a reduction grid capacity available for the spot market due to changes in the flows of Western Sweden

Objective

- On this backdrop, Energiforsk asked Ea Energy Analyses to investigate the implications of closing Ringhals reactors 1 and 2 in the given electricity market conditions of the autumn 2021.

Approach

- **Analyses of statistical data** for the autumn of 2021: fuel prices, CO2-prices, power demand, availability of grid, hydro inflow, wind power generation, electricity prices.
- **Calibration** of the electricity market model Balmorel with select statistical data to replicate electricity market prices in autumn 2021. This meant aligning fuel and CO2 prices and availability of transmission capacity between bidding zones.
- **Simulations** of the power system in 2021 with and without the two reactors at Ringhals and resulting changes to the grid capacity.

Statistical analysis

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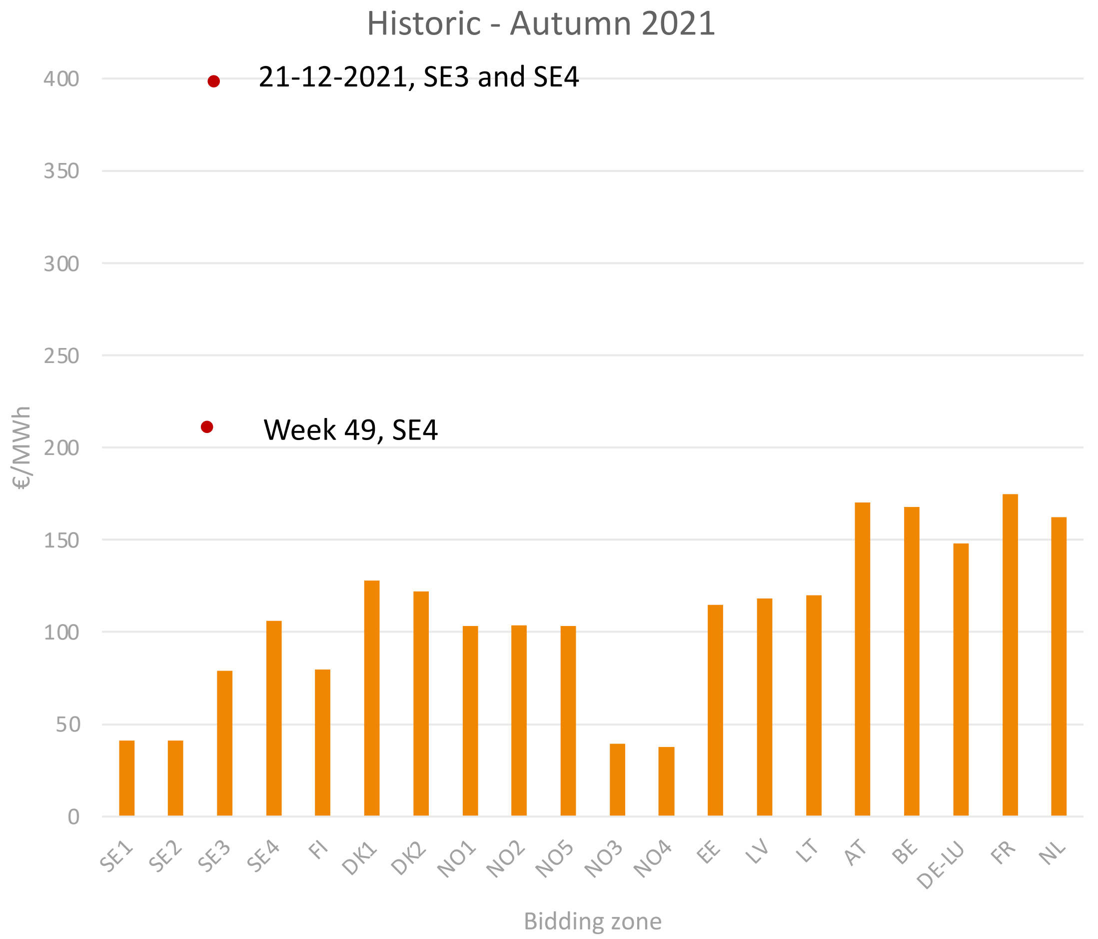
Record power prices

- Power prices in the Nordic countries have increased to record levels during the autumn of 2021. Autumn is defined as September, October and November.
- In November 2021, the system price at the Nordic level varied around an average of 100 €/MWh and the same time large price differences have been observed among the Nordic bidding zones.
- In SE1 and SE2 prices have averaged around 41,3 €/MWh during September- November whereas SE3 prices have revolved around 79,0 €/MWh and in SE4 at about 106,1 €/MWh. Germany has seen even higher average prices, in the region of 150 €/MWh.
- In December 2021 even higher price levels have been observed, including a daily average price in SE3 and SE4 of 413 €/MWh on 21 Dec. 2021.



Bottleneck between NO3 to NO1/NO5
Bottleneck between SE2 to SE3.
DK prices are highly coupled to continental prices

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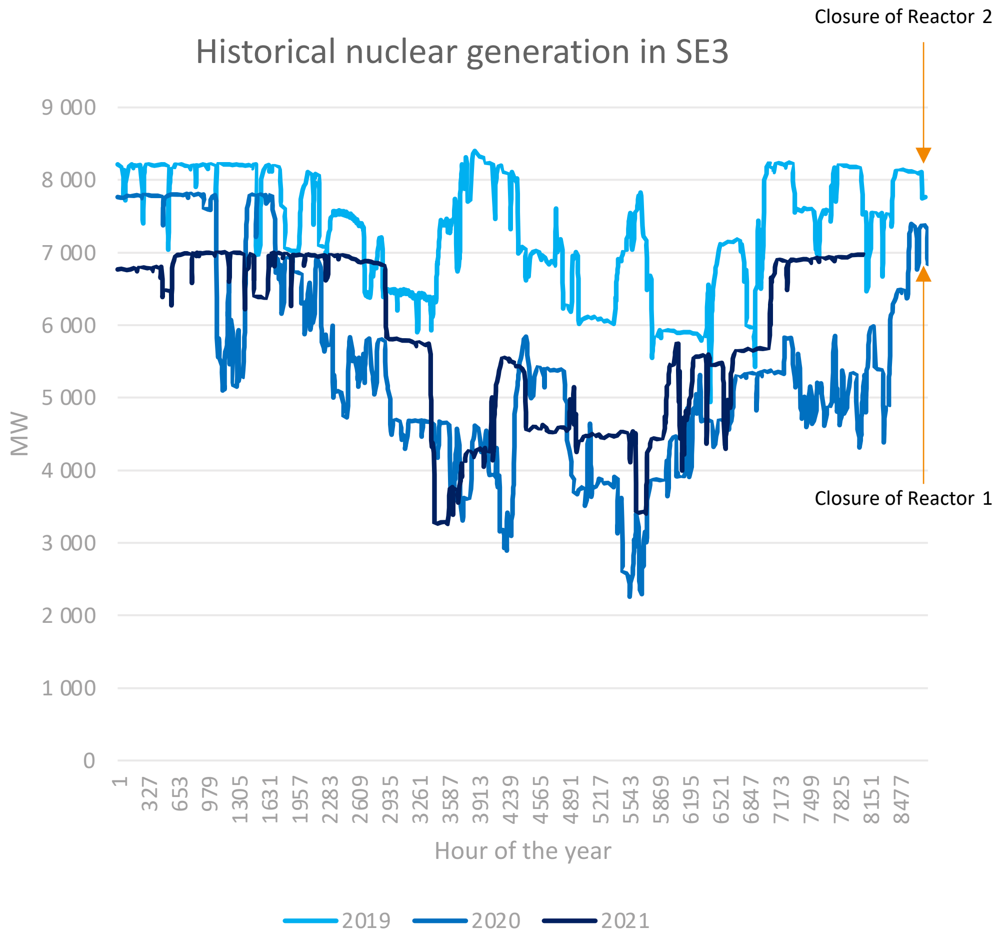
Ringhals R1&2 decommissioning

- Ringhals consists of four reactors. Ringhals 2 (R2) was permanently shut down 30 December 2019 and R1 on 31 December 2020, whereas R3 and R4 are still operational.
- The total capacity of R1&2 is 1,785 MW.
- A loss of production capacity in southwestern Sweden, where Ringhals is located, typically increases flows in the grid in western Sweden and via Norway. To keep the system safe and to avoid overloading the lines on the west side, Svenska Kraftnät decrease available spot market capacities on select interconnectors.
- The specific effects on spot market interconnector capacities is not known to Ea Energy Analyses and probably these effects will also depend on the specific system conditions and thus vary over the year.
- As rough estimate it has been assumed that the closure of R1&2 has decreased the capacity on *Snitt 2* (SE2-SE3) by around 500 MW and the capacity on *Snitt 4* by 900 MW (SE3-SE4).



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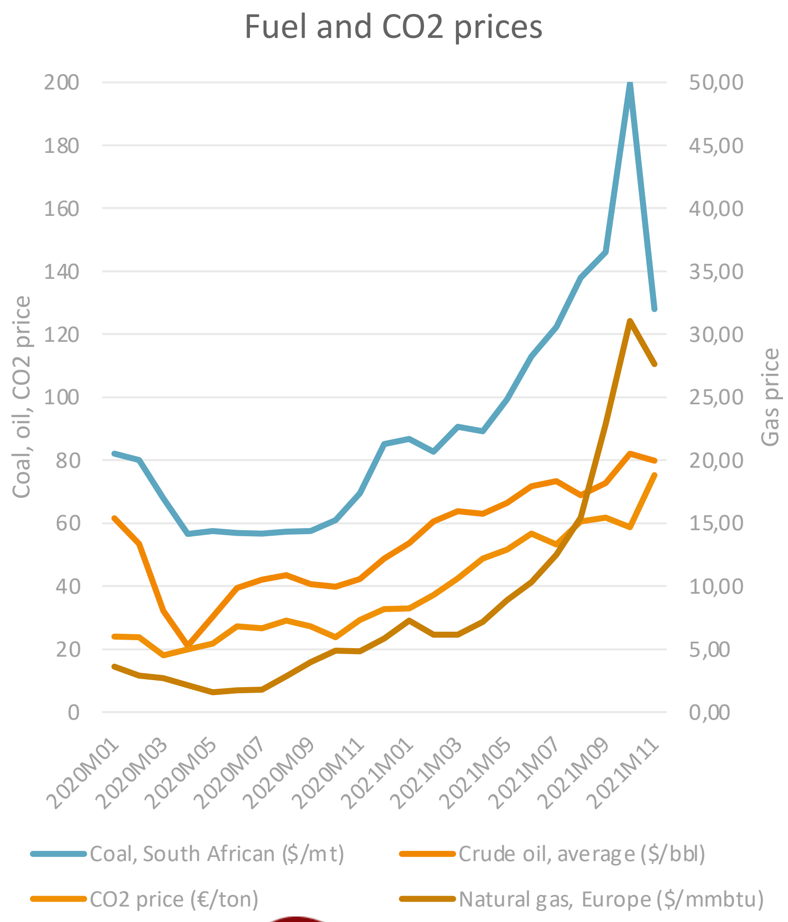
Fuel prices

- The main driver for the high power prices has been the surge in the price of CO2-allowances and in particular the price of natural gas, which has taken place throughout 2021.
- This has had a strong effect on the marginal cost of thermal power generators
- Even though fossil fuel generators only supply a small fraction of Nordic power generation, the Nordic countries are strongly interconnected with the UK, Continental Europe and the Baltics, and this way import the price signals from the rest of Europe.



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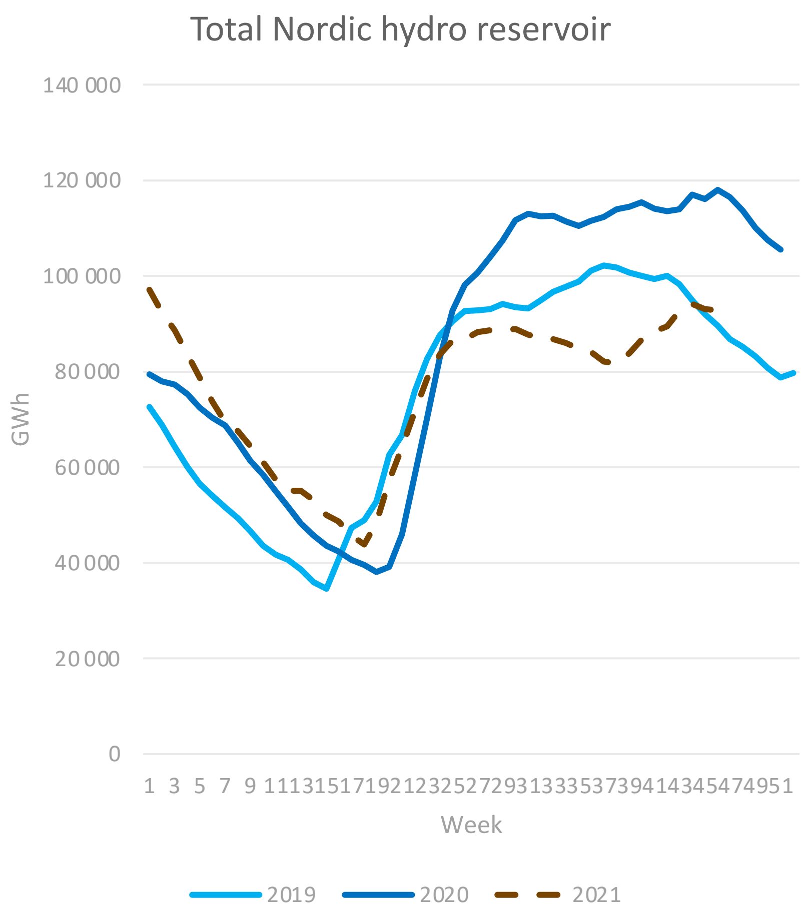
Hydro overview – Nordics

- The year 2021 is comparable to 2019 in terms of precipitation in the Nordics, however the hydro generation has been higher.
- Still, hydro reservoir levels were low in August, September, October but have recovered since then.
- The total reservoir level is around the same as in December 2019.

