Annual Market Update 2018

Electricity market insights

Introduction

A new year, a new item: the Annual Market Update

In the past, TenneT yearly published the TenneT Market Review to share its insights on last year's developments in the electricity market for everyone interested (see link for previous editions). The TenneT Market Review has been given a new look this year, in the form of the TenneT Annual Market Update before you. The structure and topics are largely comparable to the previous TenneT Market Reviews, but the format is different. The focus of this Annual Market Update is on relevant developments in the Central Western European electricity markets, and the Dutch electricity market in particular.

The developments in the Annual Market Update are structured alongside several main topics. The chapter *Electricity market prices* discusses wholesale day-ahead, intraday and futures prices and identifies price trends. As our electricity system is yet highly dependent on fossil-fuelled power, the chapter *Fuel prices* describes developments in hard coal, natural gas and emission allowance prices, as well as the margins for generators. The chapter *Power consumption & generation* focuses on the supply and demand sides of the electricity system and discusses developments in installed capacity, consumption and generation. Support for renewables in the Dutch system is discussed in the chapter *RES support schemes*, by looking at budget distribution, awarded capacity and generation of the SDE+ schemes. In the chapter *Market integration* the storyline zooms out and includes the interactions of the Dutch electricity system with neighbouring systems. Additionally, the ongoing efforts of coupling EU electricity markets are discussed in this chapter. The last two chapters focus on mechanisms in place to ensure the stability and functioning of the electricity system. *Balancing* measures, to ensure supply and demand is equal at all times, and *Redispatch* measures, to resolve congestion in the grid.

Main findings (1/3)

Higher electricity prices across Europe in 2018. Prices in NL increased faster than the CWE average.

The year 2018 saw an increase in electricity prices across Europe. The average day-ahead electricity price in the Netherlands rose by 33% to 50.7 €/MWh, a larger increase than on average in the Central Western European (CWE) region (+24%). Within the CWE region it can be seen that in previous years prices of the Netherlands and Germany were close together, as well as prices of France and Belgium. In 2018, these combinations have changed. The first half of 2018 showed prices of the Netherlands and Belgium closer together, as well as those of Germany and France. In the last quarter of 2018, prices within the CWE region are diverging. Belgium experienced high prices in the second half of 2018, due to unexpected nuclear outages.

Electricity price increases across Europe are mainly explained by increases in natural gas, coal and carbon emission allowance prices. Also, the summer drought affected prices, especially in countries that rely on hydro. Carbon prices rose sharply in 2018, caused by a new phase of the Market Stability Reserve coming into force in 2019. Speculation on carbon allowances in the second half of 2018 is reflected in the prices for futures in this period, that follow almost exactly the same trend. For Dutch generators gross margins on the wholesale market remained healthy in 2018, whereas German generators saw their margins drop below zero in several months.

A big event in 2018 was the German-Austrian bidding zone split on October 1st. In the three months after the split, prices in Germany were on average 7.3 €/MWh lower than in Austria. Another event in 2018 was the go-live of the cross-border intraday trading platform XBID on June 12th. The months after the go-live show increased cross-border trade when compared to the same months of 2017. In general, the intraday market is becoming more important, both in terms of volumes and amount of trades.

Main findings (2/3)

Mostly solar in 2018 SDE+ spring round, in total SDE+ awarded over 14 GW of RES. Imports in NL increased.

No big changes in electricity consumption within the CWE region were seen in 2018. In the Netherlands, total generation decreased and was replaced by an increased amount of imports. Natural gas remains the dominant source of electricity generation. Generation with renewables increased slightly, partly resulting from increased renewable capacity, which was mainly solar.

In the 2018 spring round of the SDE+ subsidy scheme, the total of projects submitted undershoot the available budget for the first time in SDE+ history. In the autumn round, the total submitted budget exceeded the available budget again. At the time of writing, the budget allocation of the autumn round was still ongoing. Solar dominated in the 2018 spring round, whereas a low amount of budget was allocated to onshore wind projects, caused by a low number of applications. For offshore wind, only a small auction was held in 2018: the innovation parcel Borssele V (19 MW). A new large-scale offshore auction is planned for 2019: “Hollandse Kust Zuid III & IV”. Up to and including the 2018 spring round, over 14 GW of renewable electric capacity is (projected to be) installed under SDE+ subsidy schemes, accounting for an annual generation of almost 35 TWh.

Physical net import and export positions in the CWE region remained relatively stable in 2018, but the Netherlands took more often a net import position. The Netherlands receives most imports from Germany, and exports mainly to Belgium. With the split of the German-Austrian bidding zone, the Austrian bidding zone has taken a net import position, with imports in the same order of magnitude as Belgium. The unavailability of nuclear plants in Belgium in the second half of 2018 was resolved with an increased amount of imports from France.

Main findings (3/3)

Larger imbalance volumes and higher balancing capacity prices. Redispatch costs up in NL, slightly down in DE.

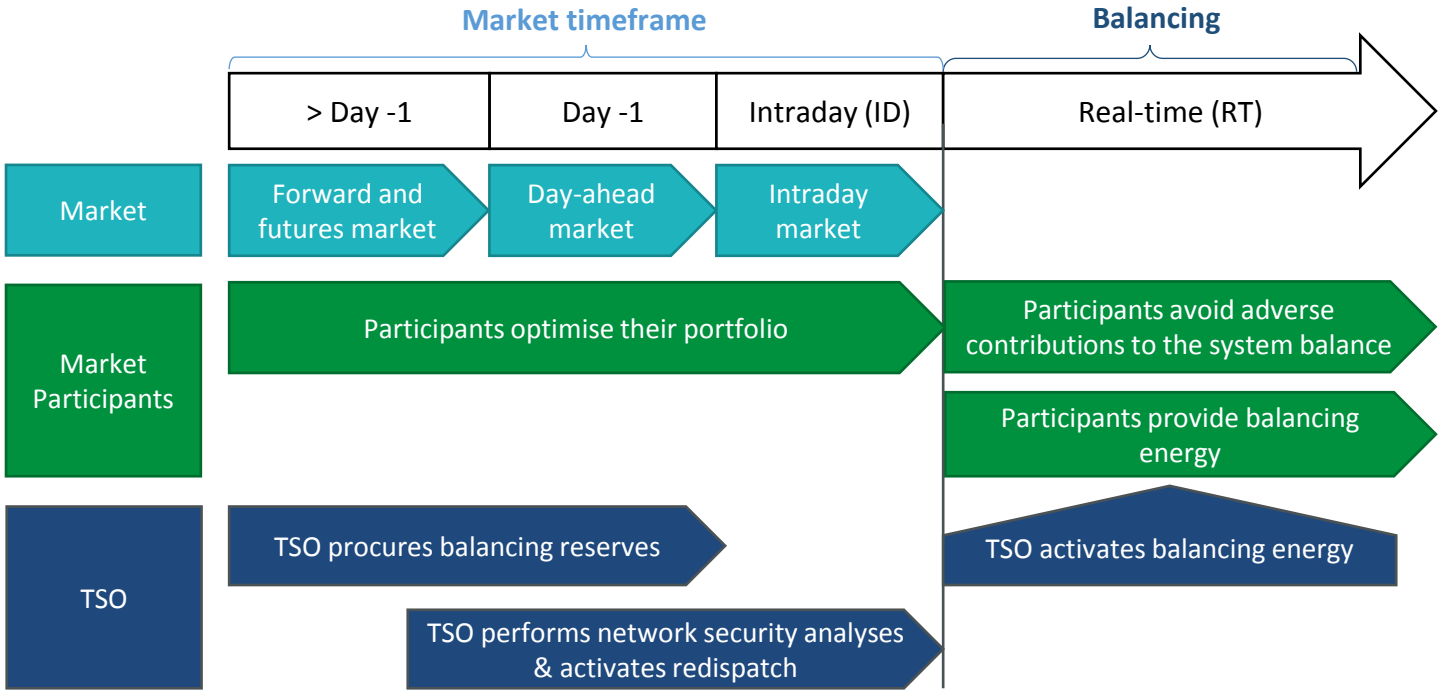
Lastly, the Annual Market Update looked into two types of important system services: balancing and redispatch.

When looking at balancing services, more ISPs with larger imbalance volumes occurred in the Netherlands, which is an continuing trend since 2013. Whereas in previous years the Dutch imbalance volumes showed that Dutch market participants tend to oversupply the system, the year 2018 showed a more symmetrical distribution of ISPs with long and short imbalance volumes. This is also seen in the imbalance price delta, which became almost equal for long and short systems in 2018. Capacity prices for all balancing products increased in 2018, mostly caused by an increased amount of manual Frequency Restoration Reserves directly activated (mFRRda) being contracted since January 2018 to comply with the EU Electricity Balancing Guideline, leading to a tighter market for all balancing products.

Costs for congestion management in the Netherlands increased to €53 million in 2018 (+16%). Most costs were related to redispatch, and a smaller share can be attributed to restriction contracts, which are contracts with market parties to withhold a share of production for a certain period. Across the border in Germany, cost for congestion management in 2018 were in the order of €1 billion. Costs decreased slightly (-5%) compared to 2017 because of more moderate weather conditions in 2018. The use of grid reserve in Germany decreased significantly in the second half of 2018, since after the German-Austrian bidding zone split the Austrian grid reserve plants were not contracted anymore, and thus not available anymore.

Market timeframes

The wholesale market consists of several markets

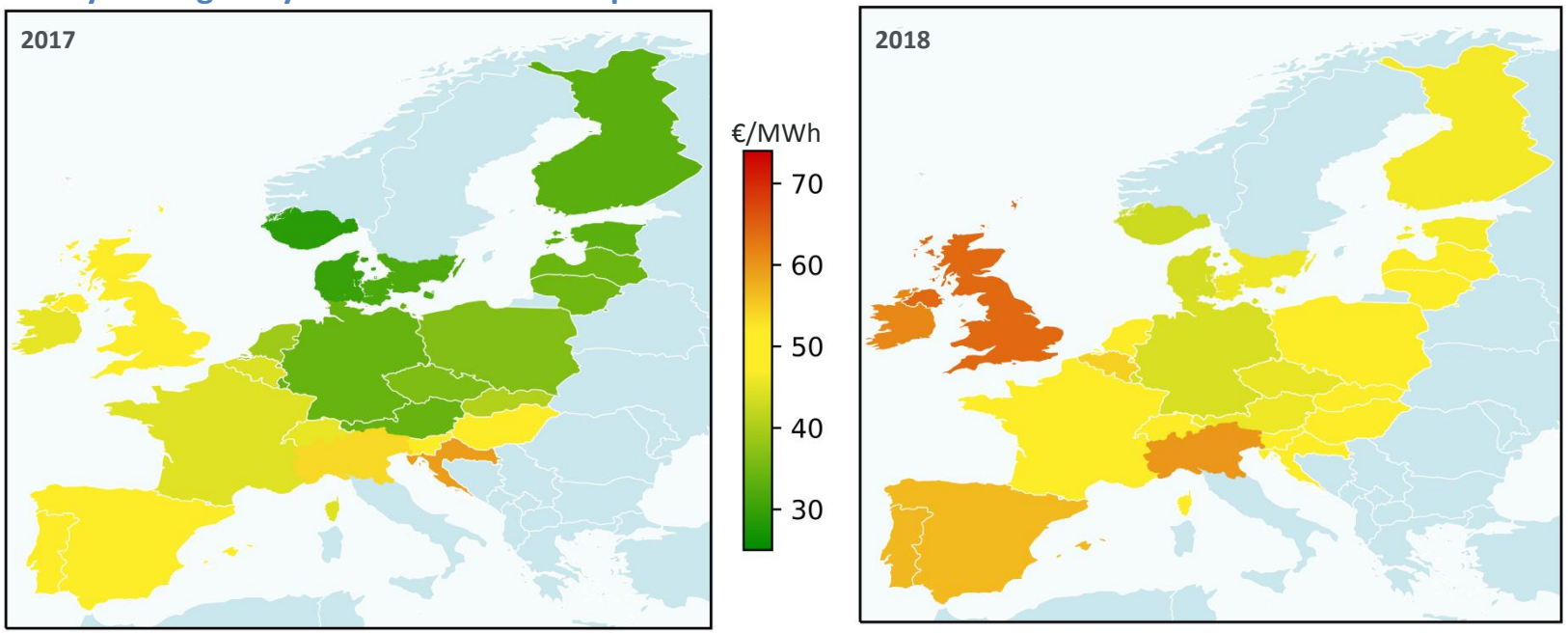


- The figure above shows the relation between the different timeframes of the wholesale market and the balancing market. In wholesale markets, electricity generators sell electricity to large industrial consumers and electricity suppliers. The electricity suppliers sell electricity to the final consumer in retail markets. The scope of this Annual Market Update is on wholesale markets.
- Important features of the electricity system are two types of system services: balancing and redispatch. TSOs procure balancing reserves that can be activated in real-time to resolve disruptions in system balance. Also, TSOs perform network security analyses to identify congestion, which is resolved by activating redispatch.