	2019	2020	2021 (until early December)
In-flow (GWh)	208,194	249,765	199,778
Generation (GWh)	201,039	223,765	204,054
Net year volume(GWh)	7,155	26,000	-4,276



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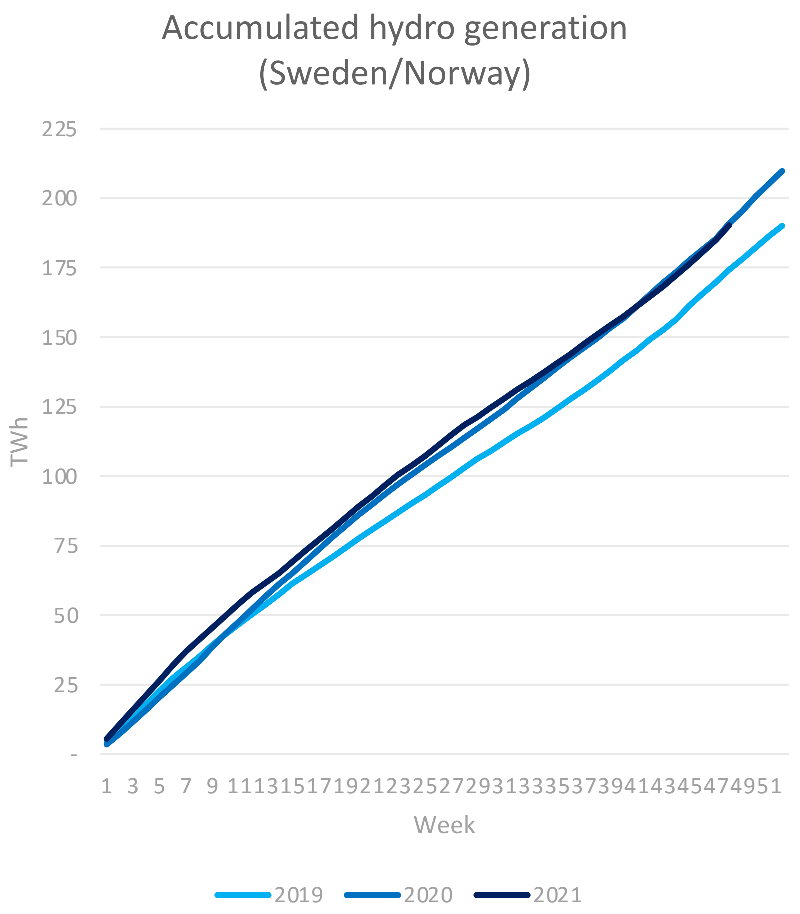
Hydro generation

- Another perspective is to look at the accumulated hydro generation of Norway and Sweden (not including Finland).
- The graph to the right shows that the accumulated generation in December 2021 is very similar to that of 2020, which saw significantly higher precipitation.



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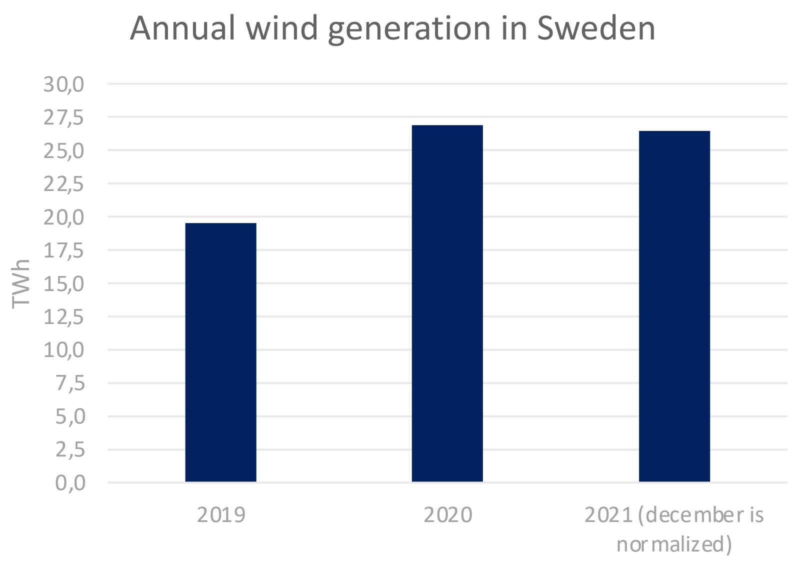
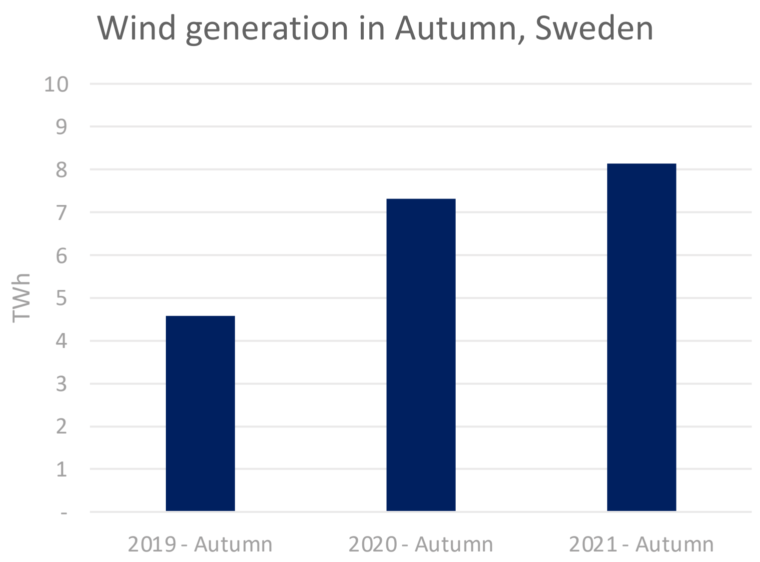
Wind generation

- Annual wind generation in Sweden was comparable to 2020 levels (in spite of increasing capacity) and substantially higher than in 2019.
- Wind generation in autumn 2021 was slightly higher than in autumn 2020 and significantly higher than in autumn 2019.
- Note that the wind generation is still moderate in the overall perspective as the total Swedish electricity consumption is around 138 TWh.



Capacity factors: 30% 32% 30%



*Autumn months are September, October, November

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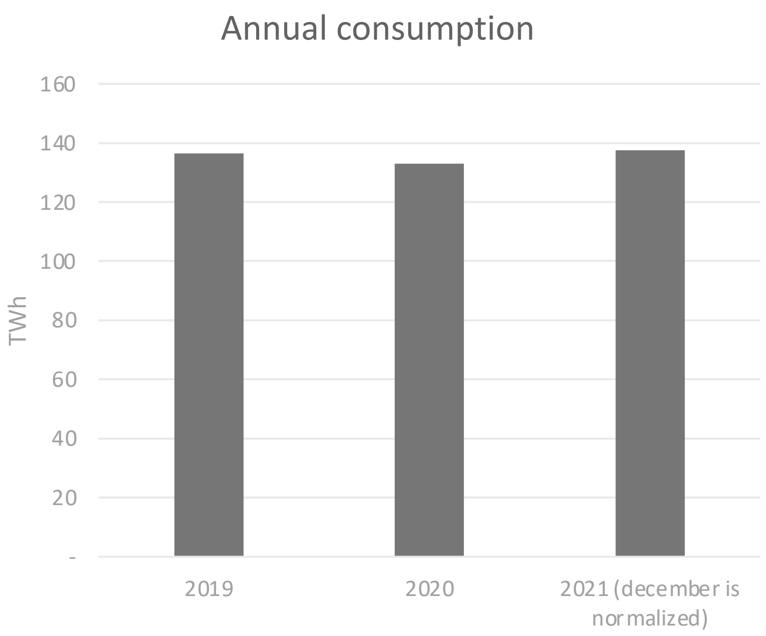
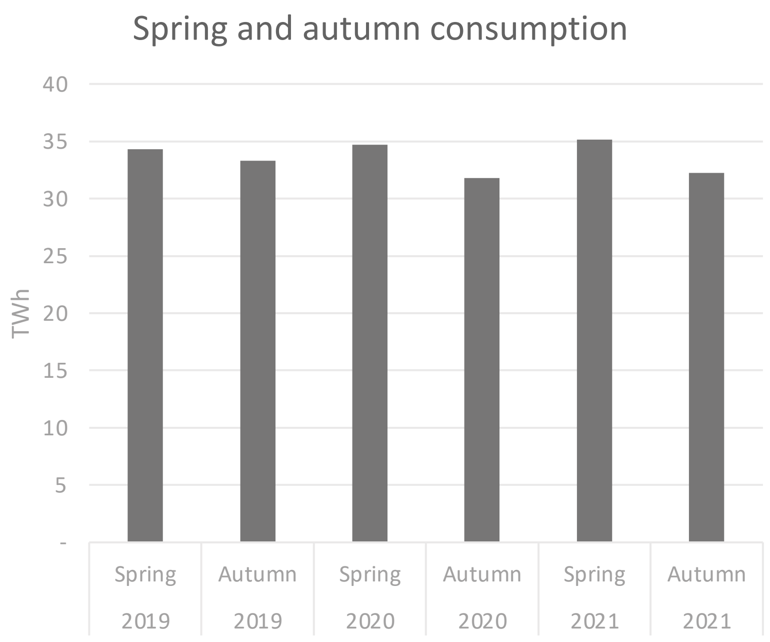
Electricity consumption in Sweden

Swedish electricity consumption on seasonal and annual basis does not appear to be significantly different relative to previous years. The slight dip in demand in 2020 may be attributed to Covid.





*Autumn months are September, October, November
*Spring months are March, April, May

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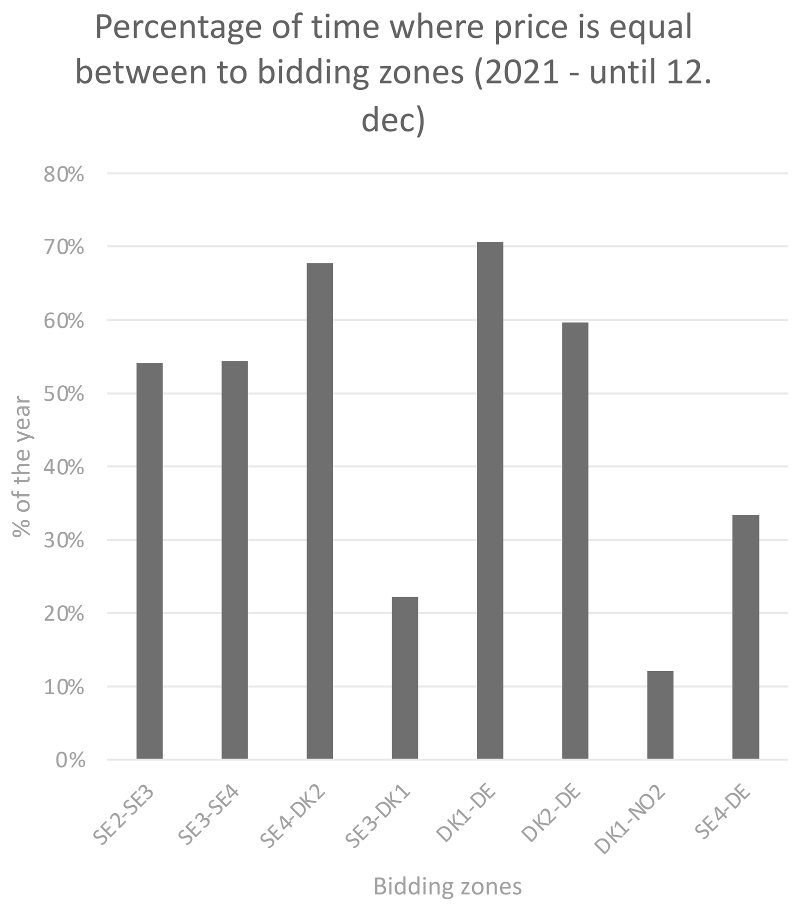
Grid bottlenecks

- The price patterns of different bidding zones gives an understanding of bottlenecks in the system.
- There were bottlenecks around half the time and thus a price difference between SE3 and SE4.
- In approximately one third of all hours, bottlenecks occurred between DK2 and SE4.
- The graphs also reveal that SE4 is well connected to Eastern Denmark (DK2) whereas both Danish price zones are closely connected to the prices in Germany.