Day-ahead prices Europe

2018: increase of day-ahead prices across Europe

Yearly Average Day-ahead Prices in Europe

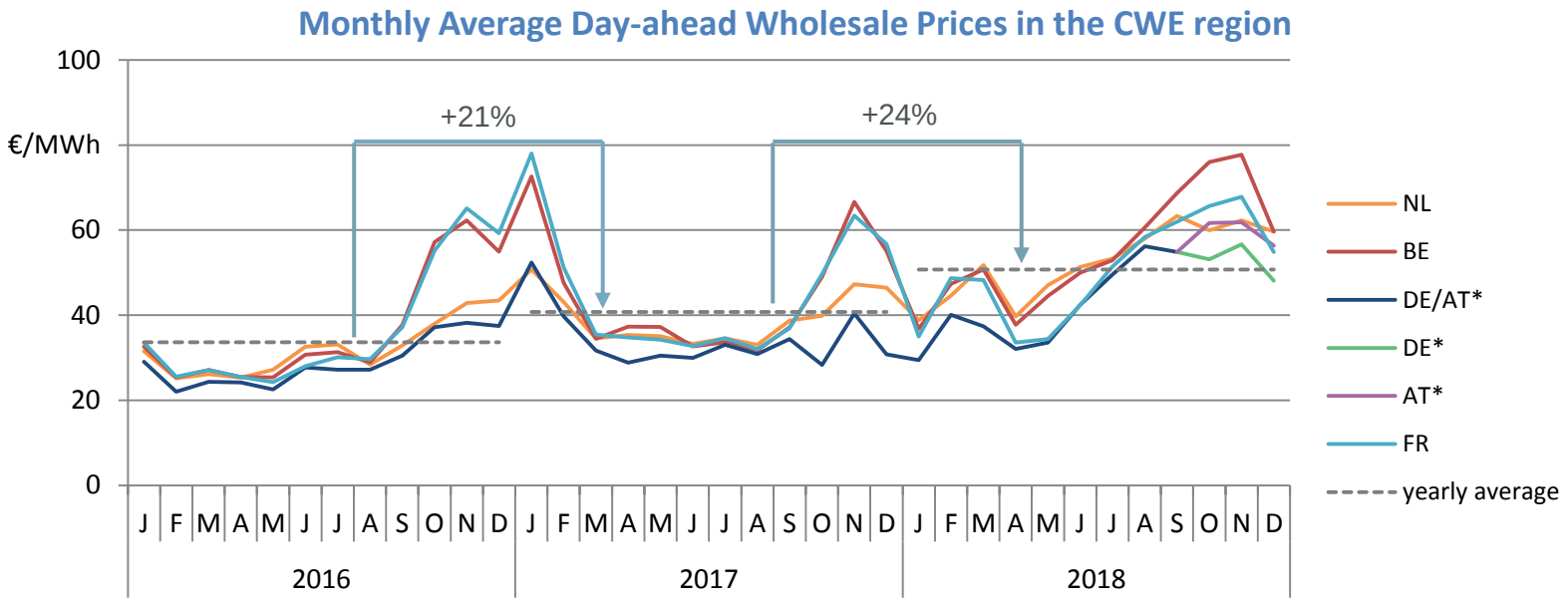


- Almost all European countries saw an increase in day-ahead prices from 2017 to 2018.
- While Nordic prices remain relatively low compared to other countries, the increase in day-ahead prices was relatively large. Also the Baltics saw a large price increase. This is possibly a result from the summer heat wave in the Summer of 2018, leading to a hydro shortage Scandinavia and low wind generation.
- Croatia was the only country that saw a price decrease in 2018 compared to 2017, due to the coupling with the Slovenian market. The lowest price increases are seen in Slovenia and Portugal (<5%)

Source: MRC Market Coupling. See annex for price per country.

Day-ahead prices CWE

DA prices in the Netherlands increased faster than the CWE region average



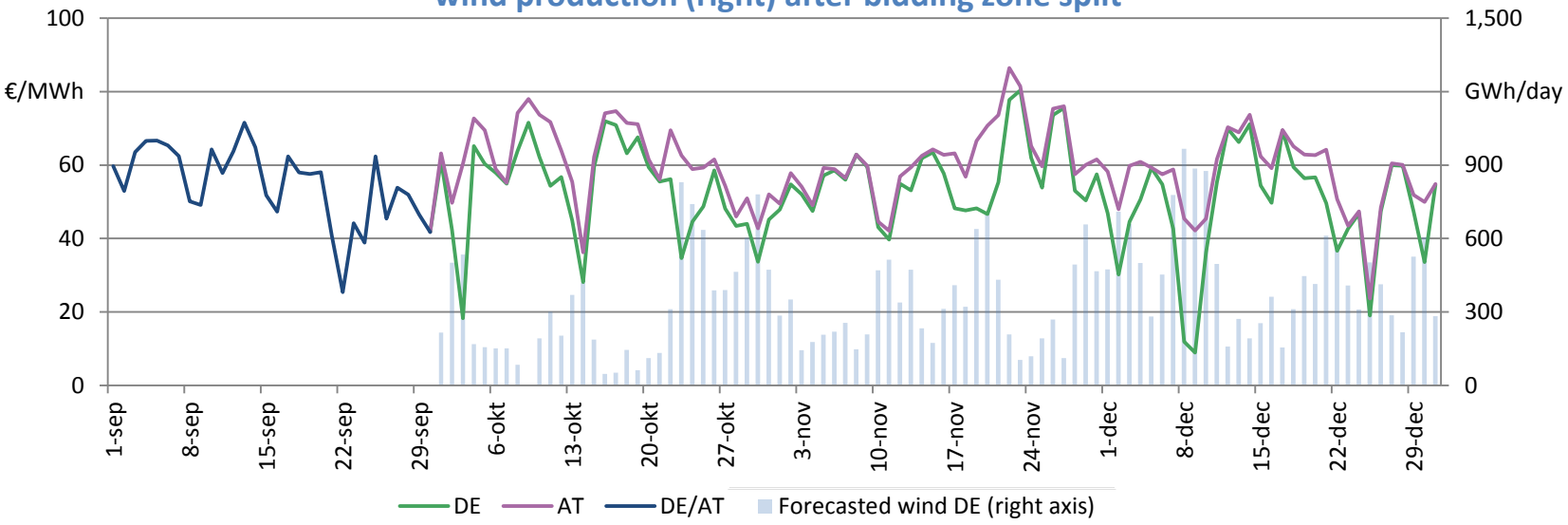
* On October 1st, 2018 the German/Austrian bidding zone split into two seperate bidding zones

- In the Netherlands, prices increased from 39.3 €/MWh to 52.5 €/MWh, an increase of 33%. This increase is larger than the CWE region average (24%, from 40.8 €/MWh in 2017 to 50.7 €/MWh in 2018).
- Increasing yearly DA prices mostly due to increasing fuel- and emission allowance prices (see slide 16/17).
- Higher prices in winter months. Winter effect bigger in Belgium and France due to a large share of electric heating in France, and capacity shortage in Belgium due to unexpectedly high nuclear outages.
- Relatively high prices in winter 2016/2017 due to cold spell.

Day-ahead prices DE & AT

Large DA price spread between DE and AT on days with high wind feed-in and low demand

Daily Average Day-ahead Wholesale Prices in DE and AT (left) and Forecasted DE wind production (right) after bidding zone split

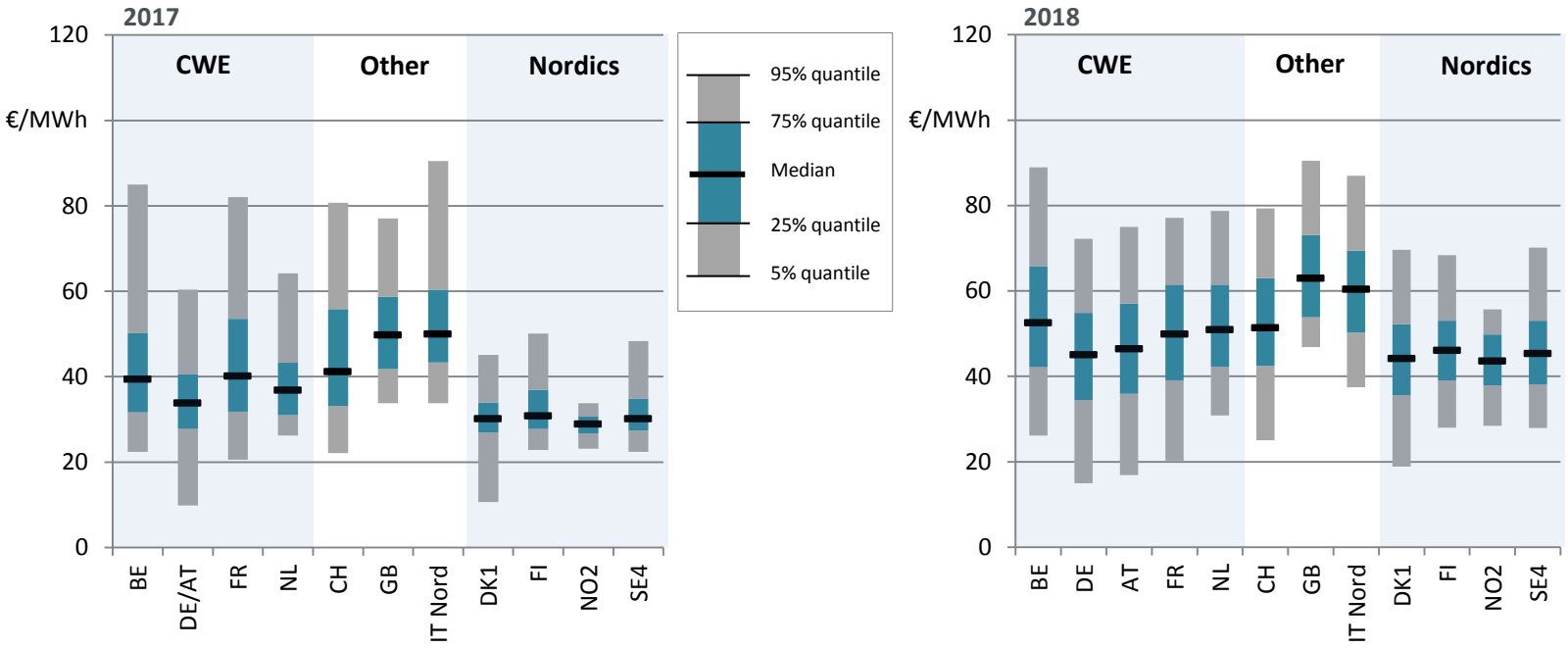


- After the split, low prices occur more often in the DE bidding zone. The average price of DE over October-December 2018 (52.6 €/MWh) is 7.3 €/MWh lower than the average price of AT in the same period (59.9 €/MWh). The average spread is significantly larger than the 2-4 €/MWh spread that was seen in the public market coupling simulations performed in the three months before the split.
- The spread between DE and AT prices is moderately correlated with the combination of high wind feed-in and low demand, mainly causing the drops in DE prices.

Price volatility (1/2)

Increasing fuel prices led to increased price volatility

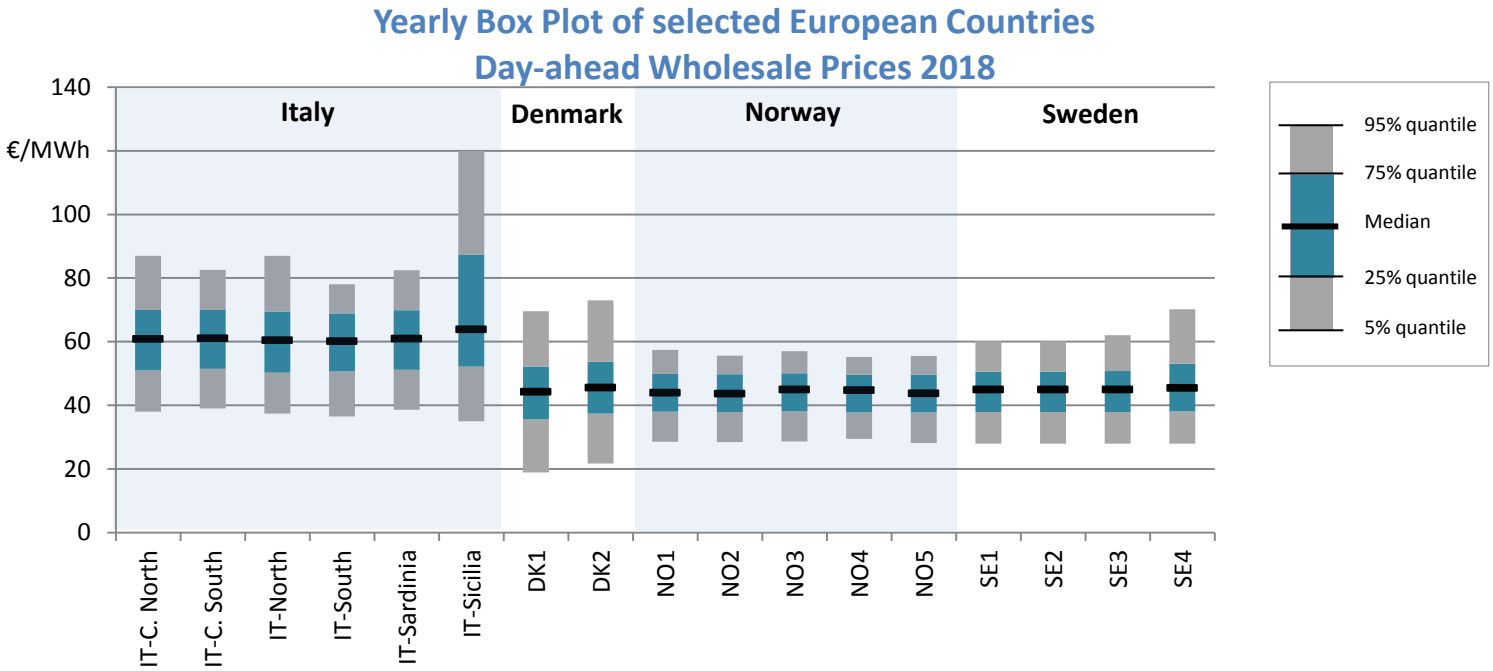
Yearly boxplots of Day-ahead wholesale prices in selected European countries



- Higher volatility in general in almost all countries and smaller differences in volatility between countries compared to 2017. Mostly due to higher DA prices in the second half of 2018 compared to the first half of 2018.
- In 2017, price volatility of DE/AT and NL are close together, as well as price volatility of BE and FR. In 2018, the price volatility of CWE countries lies closer together, with relatively high upward volatility in BE due to unexpectedly high nuclear outages and a tight market.