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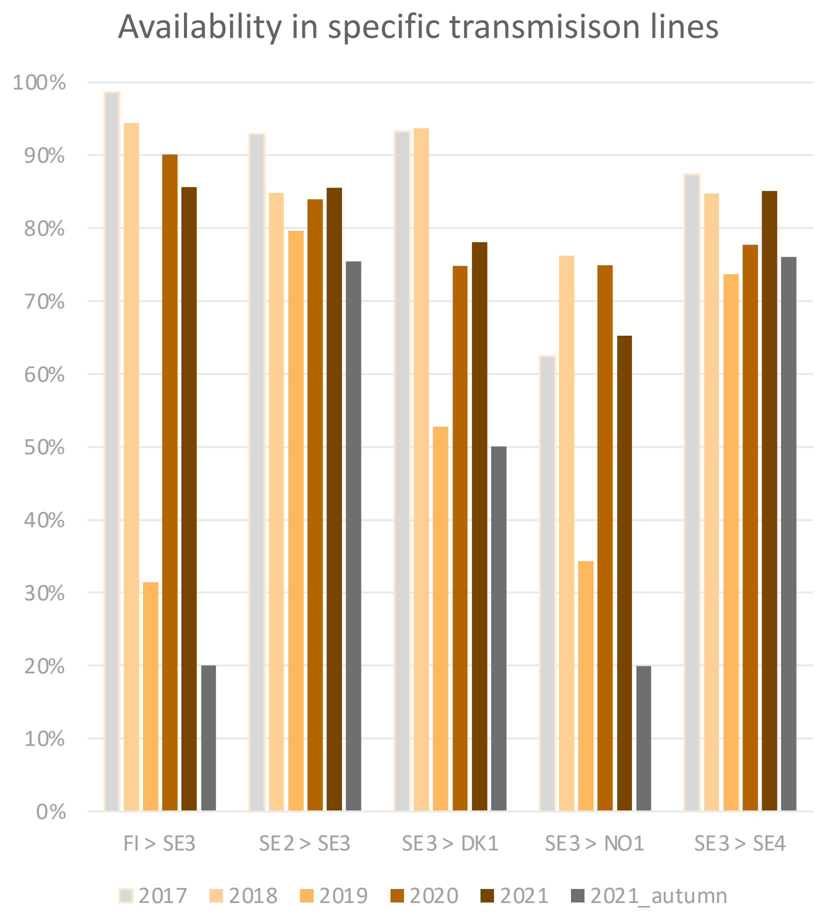
SE3 transmission lines

- The average available capacity of transmission lines that connect the SE3 bidding zone to neighboring bidding zones have been quite low in autumn 2021.
- Especially the transmission lines to DK1, NO1 and FI have been quite affected in the autumn.
- However, looking at the whole of 2021 and compare it with 2020 and 2019, we do not see the reduction in capacity that we could have expected from the closure of R1&2.
- The Southwest link is present in the model, but no effect of R1/R2 is calculated.



Data source: Nord Pool Spot
2021 data only covers January to November

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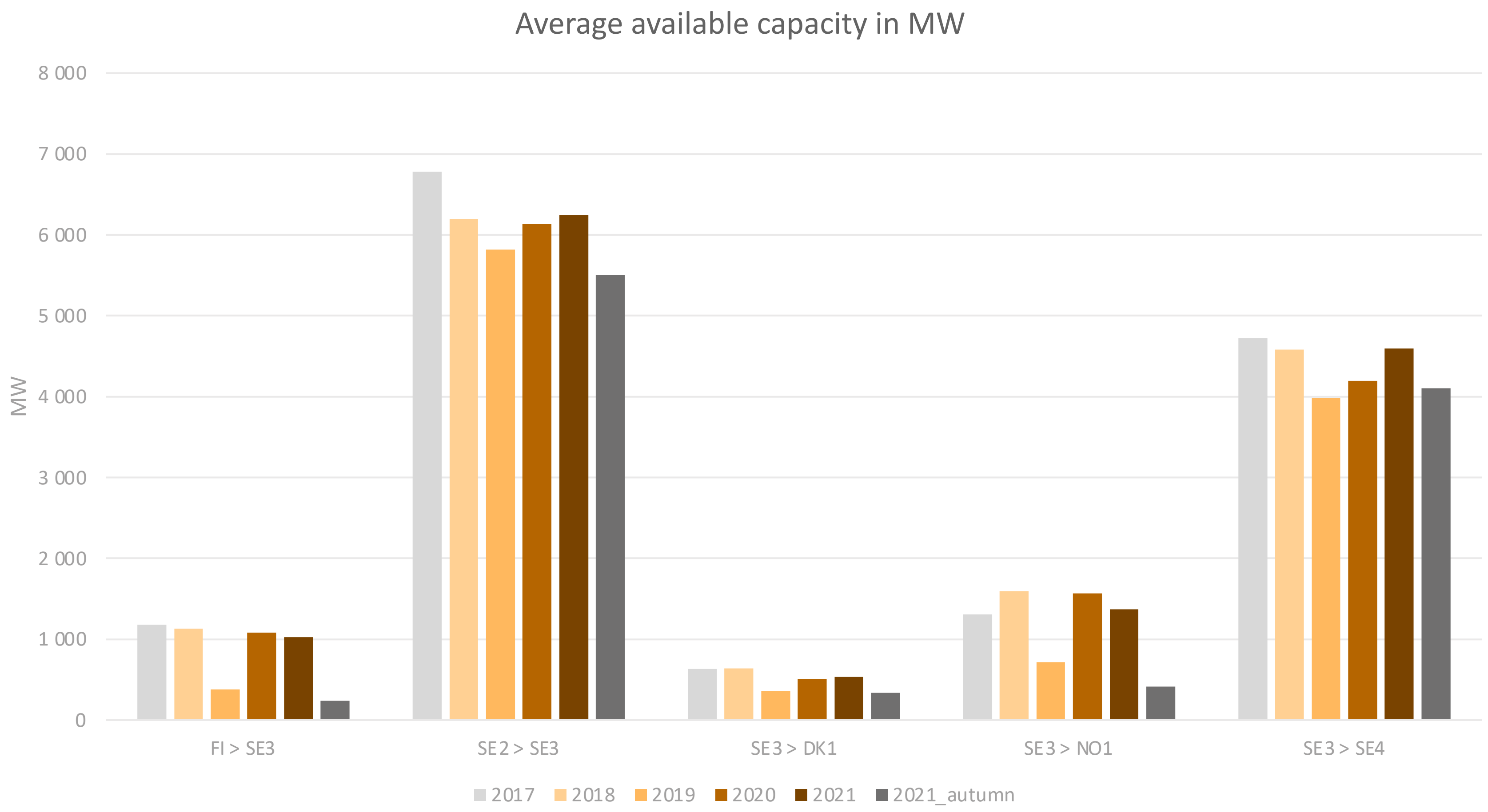
SE3 lines in MW capacity



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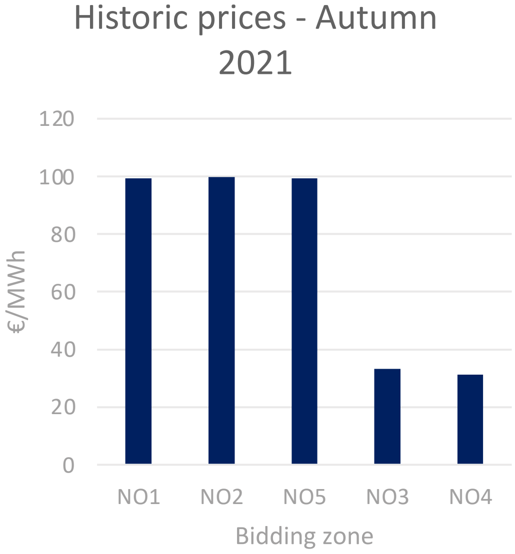
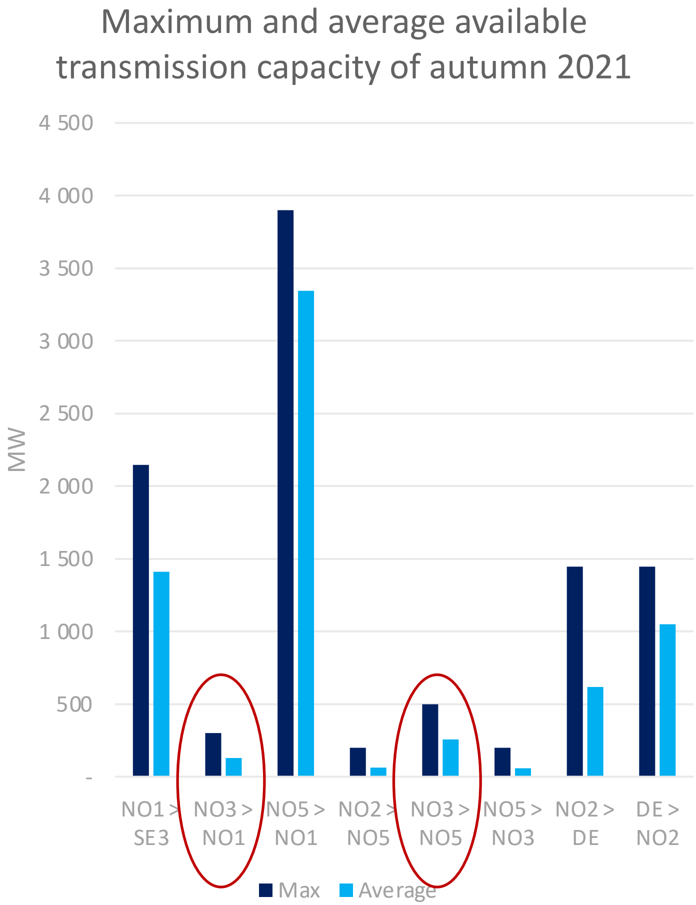
Internal Norwegian transmission lines in autumn - 2021

- Internal Norwegian transmission capacity have been creating price bottlenecks from NO3 to NO5 and NO1. Cheap electricity from hydro power cannot get south to NO1, NO2 and NO5.
- The North Sea Link cable was commissioned 1. October (NO2-UK), which can have affected the prices in NO2 and neighboring bidding zones in the autumn as UK prices are typically higher than Norwegian.





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Sources

- Price, transmission, consumption and hydro reservoir data is sourced from Nord Pool Spot.
- Generation data from ENTSO-E.

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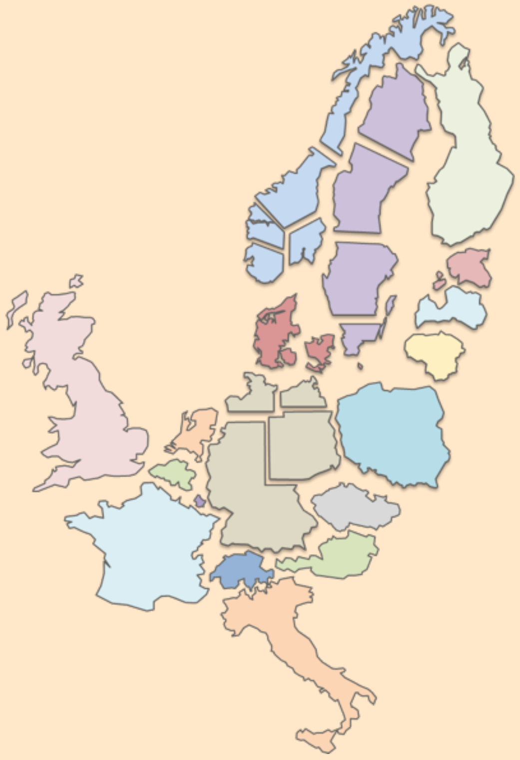
Calibration

Assumptions

- The focus is modelling of autumn conditions in 2021.
- Transmission capacity:
    - The average available capacity is based on the autumn months of 2021, that is September, October and November.
- North Sea Link between NO2 and UK is commissioned from 1. October 2021 with a limited average capacity of 30%, as it is assumed to be limited during the first months of operation. The official capacity of the Northsea Link was 50% for the first months. Historical data of the Nordic transmission lines show that lines never operate averagely at full capacity, so we have counted a capacity of 30%.
- Fuel prices and CO2 price based on averages observed in autumn months of 2021. Thus, hourly, daily variations and monthly are not considered.
- Generic model profiles for hydro inflow and solar PV has been applied because total generation for these generators in autumn 2021 in the Nordics was not considered to be significantly different from the model standard year. With respect to wind power, adjustments have been made for certain countries (Sweden and Germany) to mimic actual generation in autumn 2021.
- Generation from Danish power biomass CHP plants is limited to replicate actual 2021 generation.
- With respect to hydro power, 2021 saw quite low reservoir levels in certain months (September and October), which is likely to have affected bidding strategies. This relationship is not fully captured by the model.
- The short run marginal cost of R1/R2 is assumed to be 10.5 €/MWh. Costs related to refurbishment and fixed costs are not considered in this analysis.