Price volatility (2/2)

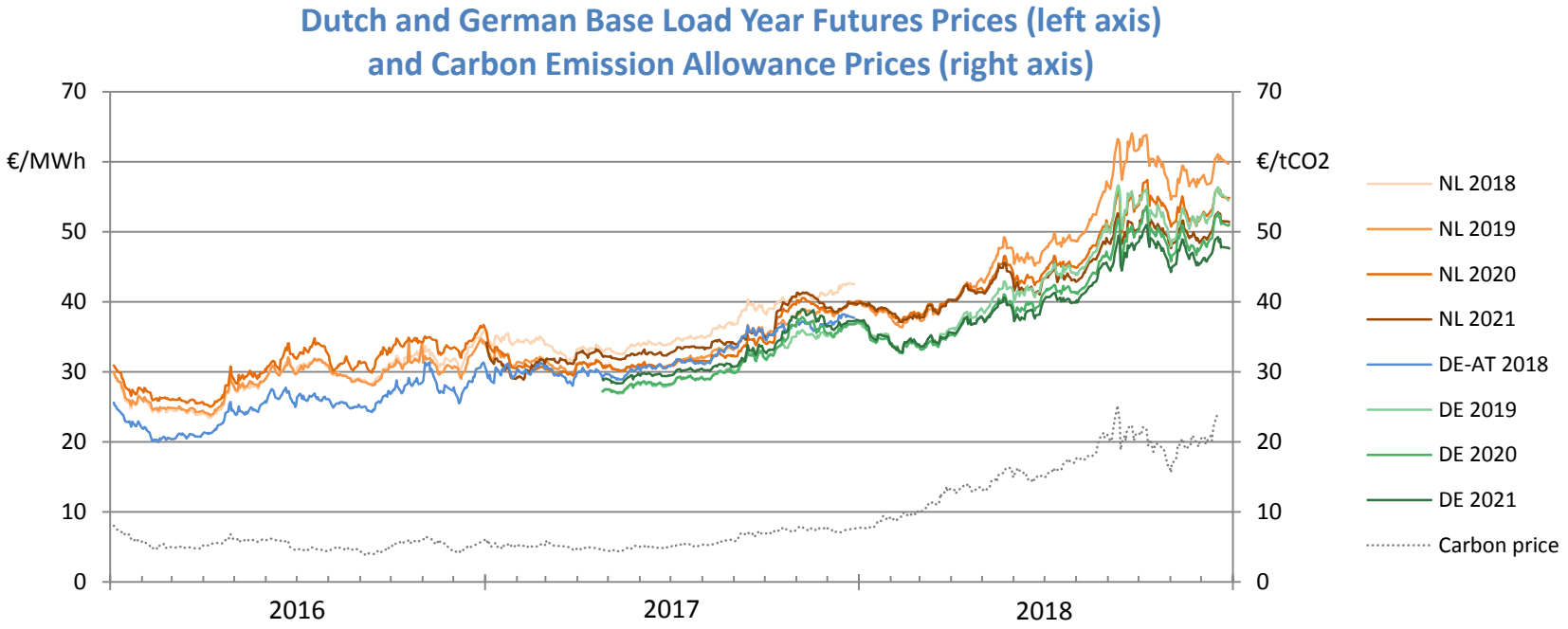
Price volatility does not vary significantly in countries with multiple bidding zones, except for Sicilia



- Price volatility is generally a little lower in bidding zones located centrally within their country.
- The island Sicily is an exception in Italy with a high upward volatility. Day-ahead prices in Sicily are historically higher than in the rest of Italy, due to its isolated location, the dependency on fossil-powered (mostly diesel) plants, and significant industrial demand (amongst others for desalinating seawater).
- The SE4 bidding zone (southern Sweden) has relatively higher prices than the other Swedish bidding zones, due to high consumption and low renewable generation compared to the rest of the country.

Futures prices NL & DE

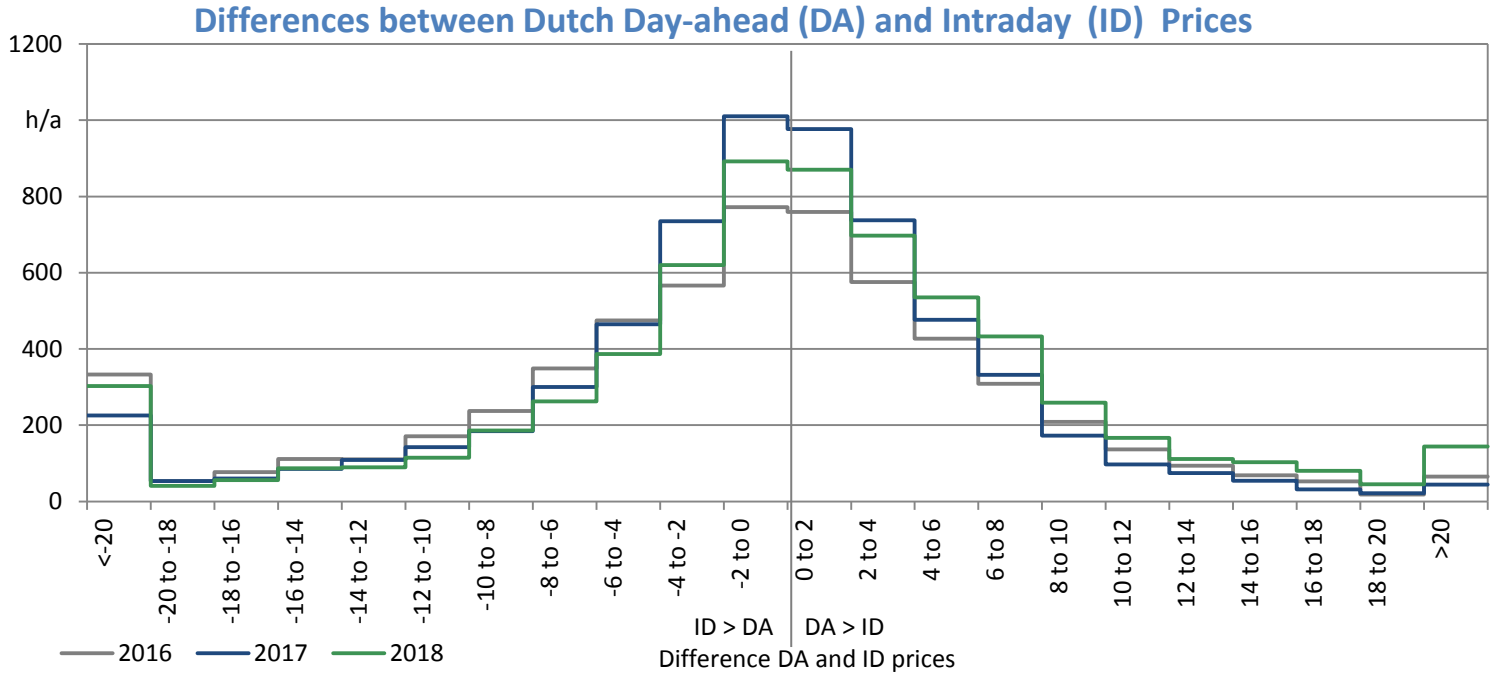
Futures price volatility in the second half of 2018 is linked to volatility in carbon prices



- After reaching a record low in February 2016, futures prices have been steadily increasing.
- Increases in future prices were relatively strong in 2018, because of increased carbon emission allowance- and fuel prices. Volatility in futures prices in the second half of 2018 is linked to volatility in carbon emission allowance prices (see also slide 17).
- The diverging futures prices show that market parties expect that the average price spread between the Netherlands and Germany will increase in the future.

Intraday prices

In 2018: larger differences between DA and ID prices and more hours with higher ID than DA prices

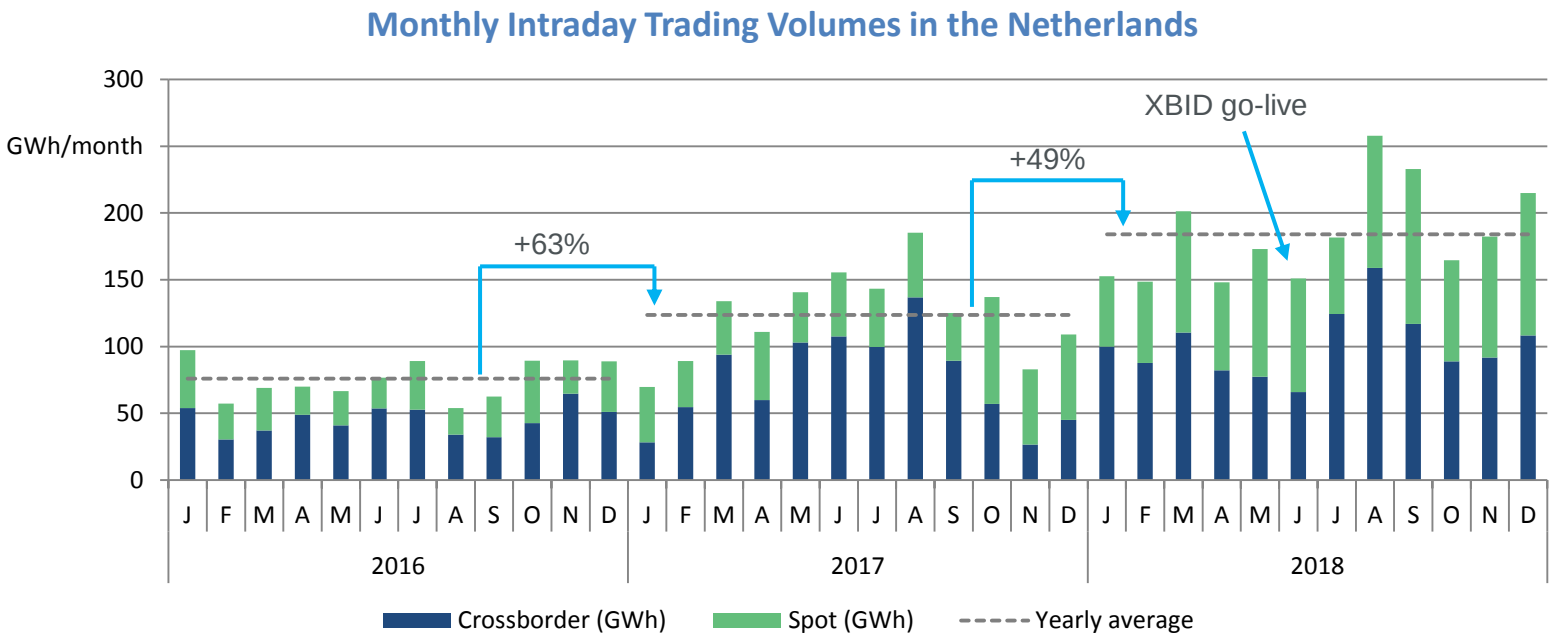


ID trade takes place in a continuous auction, so there is no single price per hour as in the DA market. Therefore, ID prices per hour have been determined by taking hourly average prices weighted on trading volumes.

- Whereas in 2017 differences between DA and ID prices were similar to 2016, the results from 2018 show more hours with larger differences between DA and ID prices. Additionally, where the graphs from 2016 and 2017 are skewed to the left, indicating more hours with higher ID prices than DA prices, the graph from 2018 is skewed to the right, indicating more often higher DA prices than ID prices.

Intraday trading volumes

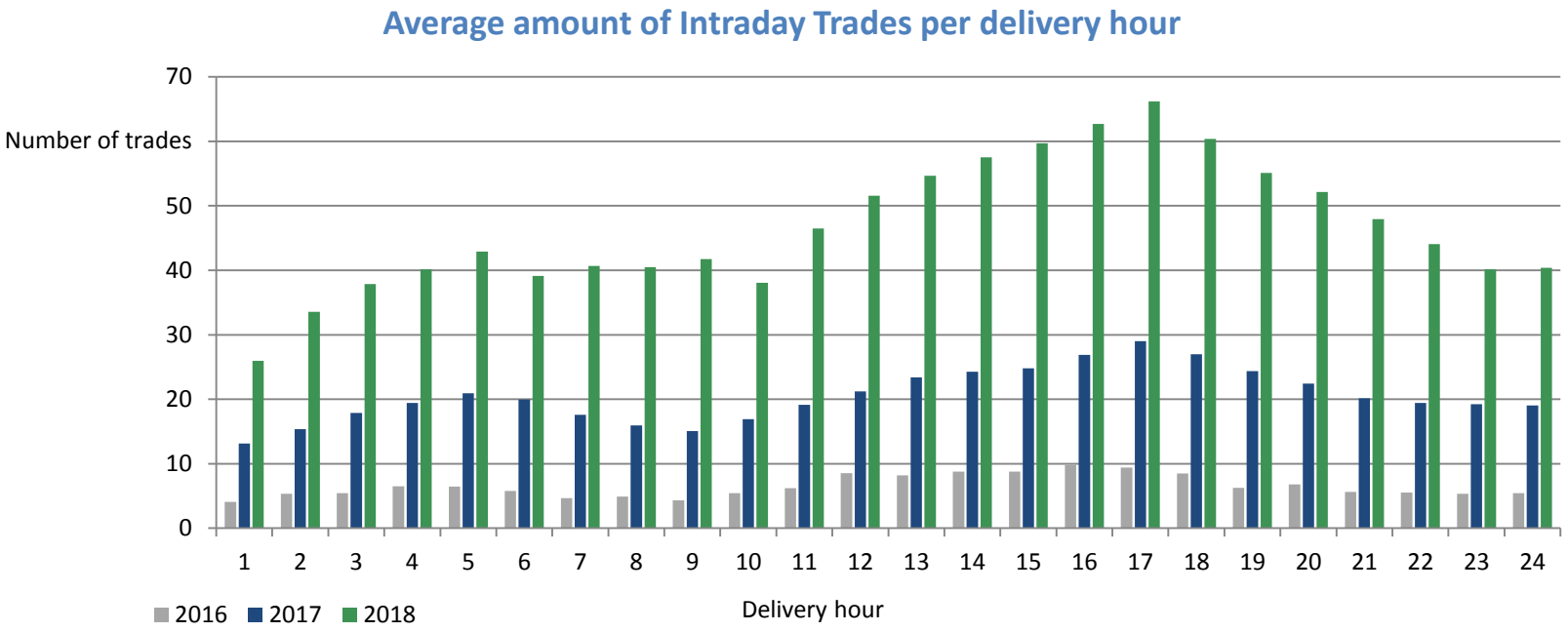
Renewables growth and XBID go-live contributed to the further increase of intraday market volumes



- Significantly more ID volumes traded in 2017 (+63%) and 2018 (+49%). A possible explanation is the larger share of variable renewables in generation. Market participants use the intraday market to optimise their position, since new information (better renewable feed-in forecasts, demand changes, unexpected outages, etc.) becomes available after closure of the DA market. More variable renewable generation thus leads to a shift of trade closer to real-time.
- Cross-border trade in Q4 2018 relatively high, probably due to the go-live of cross-border intraday trading platform XBID on June 12th, 2018.

Intraday trades

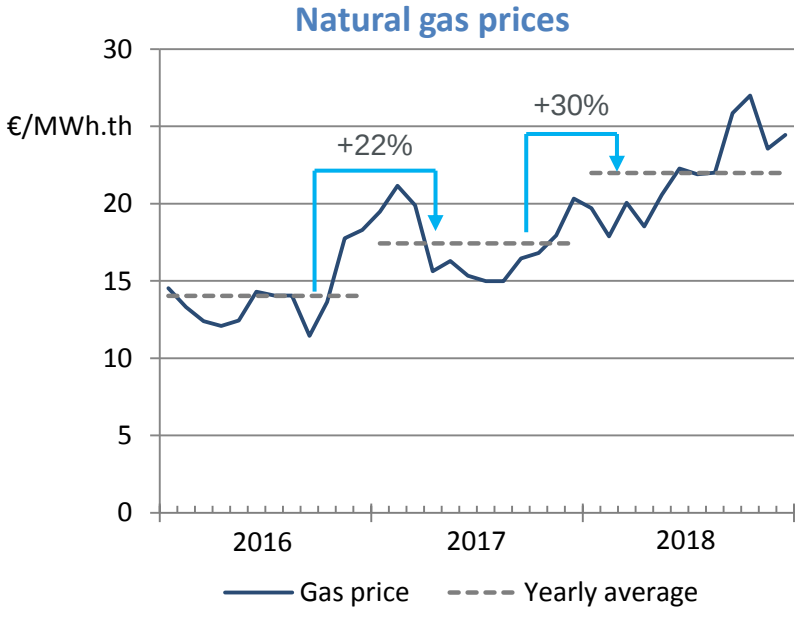
Especially in terms of amount of trades, the ID market is increasing. Most ID trades for delivery in evening peak.

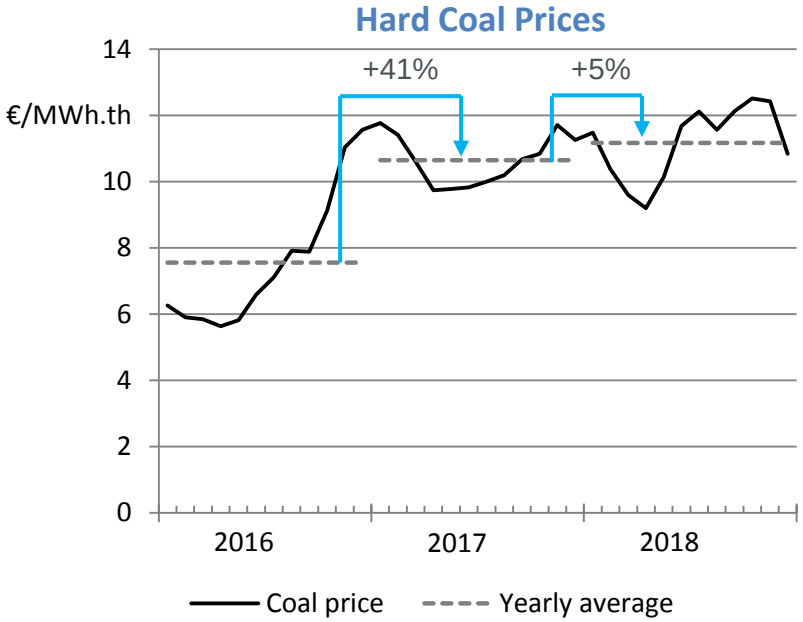


- This figure shows for the average amount of trades pre delivery hour of the day.
- In 2017 and 2018 there was a larger variability in the hours in which ID trades are made compared to 2016, probably because the amount of trades increased significantly, making the variability more clear.
- ID trades are peaking in the evening, related to increases in electricity consumption in the evening hours.
- Also a “night peak” around 5 am, probably due to ramp-up of generation units.

Fuel prices

Fuel prices have been increasing since 2016





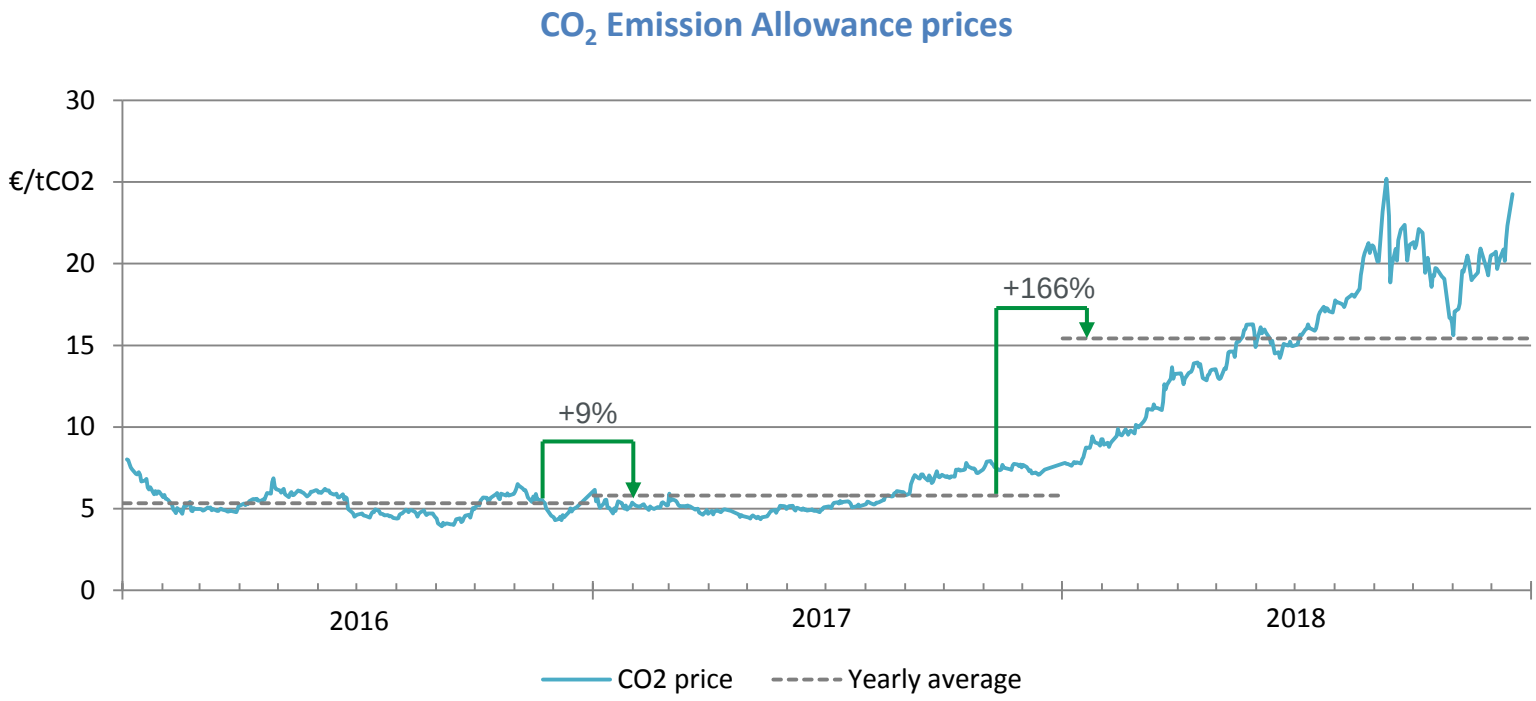
Gas prices are based on OTC natural gas prices at the Dutch virtual exchange Title Transfer Facility (TTF).

Coal prices are based on the over the counter API#2 price index.

- The average yearly gas price increased by 30% from 17.2 €/MWh$_{th}$ in 2017 to 22.3 €/MWh$_{th}$ in 2018. The increase was higher than from 2016 to 2017 (22%). Prices were volatile in spring 2018, caused by successive cold snaps leading to high gas demand, while stock levels were low as usual at the end of winter. Prices remained high during the rest of the year because of required injections to increase stocks levels.
- Hard coal price increased from by 5% from 10.7 €/MWh$_{th}$ in 2017 to 11.2 €/MWh$_{th}$ in 2018. The increase was much lower than the year before (41%), mainly due to the drop in prices in spring 2018. Despite low temperatures in Europe, high stock levels lead to little spot demand

Carbon prices

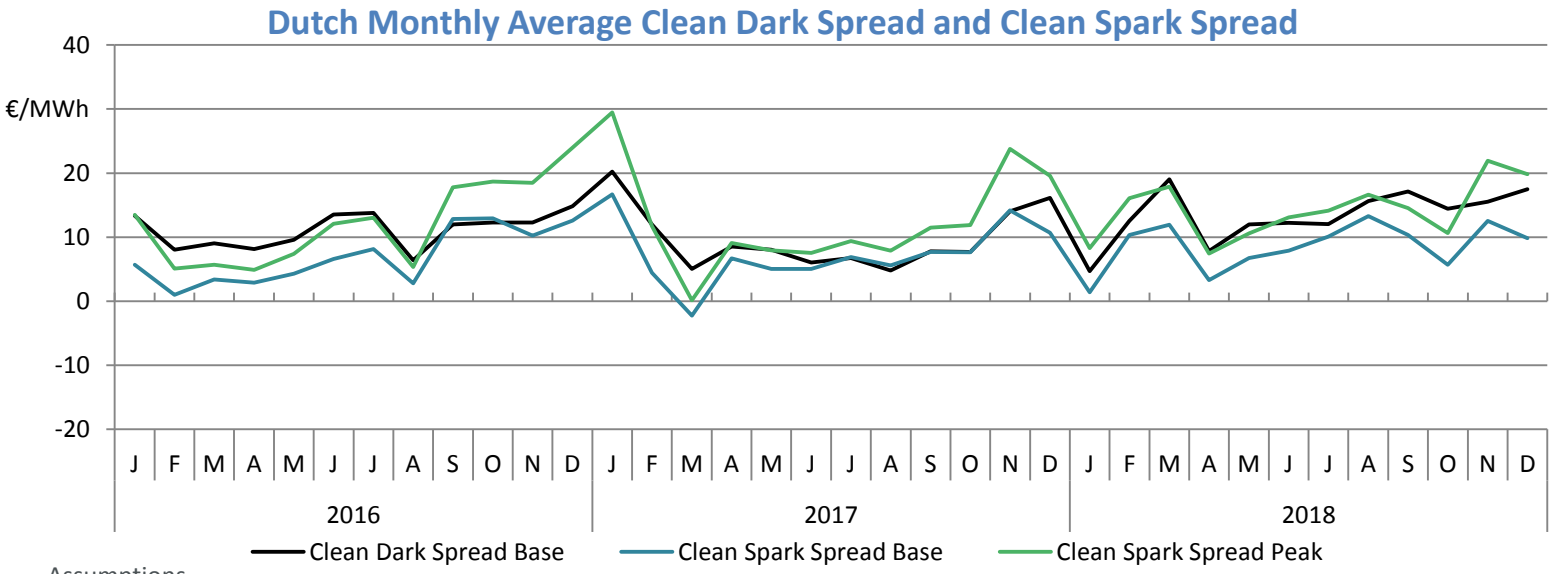
Carbon prices have increased sharply in 2018



- Prices of EU Emission allowances (EUA) reached a 10-year record of 25.2 €/tCO2 on September 10, 2018 and have remained relatively high ever since. The main reason for this development is a new phase in the EU Emission Trading Scheme: a Market Stability Reserve will come into force in January 2019 (see link for more information), which will lead to cuts in EUAs.
- The volatility in late Q3 and Q4 can be explained by speculation on EUA prices, fuelled by political uncertainty in the UK, statements on the coal phase out in Germany, and debate on carbon floor prices.