Geographic scope of the model

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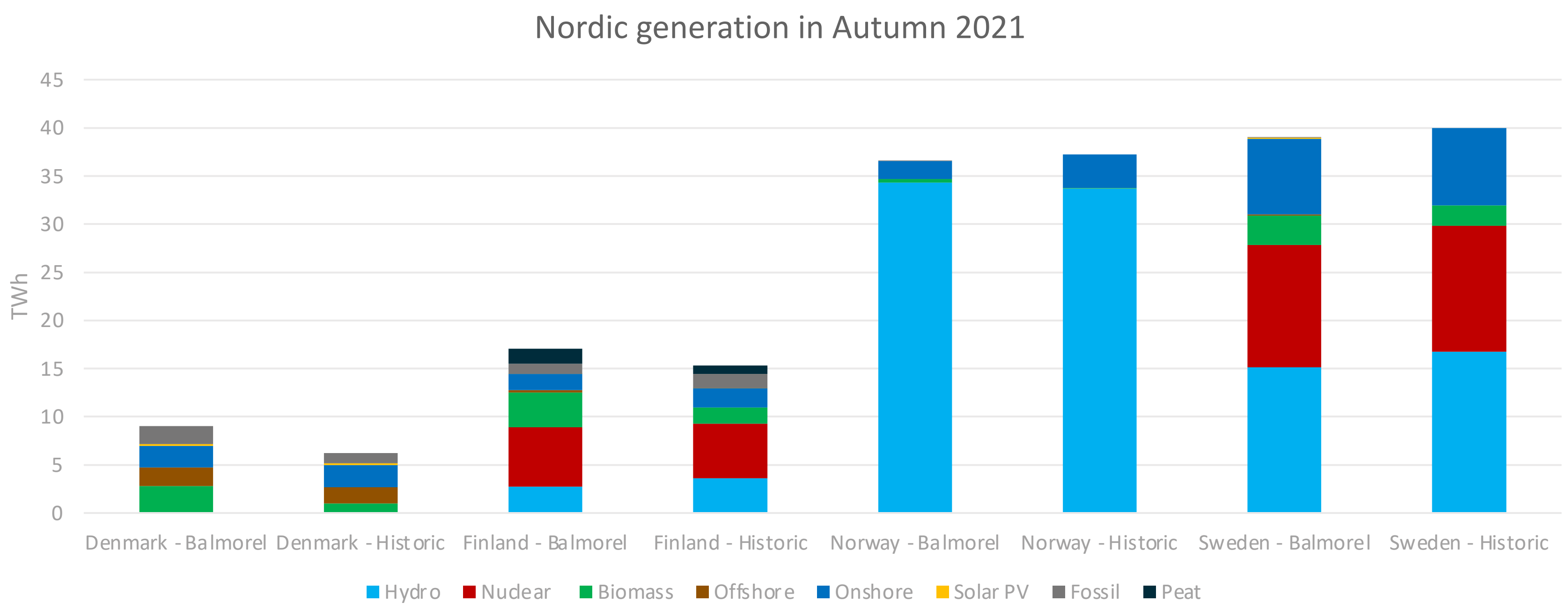
Nordic generation in autumn, 2021

The calibration of model has led to reasonable fit with the actual generation in the autumn of 2021. Small variations can occur as the wind speed, solar irradiation and hydro rainfall profiles are normalized on an annual basis.

Biomass power plant appear to respond more flexible to the high-power prices in the model compared observed generation patterns. It is possible that biomass logistics could prevent biomass CHP's from generating as much as they are able to in the model. Also, local small-scale CHP generation are typically back-pressure plants, which produce electric and heat in a fixed ratio. Therefore, electricity production can only be scaled up, when there is demand for heat.



*Historic = observed autumn 2021 data.

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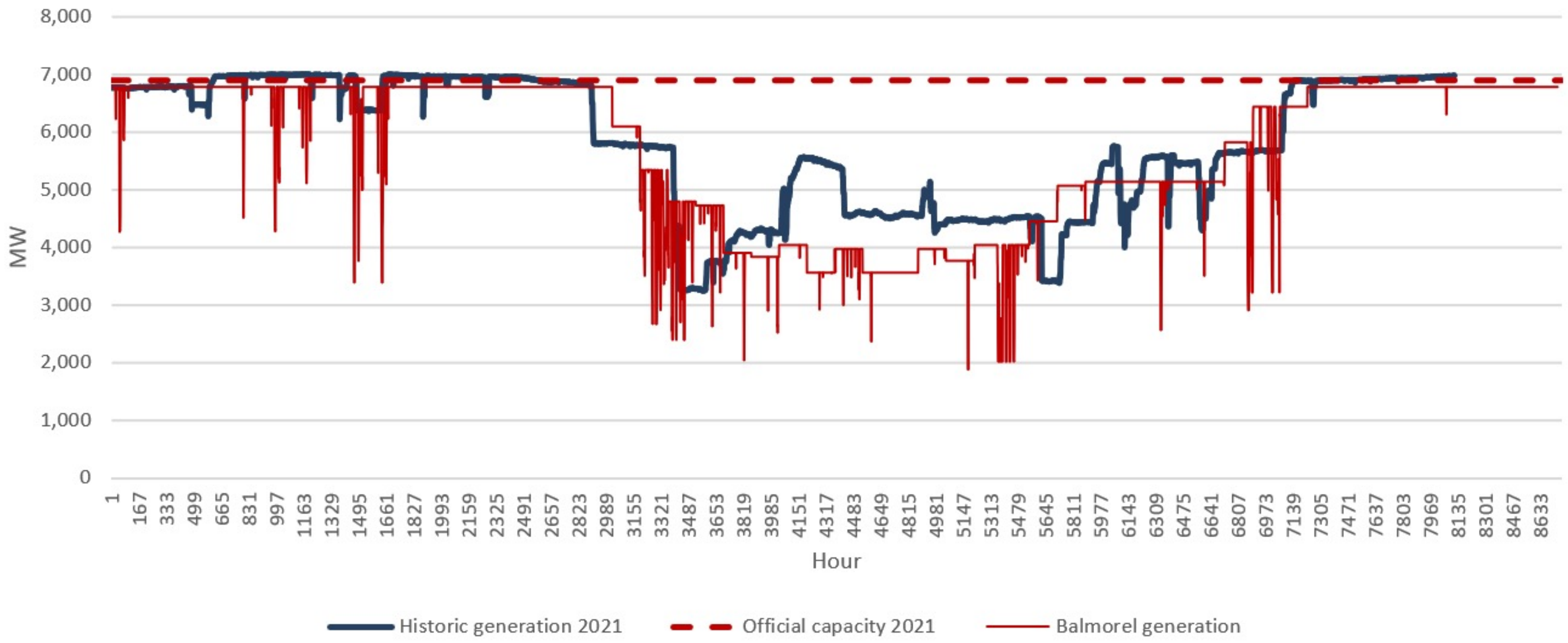
Nuclear generation

Statistics show, that Swedish nuclear power capacity is reduced during summer months for maintenance purposes. This is also reflected in the modelling.



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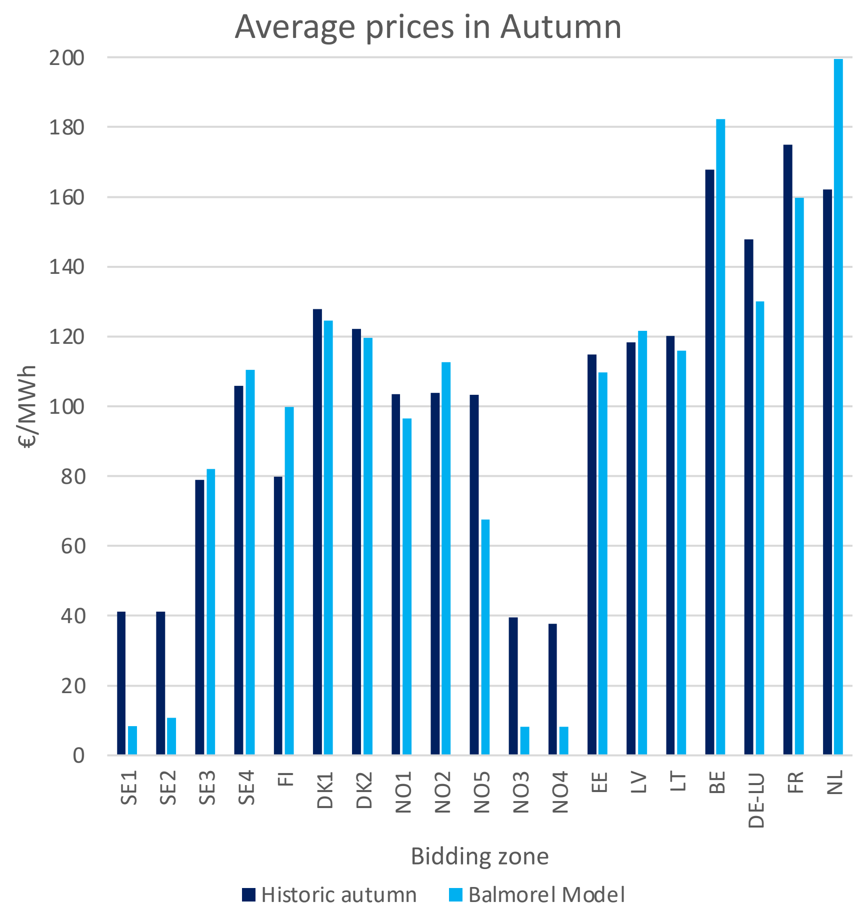
Average prices

The graph to the right shows a reasonable match between statistical average prices and modelled prices in most bidding zones.

There are multiple reasons why the prices from Balmorel may differentiate from the historical prices:

- Balmorel applies average fuel price during autumn 2021. As depicted on slide 6 fuel prices have in fact varied considerable over the three months.
- Nordic hydro reservoir was historically low at the beginning of autumn, around week 37. This will likely have affected the bidding and production strategy of the hydro generators to be more conservative. This may explain why Balmorel sees lower prices in SE1, SE2, NO3, NO4 and NO5
- There is a considerable difference for Finland which could be caused by different fuel price mechanisms that Balmorel does not capture. For example, Finnish power producers may have contracted gas from Russia on long-term contracts protecting them against the very high gas spot prices in rest of Europe.
- The average available transmission capacity from historical data is applied in Balmorel. This does not capture sudden decreases or increases in the available transmission capacity of individual lines which is seen in the actual data.



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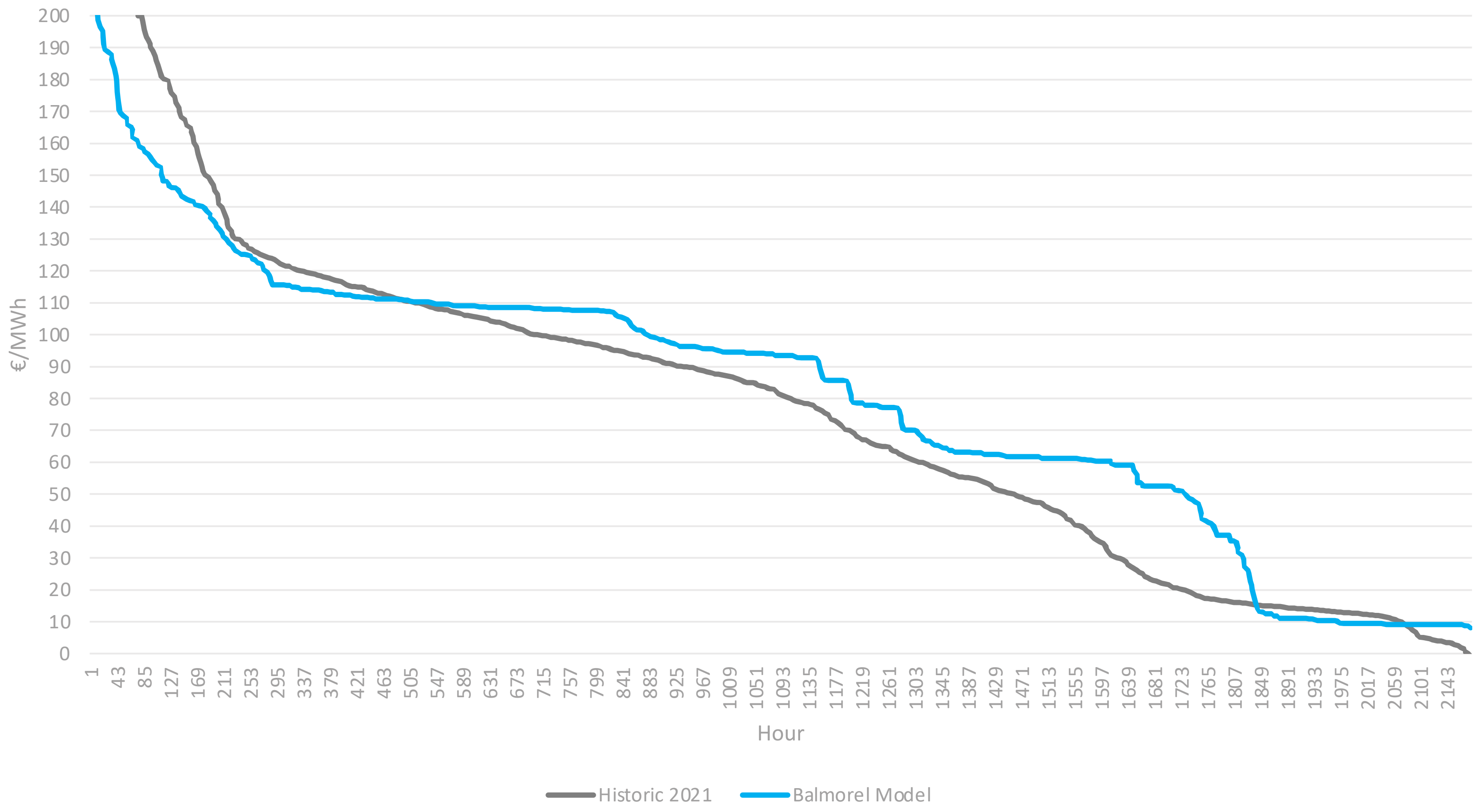
Price duration curve SE3