Generator margins in NL

Despite rising carbon prices, margins for NL coal plants improved. Overall healthy margins for NL generators.



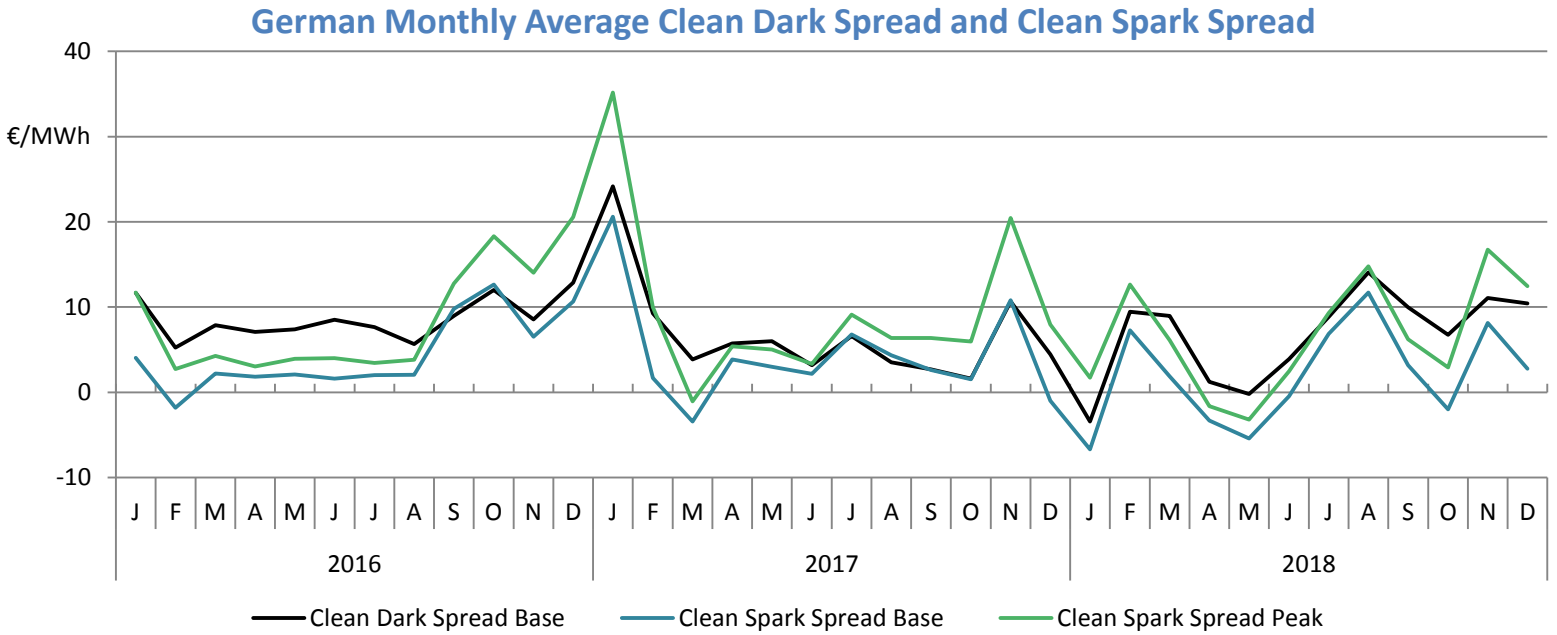
Assumptions.

Coal: efficiency 40%, emission factor 0.0917 tCO_2/GJth, heating value 25.1 MJ/kg; Gas: efficiency 55%, emission factor 0.0556 tCO_2/GJth,.

- In 2016 and 2017, gas generators for base- or peak load have had higher margins than coal generators in the Netherlands. This trend is less apparent in 2018.
- Despite rising carbon emission allowance prices hitting coal-fired generation harder than gas, coal margins improved in 2018. Electricity prices in the Netherlands are strongly influenced by gas fuel price developments, because gas-fired power plants most of the time set the electricity price in NL. These gas-fired power plants increased their bid prices in 2018 to compensate for higher fuel costs, which offset the cost increase for coal-fired power plants caused by carbon prices.

Generator margins in DE

Q2 2018: negative margins for German generators

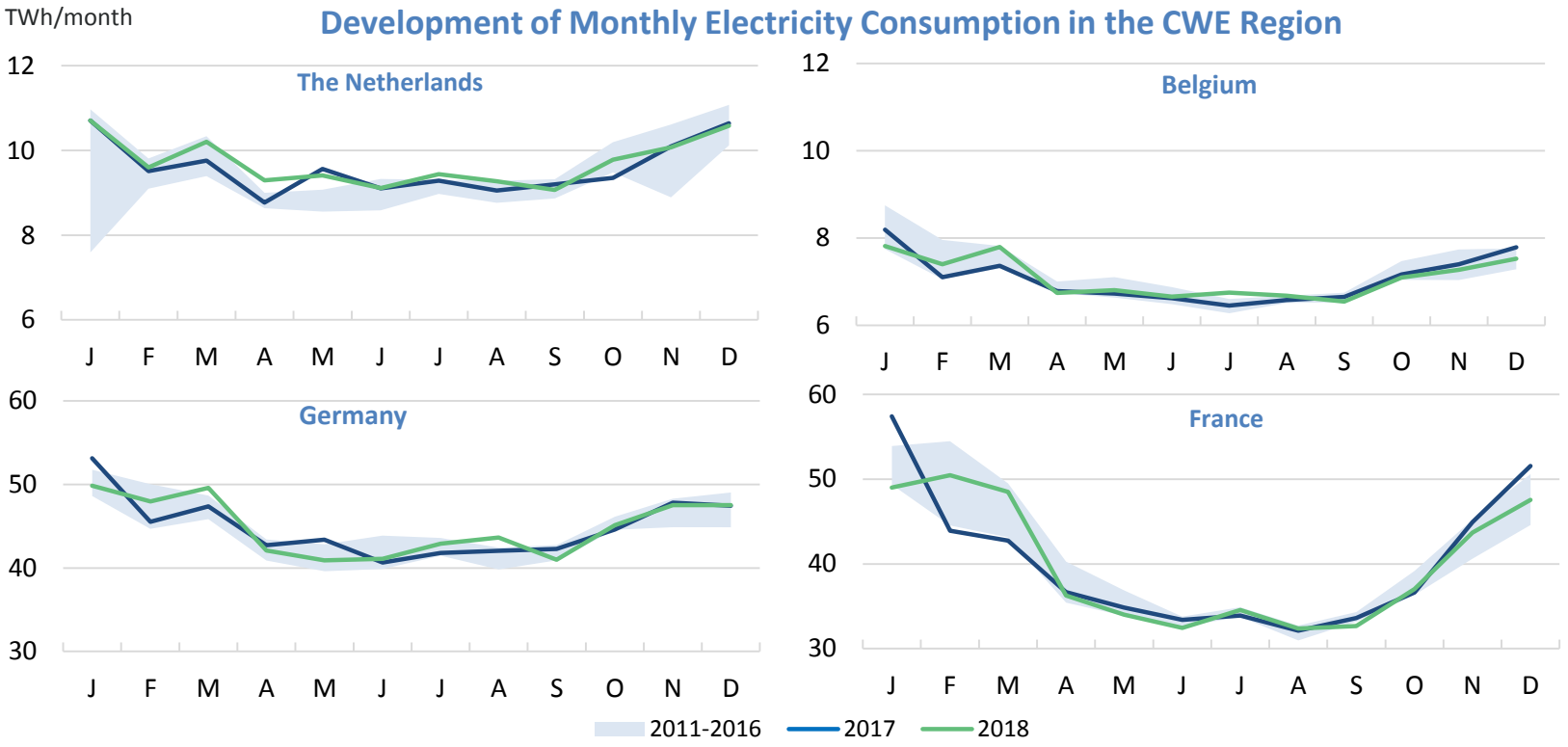


Assumptions.
Coal: efficiency 40%, emission factor 0.0917 tCO_2/GJth; heating value 25.1 MJ/kg; Gas: efficiency 55%, emission factor 0.0556 tCO_2/GJth.

- In Germany 2018 shows low margins both for coal and gas generators. Unlike the Netherlands, electricity generation in Germany is not gas-dominated, showing less spread between coal and gas generator margins.
- In the first half of 2018, bullish coal and carbon prices pushed generator margins for the least efficient plants to record lows, while the share of renewables continued to increase.
- In Q3 generator margins recovered due to higher prices caused by low summer wind and Belgian nuclear unavailability.

Consumption in CWE

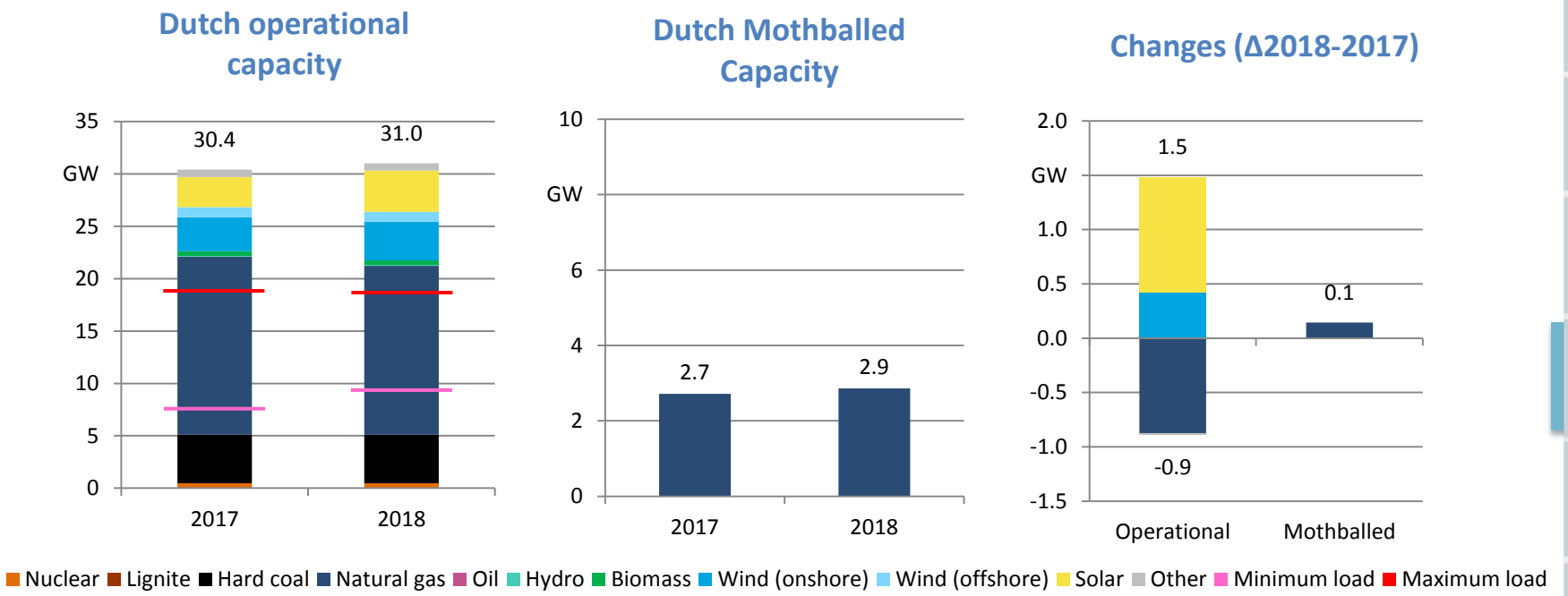
Average consumption in CWE, with a few exceptions



- Electricity consumption of most countries in 2017 and 2018 remains within the 2011-2016 average, with a few exceptions, e.g. the Netherlands in spring months.
- Electricity consumption of the Netherlands and Belgium in 2018 higher than in 2017.
- Electricity consumption of France is relatively high during cold periods and low in the summer, due to a large share of electric heating in heating demand.

Capacity in the Netherlands

Growth in renewable capacity mainly due to solar



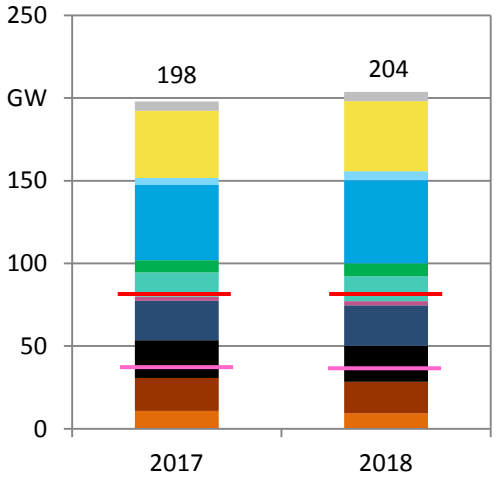
- Operational capacity increased by 1.5 GW, mainly due to added solar capacity (1.1 GW) and also due to added onshore wind capacity (0.4 GW).
- Operational capacity decreased by 0.9 GW, mainly due to the mothballing of Moerdijk 1 and a single unit of the Eemscentrale power plant. Still, the mothballed capacity increased only by 0.1 GW as the additions were largely offset by the definite closure of the Claus-Centrale A which was previously mothballed.

Source: TenneT NL, CBS, Nationale Energieverkenning, ENTSO-E Power Statistics

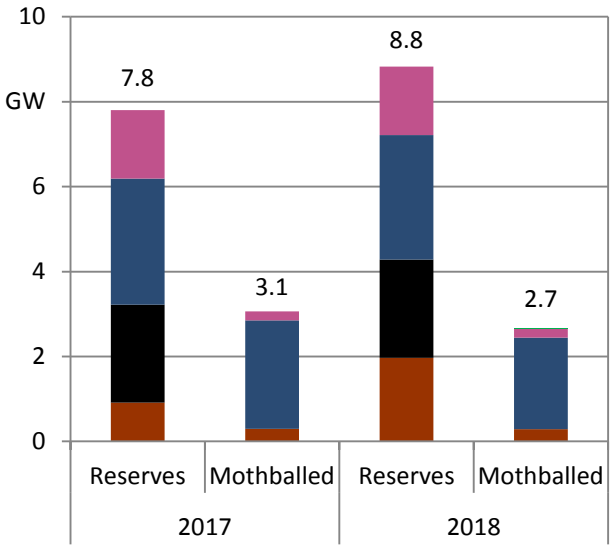
Capacity in Germany

Growth of renewable capacity mainly due to wind

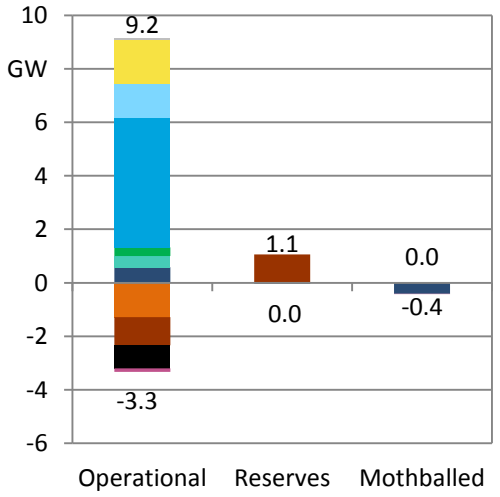
German operational capacity



German Reserve and Mothballed Capacity



Changes (Δ2018-2017)

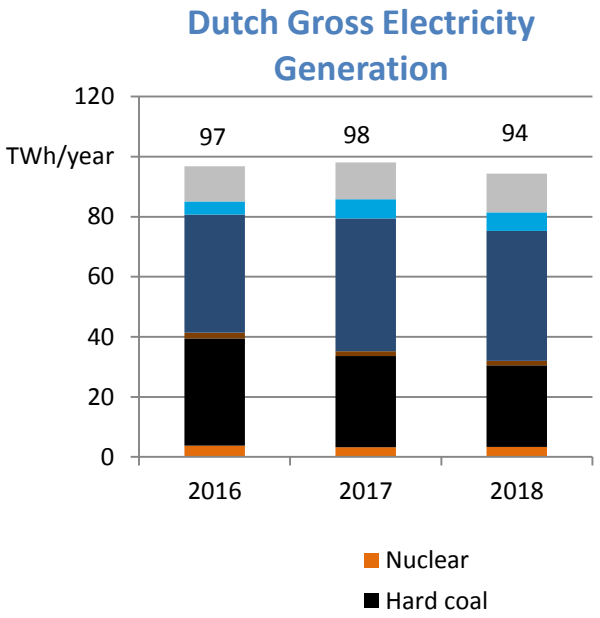


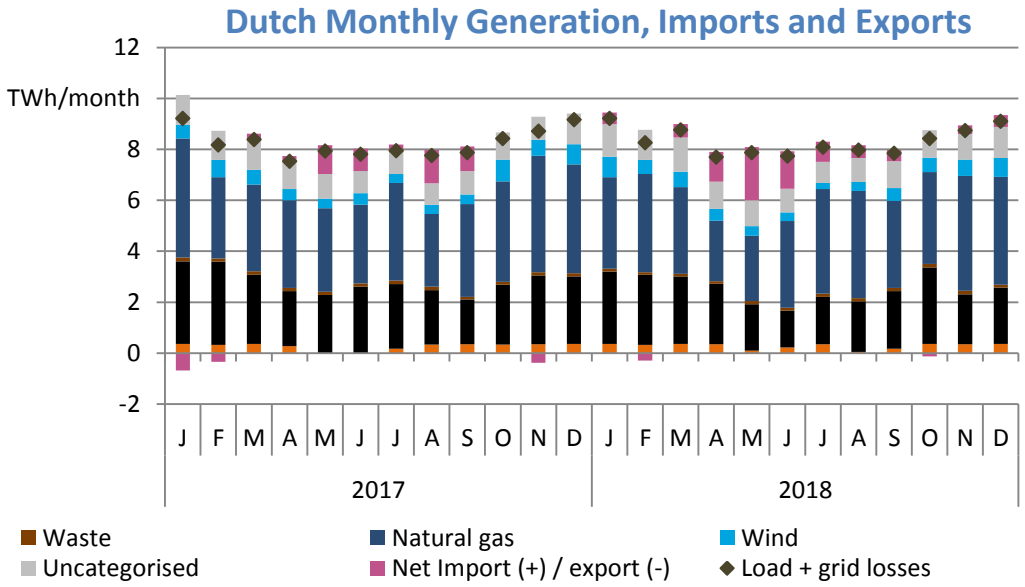
Nuclear | Lignite | Hard coal | Natural gas | Oil | Hydro | Biomass | Wind (onshore) | Wind (offshore) | Solar | Other | Minimum load | Maximum load

- As in previous years, German conventional capacity decreased. A total of 3.3 GW fossil capacity was phased out of the market, whereas 0.9 GW gas entered. Renewable capacity increased by more than 8 GW in 2018, mainly due to added on- and offshore wind capacity.
- Reserve capacity increased with 1 GW to a total of almost 9 GW, mostly hard coal and gas fired.
- Mothballed capacity decreased mainly due to the de-mothballing of the two 200 MW gas-fired Weisweiler units in Eschweiler-Weisweiler, Nordrhein-Westfalen.

Generation & trade in NL

Relatively little generation from coal in 2018



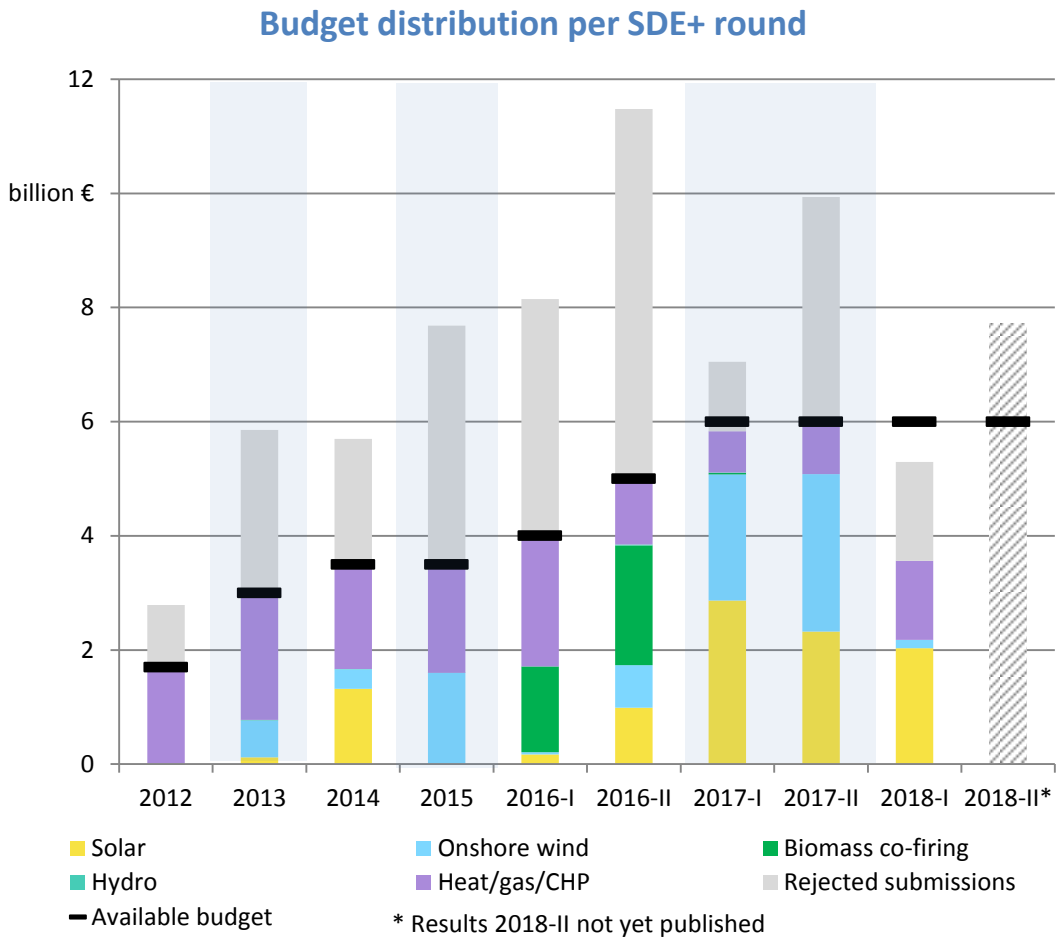


* Generation shown is electricity infeed measured on public grids: ¬82-85% of total NL generation. Uncategorised: units <10MW. Solar generation not available in measurements. Generation from biomass co-firing reported as hard coal due to data unavailability.

- Dutch gross electricity generation* decreased from 98.1 TWh in 2017 to 94.4 TWh in 2018, whereas yearly net import increased from 3.54 TWh in 2017 to 7.82 in 2018. This can be attributed to relatively higher day-ahead prices in the Netherlands in 2017 compared to Germany (see slide 5), which is main import country of the Netherlands (see slide 31/32).
- Record high imports in Q2 2018 due to maintenance (Borssele, Amer 9, Hemweg 8)
- Significant increase of coal fired generation in October due to significant price drop of coal in Q4. This increase is not sustained in Nov and Dec due to foreseen and unforeseen outages of coal fired capacity.