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Simulations with/without additional production capacity

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Scenario terminology

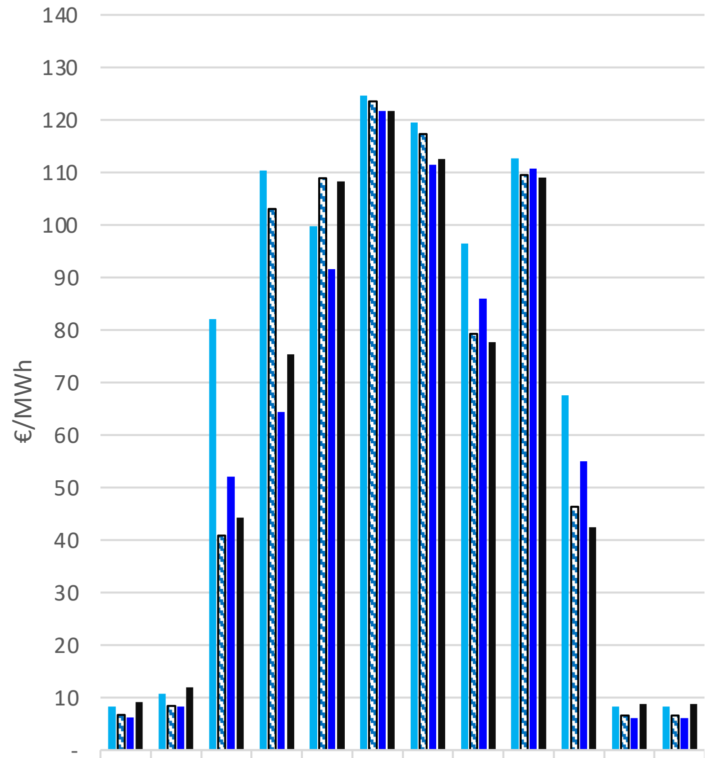
- Reference scenario
  - Calibrated historical year – autumn 2021
- Ringhals scenario
  - Including Ringhals reactors 1 and 2
    - 1,785 MW capacity
- Offshore scenario
  - Adding 3,500 MW of offshore capacity in SE4
- Ringhals+transmission scenario
  - Including Ringhals reactors 1 and 2
    - 1,785 MW capacity
  - Increased transmission capacity internally in Sweden
    - +500 MW from SE2 to SE3
    - +900 MW from SE3 to SE4

Average prices in Autumn

- Adding Ringhals 1 and 2 on their own would have a very significant decreasing effect on the price level in SE3 (50 % decrease) but still a moderate effect on SE4 (6% decrease). The limited effect on SE4 prices is explained by the bottleneck on Snitt 4 between SE3 and SE4 that become more pronounced when R1 and R2 are inluded.

- The combined effect of Ringhals 1 and 2 and increased transmission will have a significant impact on the average price of SE3 (46 % decrease) and SE4 (32 % decrease), as bottlenecks are moved further south to SE4's connections to DK, DE, PL and LT.

- Adding offshore capacity to SE4 has a strong effect on power prices in both SE4 (42 % decrease) and SE3 (37 % decrease). The location of the offshore wind in SE4 – south of the Snitt 4 bottleneck – is the reason for the strong price effects in both bidding zones even though the offshore cases does not imply additional transmission capacity between SE3 and SE4.



	SE1	SE2	SE3	SE4	FI	DK1	DK2	NO1	NO2	NO5	NO3	NO4
Reference	8	11	82	110	100	125	120	96	113	68	8	8
Ringhals	7	8	41	103	109	124	117	79	110	46	7	7
Offshore	6	8	52	64	92	122	111	86	111	55	6	6
Ringhals+transmission	9	12	44	75	108	122	113	78	109	42	9	9

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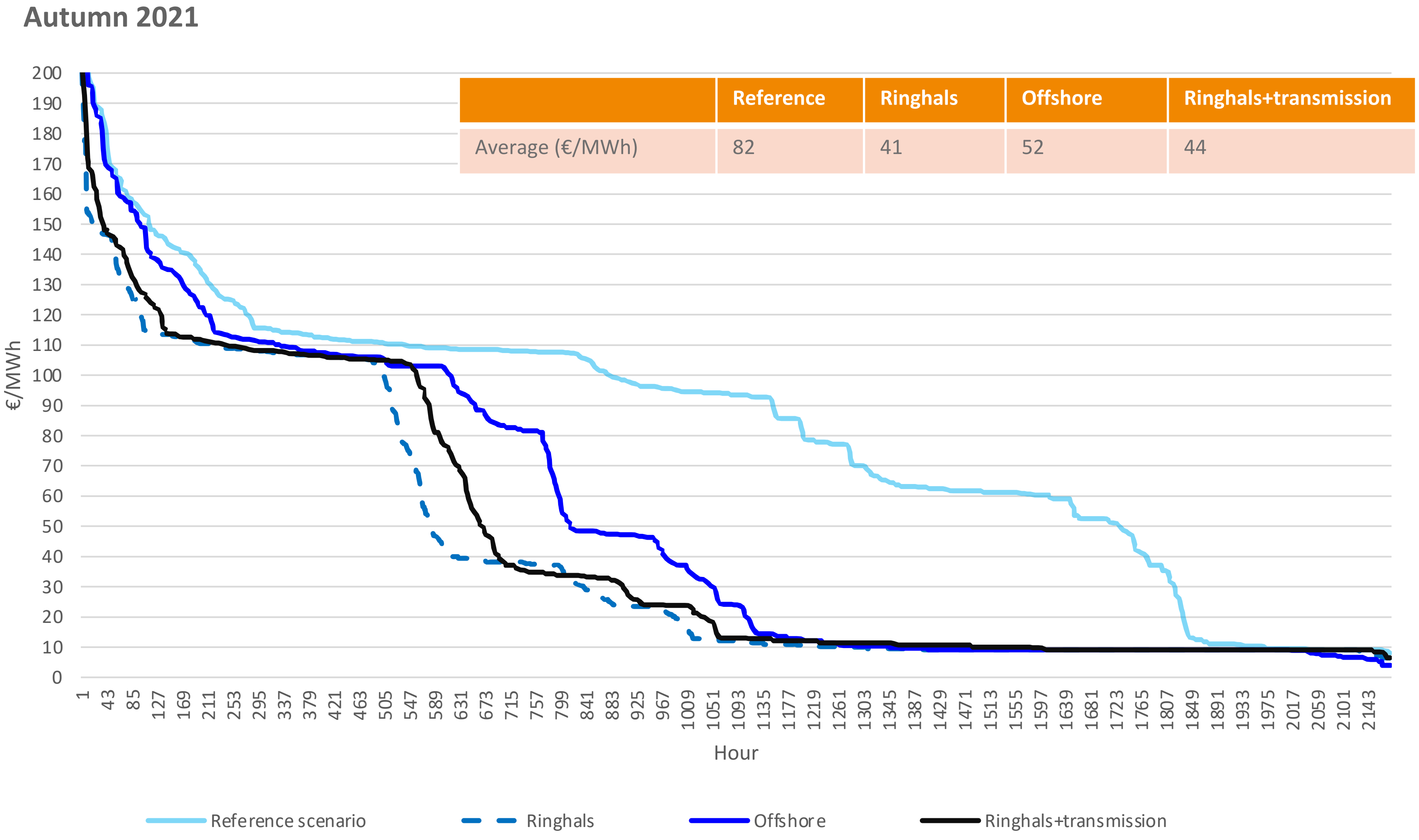
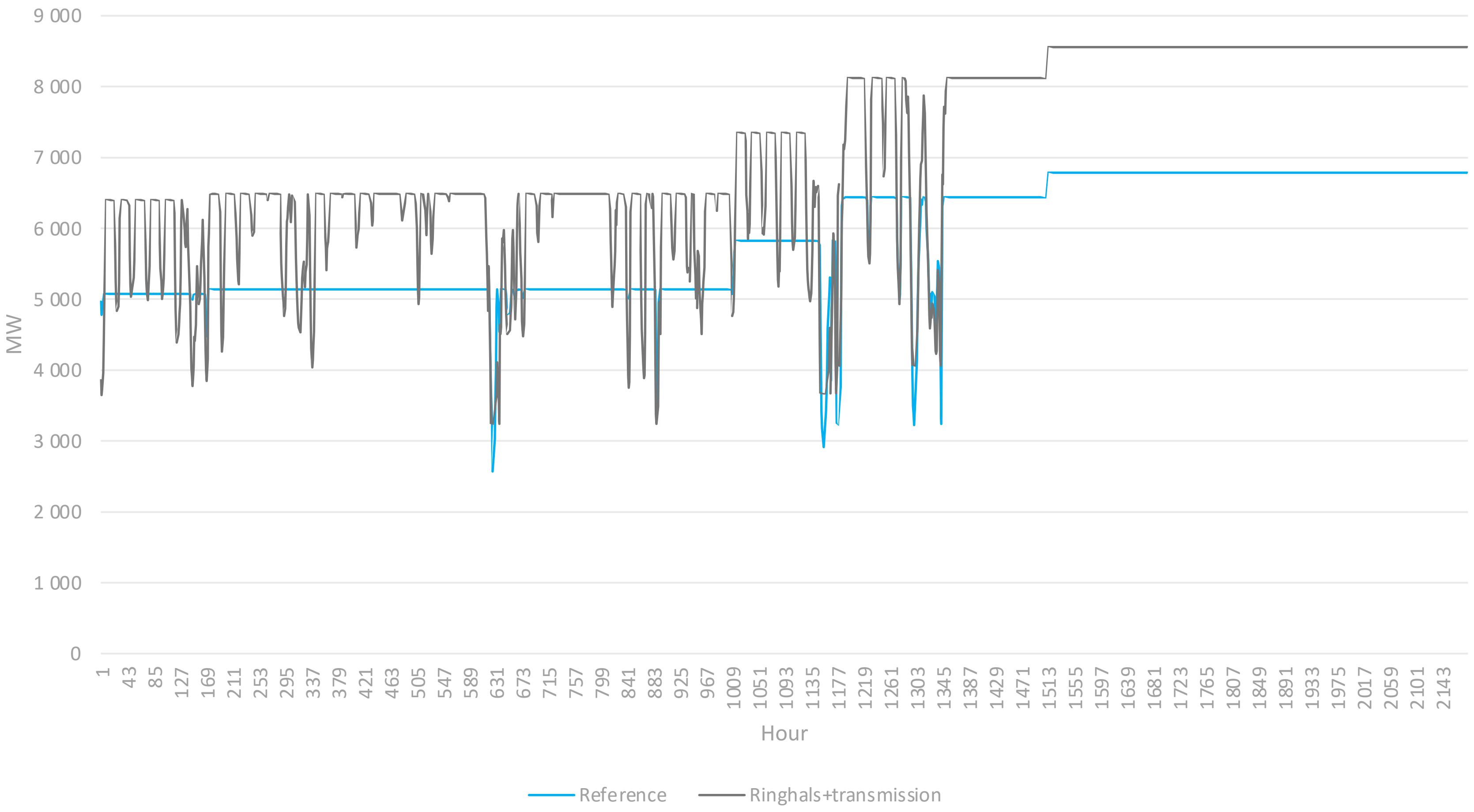
Price duration curve of SE3



	Reference	Ringhals	Offshore	Ringhals+transmission
Average (€/MWh)	82	41	52	44

Nuclear generation in reference and Ringhals + transmission in Autumn



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Side analysis – autumn 2021 with average fuel prices

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Assumptions

Same preconditions as main analysis, but with lower gas and coal prices reflecting average prices observed during 2010 to 2020. Moreover, the CO_2 price is set to level of 75 €/ton.

- 7.17 €/GJ for gas
- 3.13 €/GJ for coal
- 75 €/ton for CO_2 allowances.

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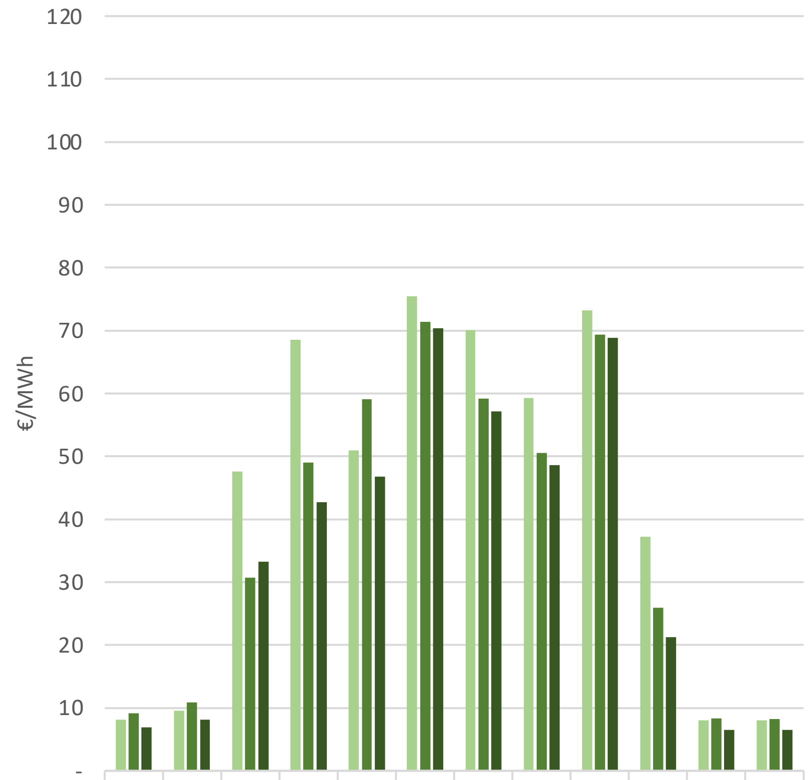
Power prices in Autumn 2021 with average fuel prices

The magnitude of average power price changes in SE3 and SE4 are in the order of 15-25 €/MWh which is significantly lower relative to the scenarios applying the observed very high gas and coal prices in autumn 2021 (these showed for example that R1/R2 had a 41 €/MWh price impact in SE3 and offshore capacity had a 44 €/MWh impact in SE4).

Still the relative changes (%) are significant:

The combined effect of Ringhals 1 and 2 and increased transmission markedly reduces prices of SE3 (35 % decrease) and SE4 (29 % decrease), as bottlenecks are moved further south to SE4's connections to DK, DE, PL and LT.

Adding offshore capacity to SE4 has a strong effect on power prices in both SE4 (38 % decrease) and SE3 (31 % decrease).



	SE1	SE2	SE3	SE4	FI	DK1	DK2	NO1	NO2	NO5	NO3	NO4
Normal year	8	10	48	69	51	75	70	59	73	37	8	8
Normal_Ringhals+transmission	9	11	31	49	59	71	59	51	69	26	8	8
Normal_offshore	7	8	33	43	47	70	57	49	69	21	6	6

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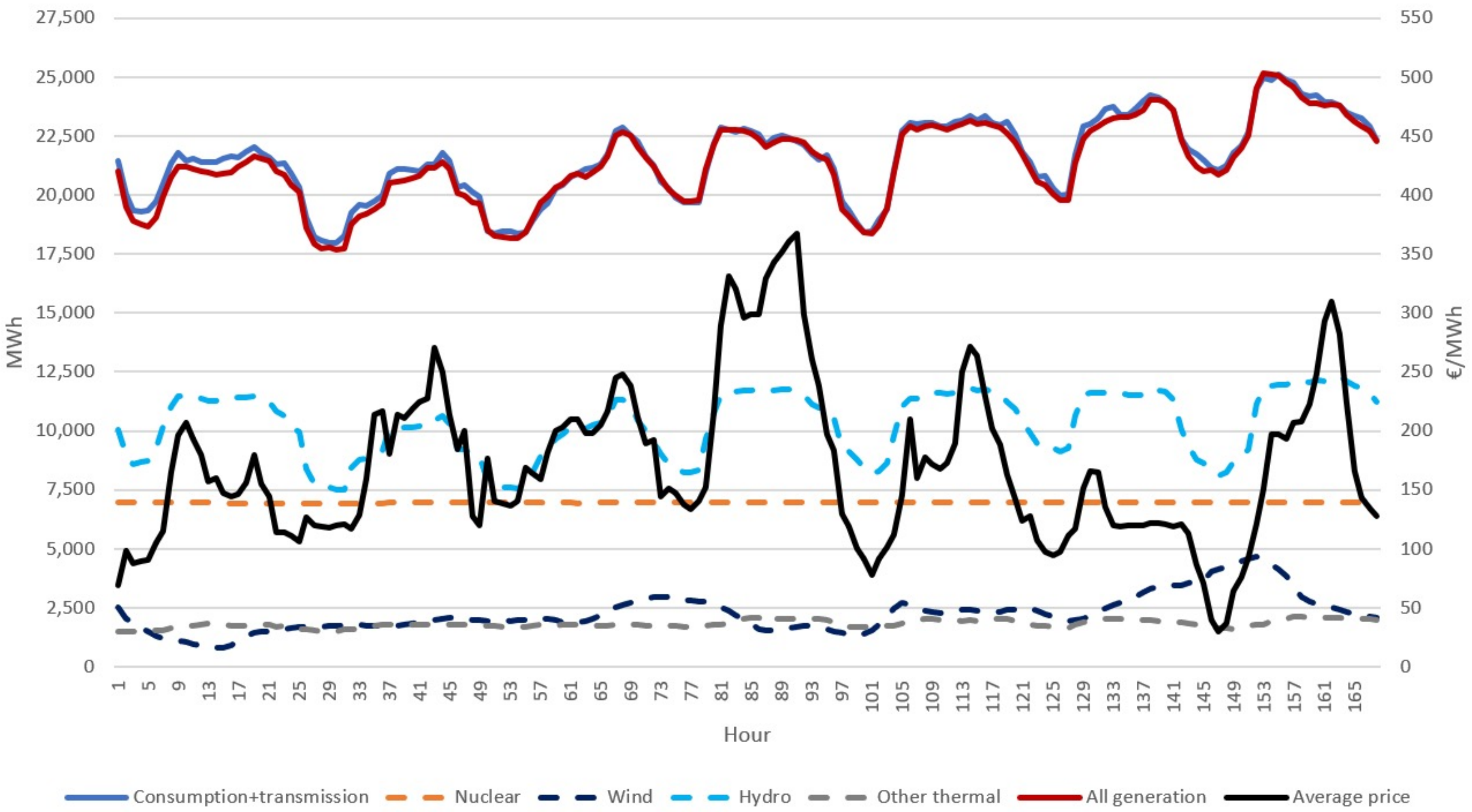
Appendix

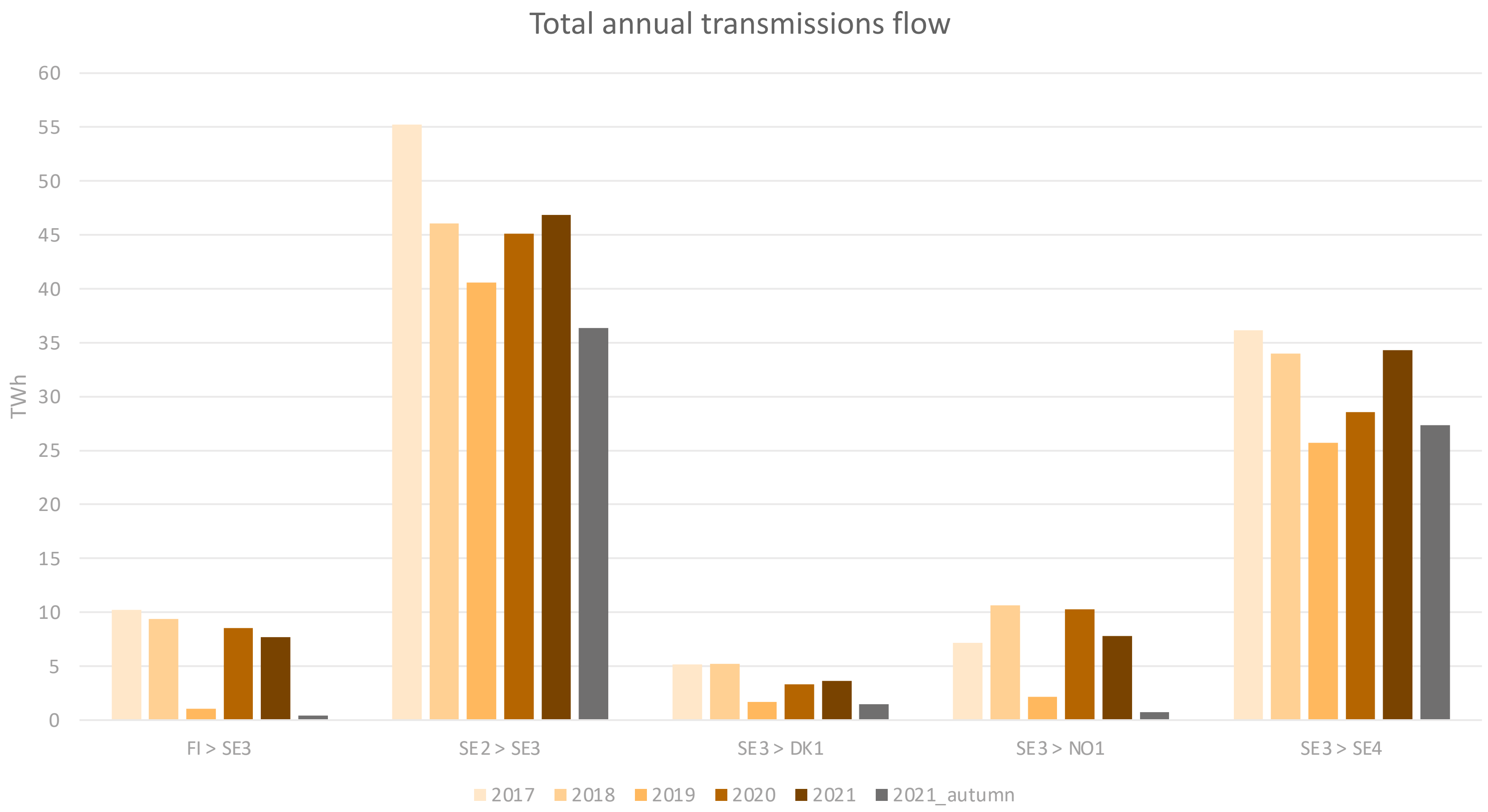
Average prices

€/MWh	Historic autumn 2021	Reference	Ringhals	Offshore	Ringhals+transmission
SE1	34	8	7	6	9
SE2	34	11	8	8	12
SE3	73	82	41	52	44
SE4	101	110	103	64	75
FI	73	125	124	122	122
DK1	123	120	117	111	113
DK2	117	100	109	92	108
NO1	99	96	79	86	78
NO2	100	113	110	111	109
NO5	99	68	46	55	42
NO3	33	8	7	6	9
NO4	31	8	7	6	9
EE	109	110	114	106	113
LV	113	122	124	113	119
LT	115	116	118	109	116
AT	163	93	93	92	93
BE	161	182	182	182	182
DE-LU	142	130	130	129	129
FR	166	160	160	160	160
NL	156	199	199	199	199