Budget distribution SDE+

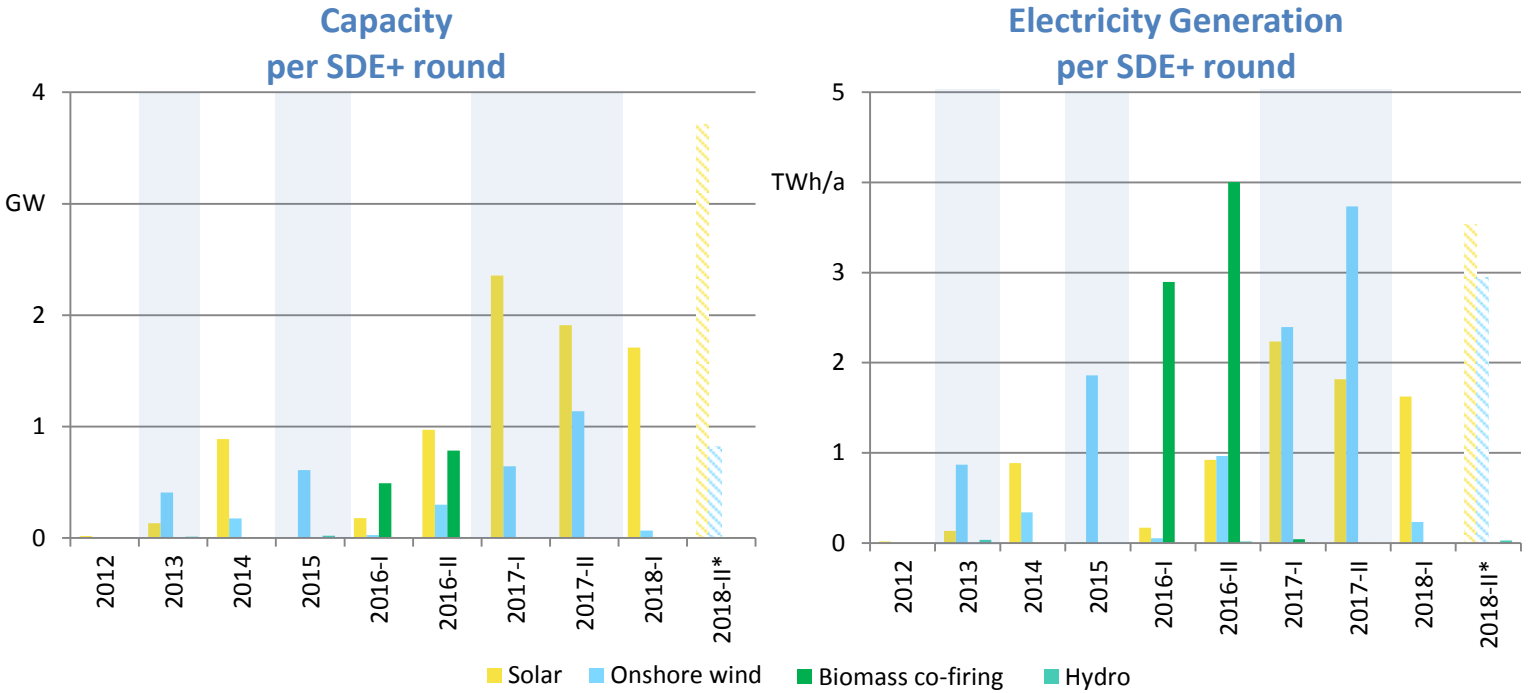
Total budget & share onshore wind in SDE+ decreased



- A total of €5.3 billion was submitted for the 2018 spring round (2018-I), undershooting the available budget (€6 billion) for the first time. The total allocated budget in the 2018-I round decreased to €3.6 billion, compared to €5.8 and €6.0 billion in 2017-I and 2017-II, respectively. Solar accounted for the largest share of allocated budget (€2.0 billion), followed by heat/gas/CHP (€1.4 billion).
- The share of onshore wind was remarkably low in the 2018-I round. However, a considerable share (budget of €2 million) has applied for the 2018-II round*.
- For offshore wind, there was only a small tender in 2018: the innovation parcel Borssele V (19 MW).

Capacity & generation SDE+

SDE+ of ’17 and ’18 will lead to GWs of solar capacity

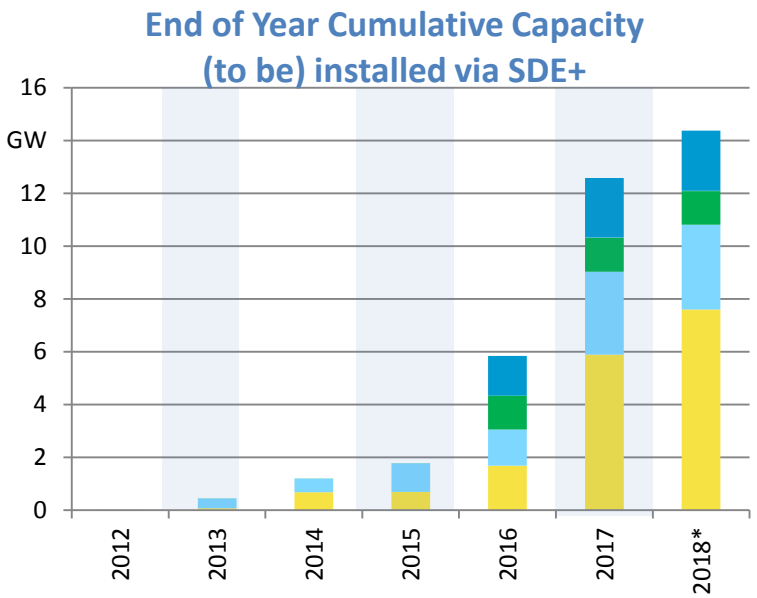


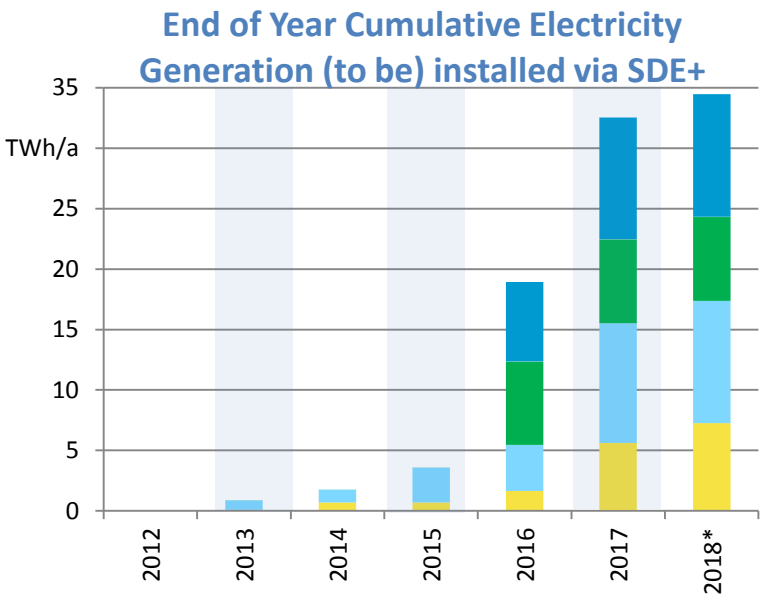
* For 2018-II results are not yet published. Therefore, submitted capacity and generation is shown. These values will become lower when results are published, due to rejected projects.

- In each round except 2015, the SDE+ budget allocation resulted in a majority of solar capacity.
- A clear discrepancy is seen between awarded capacity and awarded electricity generation per SDE+ round. Even though the majority of capacity was awarded to solar in recent years, electricity generation from wind or biomass co-firing is higher. This can be attributed to the higher load factor of these technologies.

Cumulative capacity/generation

Over 14 GW renewable electricity capacity is (projected to be) installed under SDE+ subsidy scheme





* Results 2018-II not included because they are not yet published

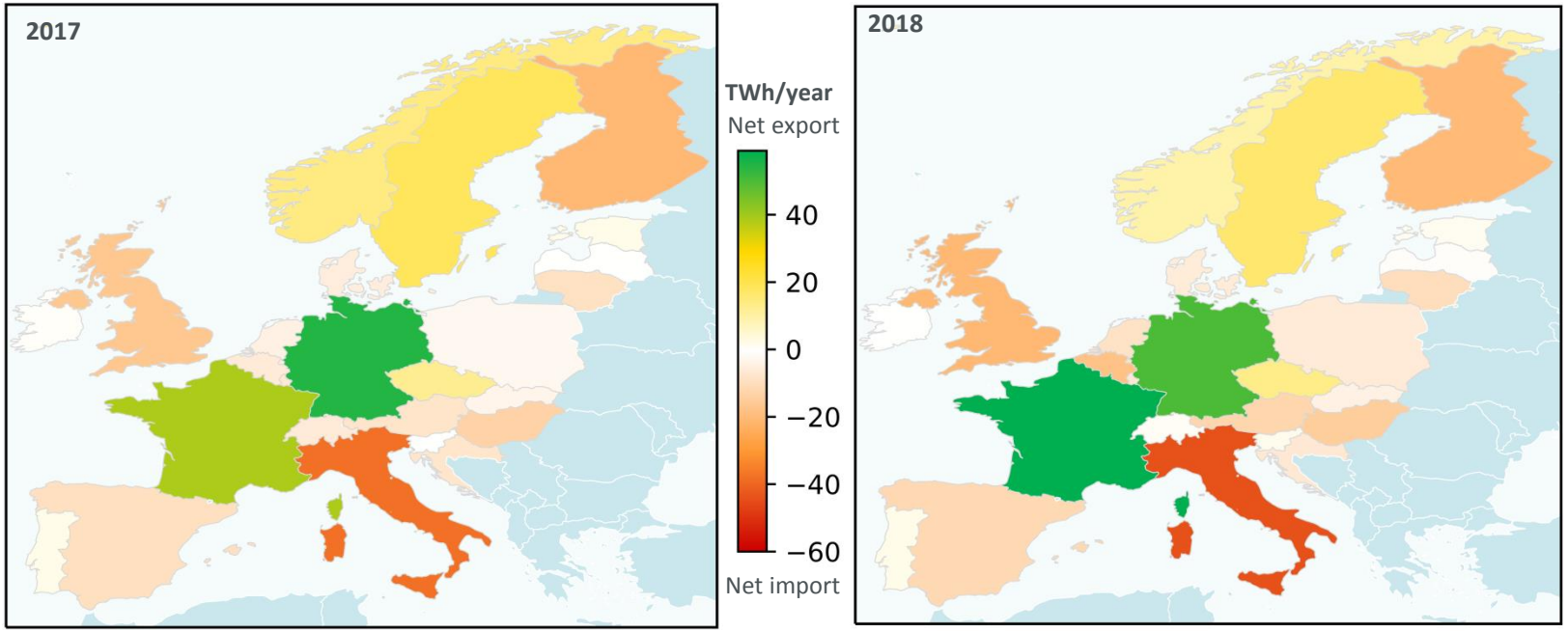
Solar | Onshore wind | Biomass co-firing | Hydro | Offshore wind

- After 6.5 years of SDE+ subsidy schemes, over 14 GW of awarded capacity renewable solar, onshore wind, hydro, biomass co-firing is in operation or is planned to be installed.
- This capacity is good for a yearly electricity generation of almost 35 TWh. With an annual consumption of 117 TWh in 2018, renewable generation resulting from SDE+ subsidies would correspond to 30% of total annual consumption. The increasing trend of awarded electricity generation slowed in 2018 due to the large share of awarded solar capacity in the 2018-I round, and the fact that the results for the 2018-II are not yet published.

Aggregated exchange EU

Minor changes in net export positions in 2018

Yearly Aggregated Physical Import and Export Volumes



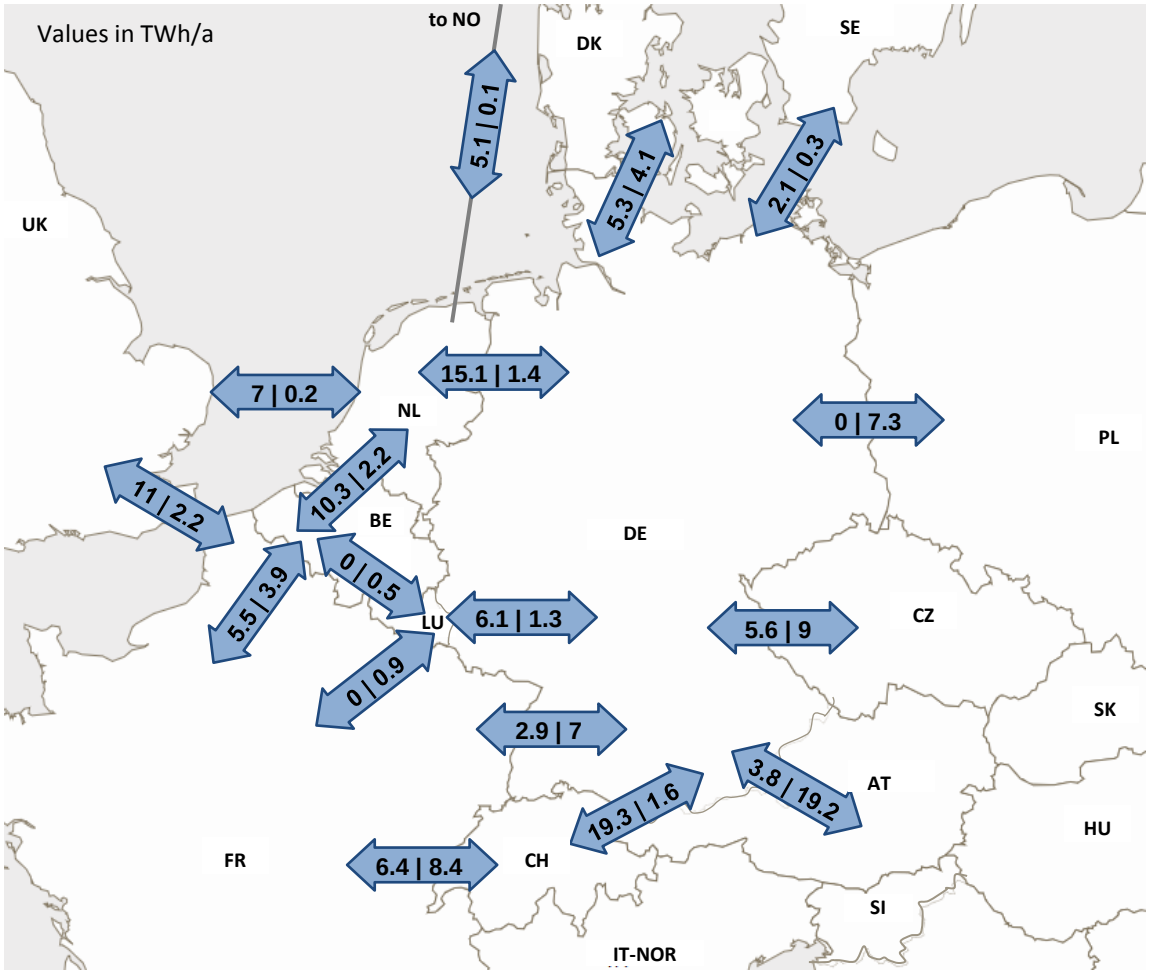
- The Netherlands is a net importing country. Net import increased from 3.8 TWh in 2017 to 8.2 TWh in 2018 (+118%). Germany is a net exporting country due to large capacity of wind and coal (low marginal costs). Net exports decreased from 55.4 TWh to 51.1 TWh (-8%). Germany and France are the largest exporting countries within the EU.
- In 2018: France overtook Germany as largest exporting country. Switzerland changed from net importing to net exporting country. Lower export positions are seen for Norway and Sweden due to the summer drought and low hydro stocks.