Historical dispatch in Sweden in week 48 – 2021

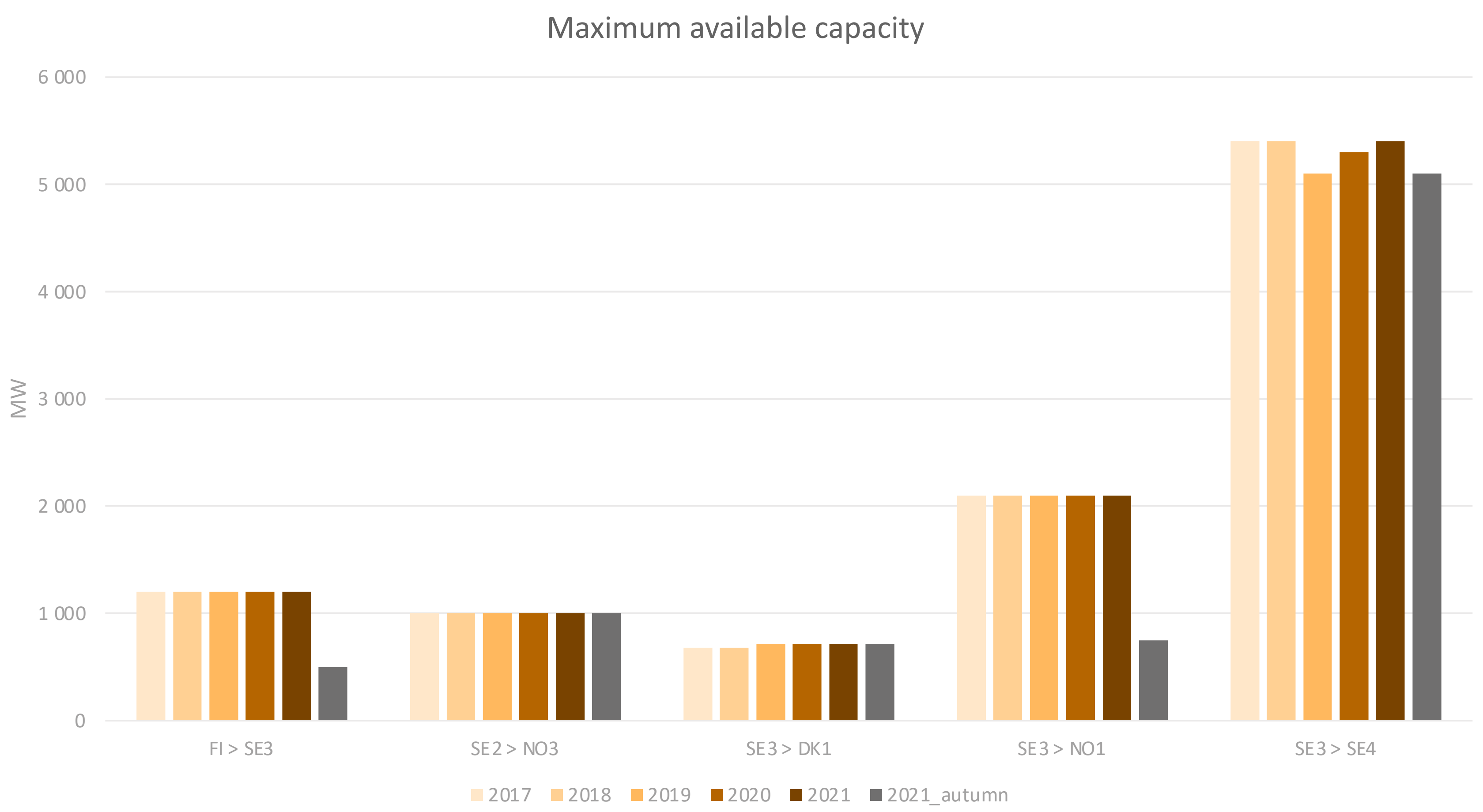


SE3 lines



Total annual transmissions flow
TWh
60
55
50
45
40
35
30
25
20
15
10
5
0
FI > SE3
SE2 > SE3
SE3 > DK1
SE3 > NO1
SE3 > SE4
2017
2018
2019
2020
2021
2021_autumn

SE3 lines



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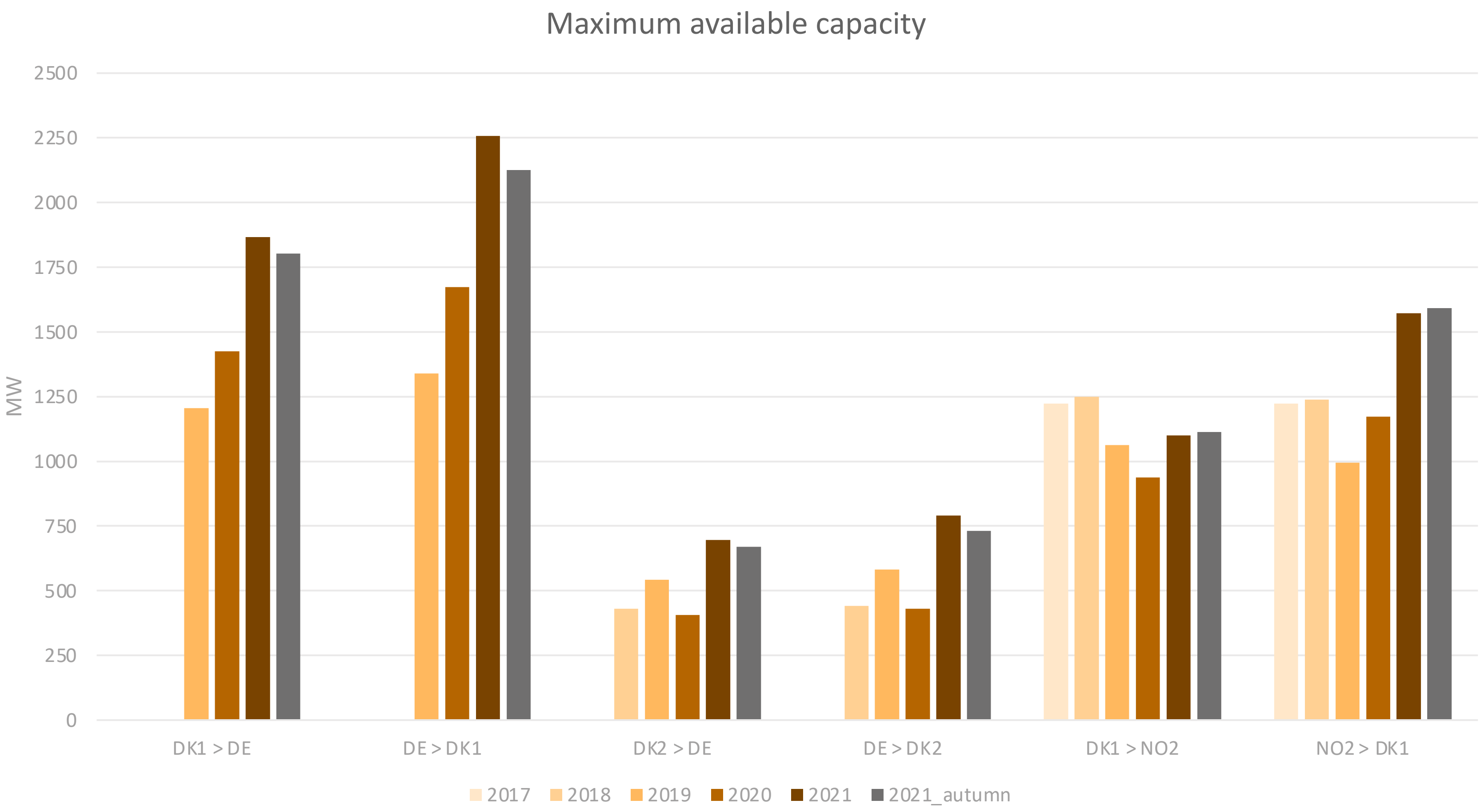
DK lines



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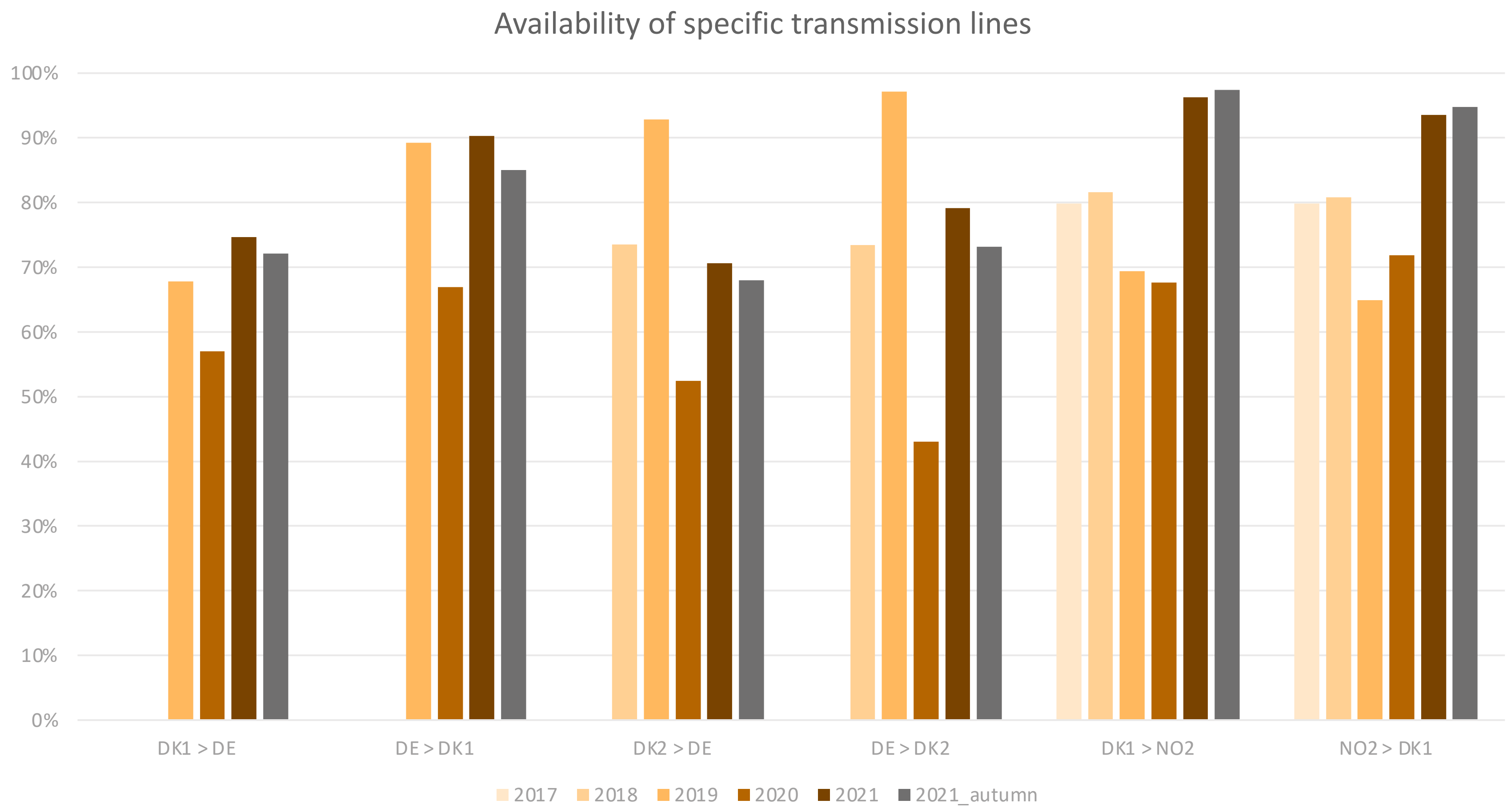
DK lines



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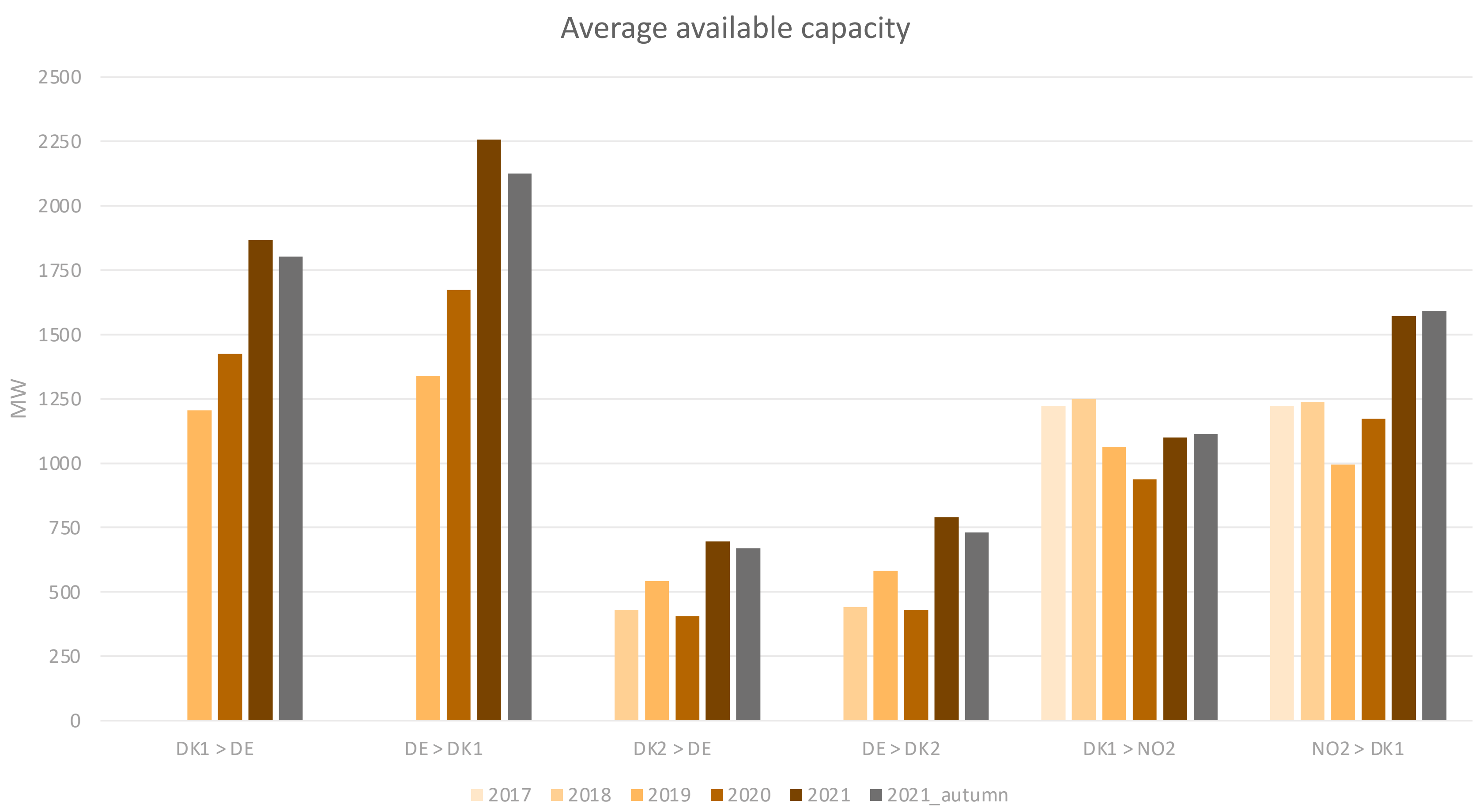
DK lines



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Capacity factors Denmark (ENTSO-E data)

Capacity(MW)	Offshore	Onshore
2021	1700	4426
2020	1700	4402
2019	1700	4481
Generation(MWh)	Offshore	Onshore
2021	7202745	8873482
2020	6313851	10103228
2019	5617384	10315259
Capacity factor(%)	Offshore	Onshore
2021	48%	23%
2020	42%	26%
2019	38%	26%

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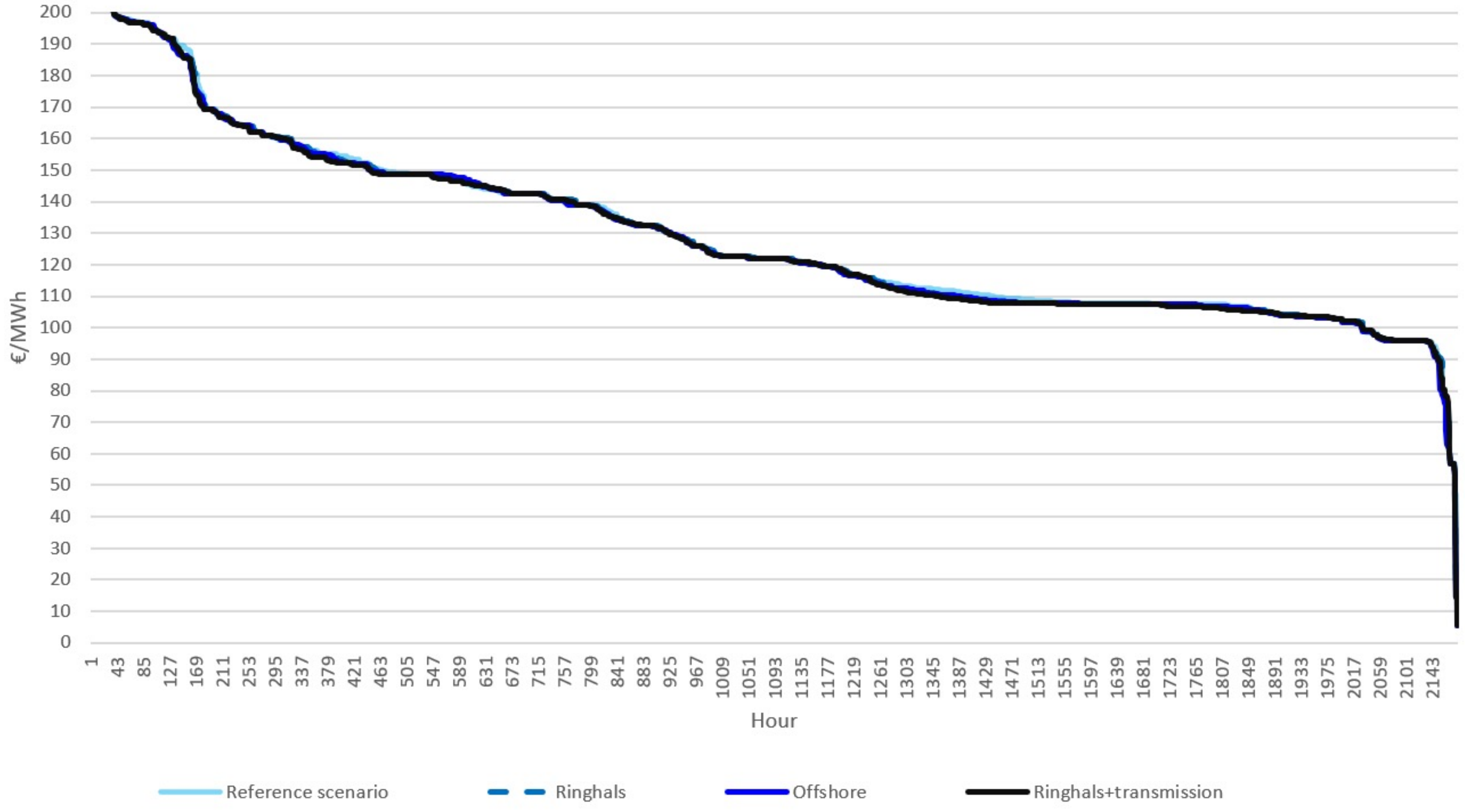
Price duration curve Germany



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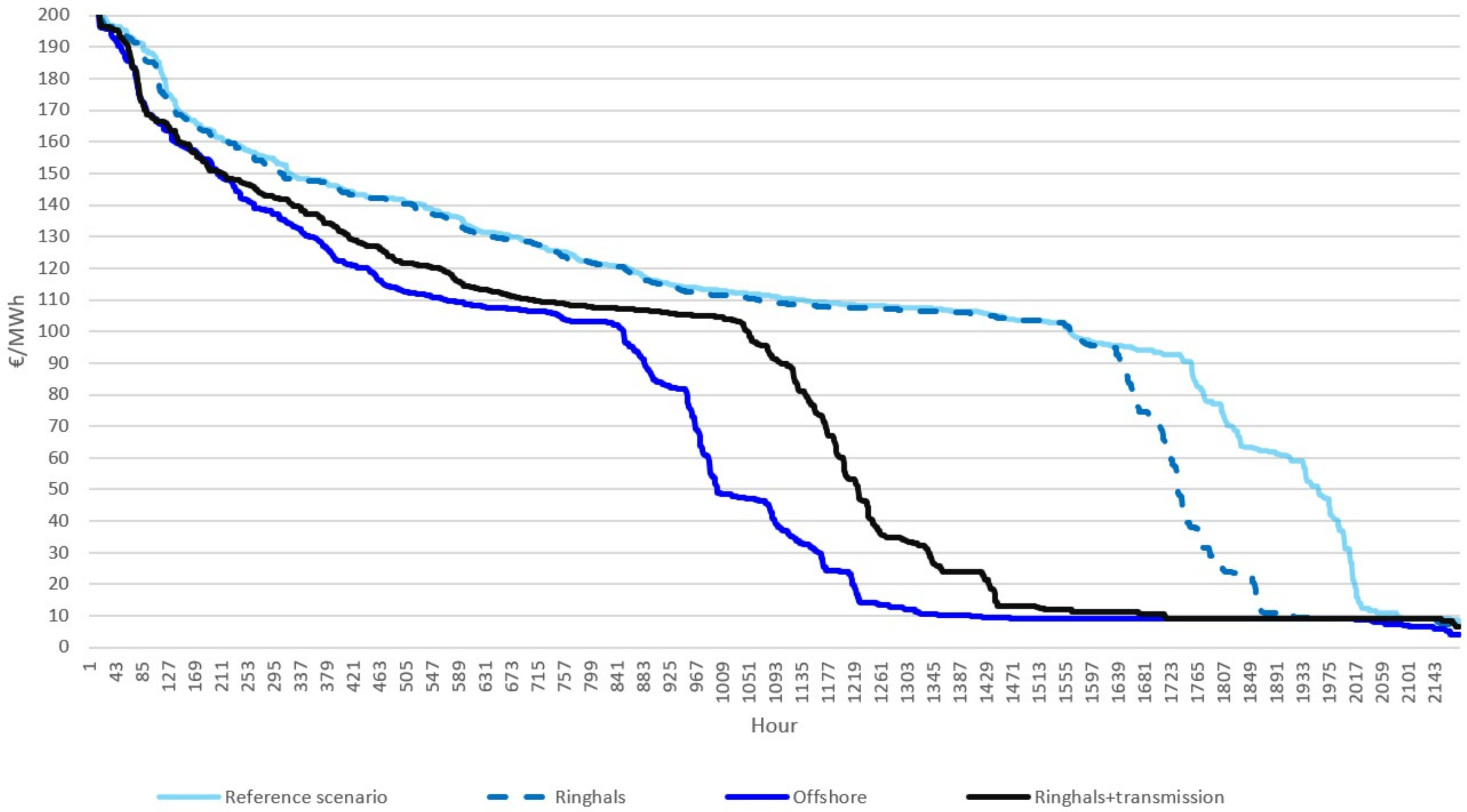
Price duration curve SE4



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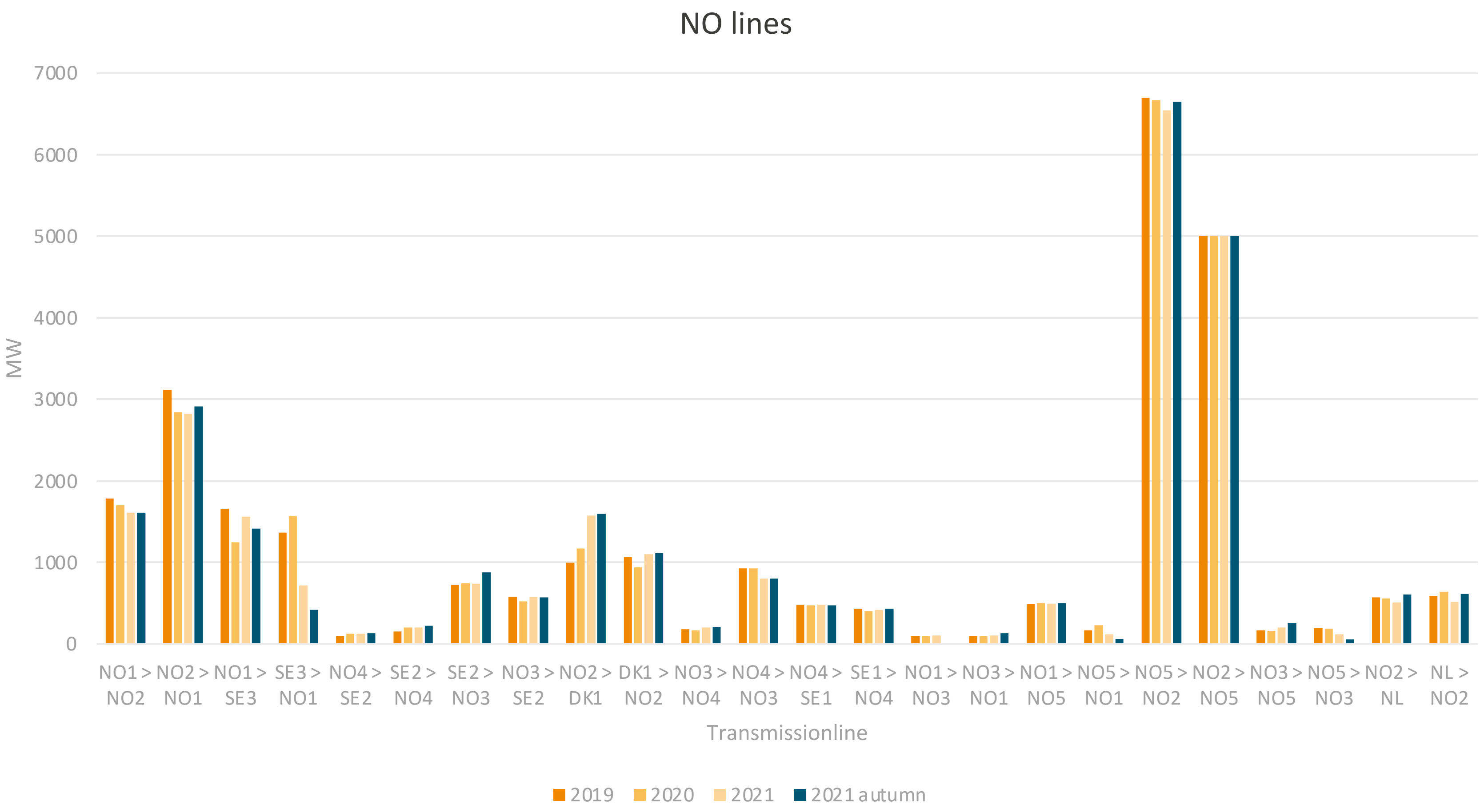
All NO lines



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IMPACT ON ELECTRICITY PRICES OF ADDED GENERATION IN SOUTHERN SWEDEN

A study about the impact on electricity prices of more electricty generation in southern Sweden. How much would it have mattered in the autumn of 2021 and what does that tell us about the way forward?

The study finds that greater capacity to produce electricity in southern Sweden would likely have reduced prices significantly during the autumn of 2021.
If, hypothetically, Ringhals 1 and 2 had been operating, prices in SE3 and SE4 during September-November 2021 could have been 30-45% lower than observed. Similarly, with an additional 3.5 GW of offshore wind capacity in SE4, prices in SE3 and SE4 could have been 35-50% lower than observed in the same period. Grid bottlenecks are the main reason for the large price reduction in southern Sweden – most of any additional power generation would have been 'trapped' in southern Sweden.

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