Source: ENTSO-E Power Statistics. See annex for volumes per country

Cross-border flows 2017

Most Dutch imports are from DE and exports to BE

Physical cross-border flows in CWE region in 2017

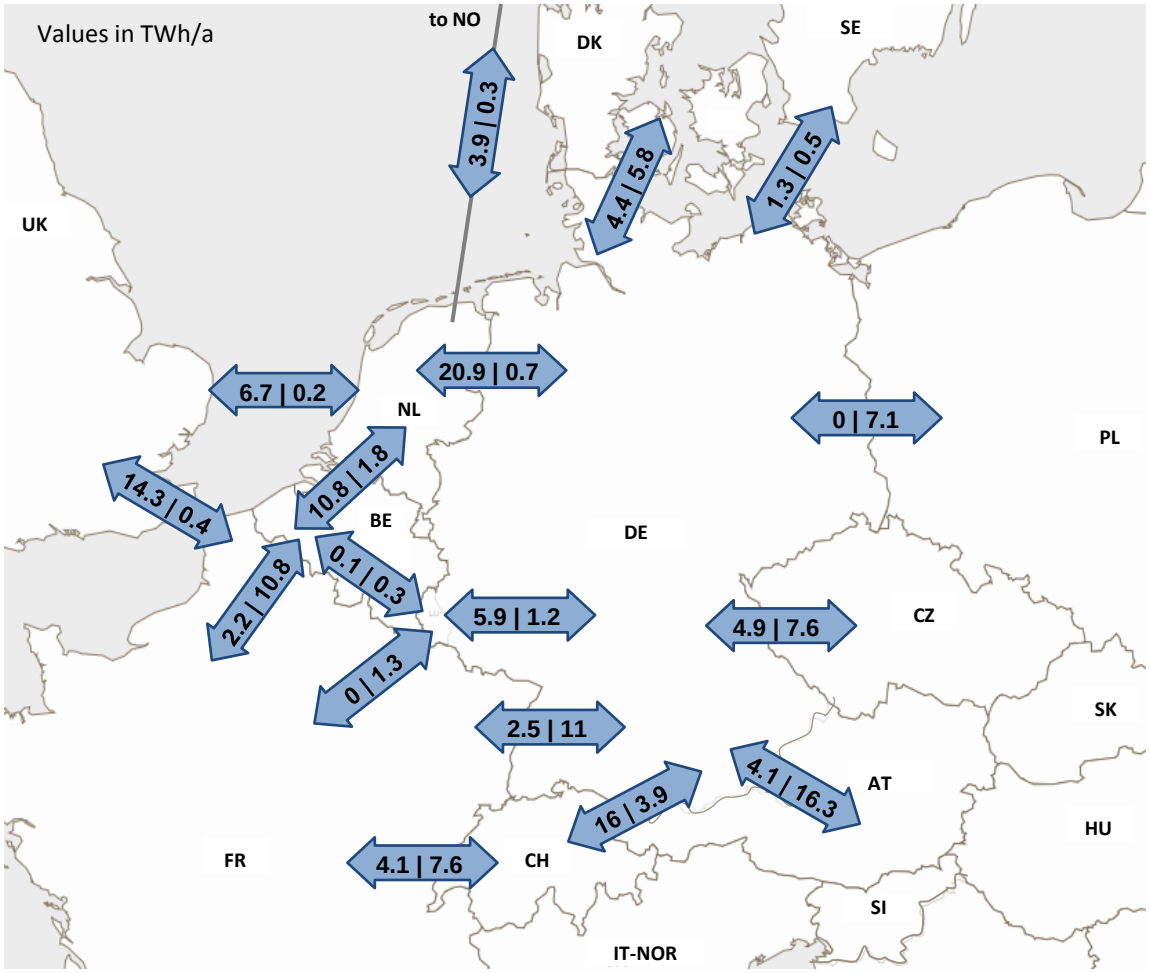


- The Netherlands receives most of its imports from Germany (15.1 TWh). This is complemented by imports from Norway via NorNed (5.1 TWh) and Belgium (2.2 TWh). The majority of exports is going to Belgium (10.3 TWh), followed by the UK (7 TWh).
- Germany's main exports are to Switzerland (19.3 TWh), Austria (19.2 TWh) and the Netherlands (15.1 TWh). Total imports are much lower as Germany is a net exporting country, but are mostly received from France (7 TWh), the Czech Republic (5.6 TWh) and Denmark (5.3 TWh).
- Note that this figure shows physical flows between countries, which are different from scheduled commercial exchanges between bidding zones.

Cross-border flows 2018

Belgian capacity shortage resolved by French imports

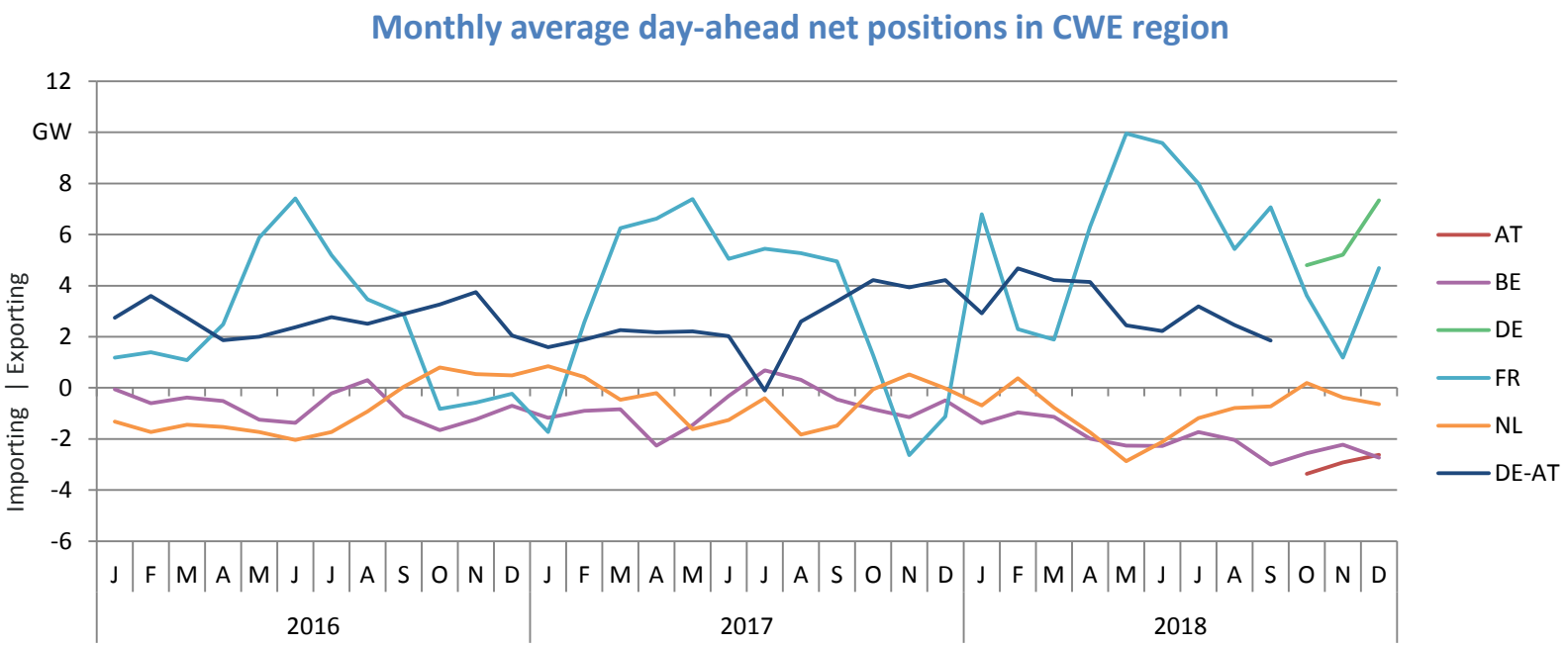
Physical cross-border flows in CWE region in 2018



- The unavailability of nuclear plants in Belgium in the second half of 2018 was resolved with an increased amount of imports from France.
- In 2018, exports from the Netherlands stayed relatively the same compared to 2017. Imports from Germany increased significantly, partly due to the new interconnector Doetinchem – Wesel that came into operation in the second half of 2018.
- Imports from Norway decreased, due to a lower availability of the NorNed interconnector.
- German exports to Austria, the Czech Republic and Switzerland decreased.
  - For Austria, due to the split of bidding zone DE-AT into DE and AT.
  - For the Czech Republic and Switzerland, because of more often higher prices in Germany (see slides 33-34).

Net positions CWE

New AT bidding zone has taken a net import position

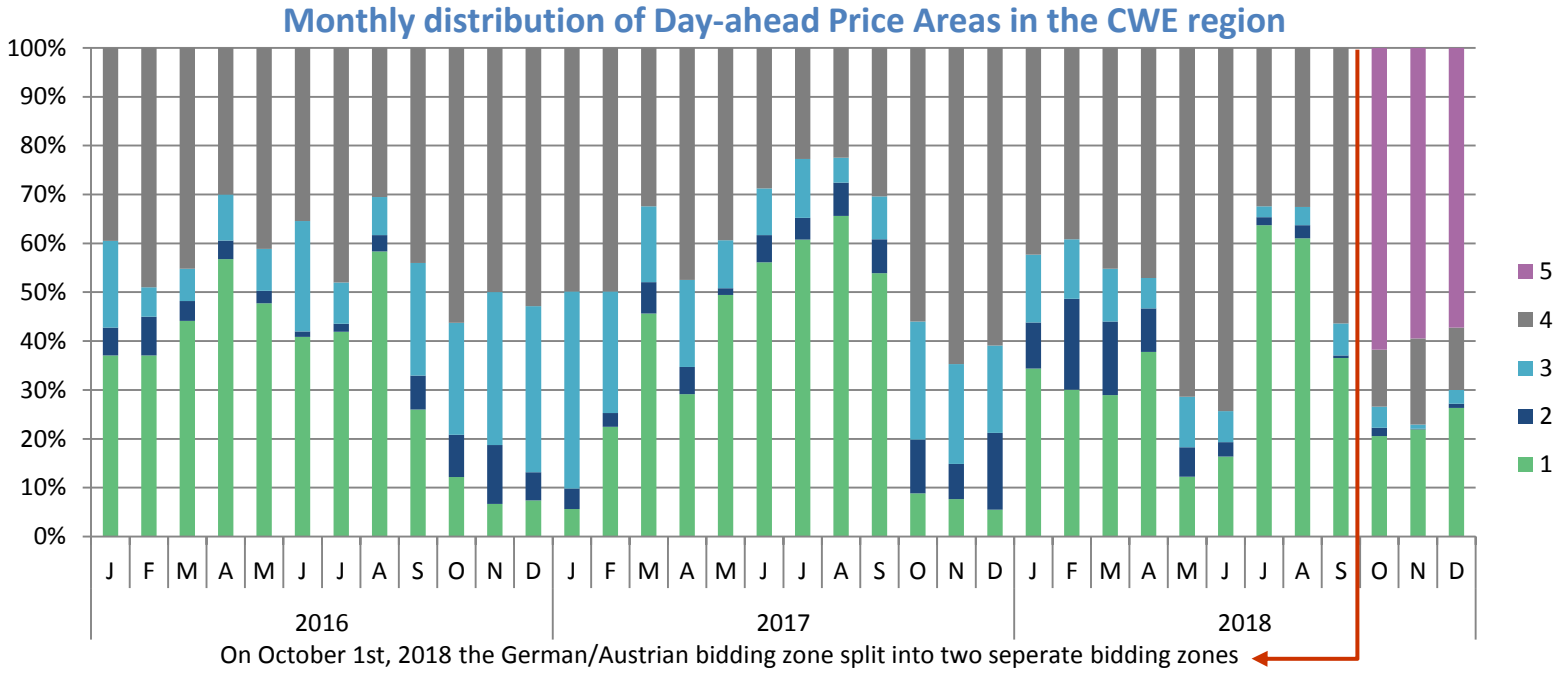


* Net positions represent the commercial net positions after the closure of the day-ahead market

- Since the split of bidding zone DE-AT into DE and AT, internal DE-AT trades are now part of cross-border trade. The split positioned AT as a net importer. The export position of DE increased by the split.
- More import of NL in 2018 (see slide 33-34) mainly due to high imports late spring/early summer (May-July).
- FR exports mostly in summer, and not in winter when indigenous production is necessary to cover the (largely electric) domestic heat demand.

Price areas in CWE

Full price convergence low in Q2 and, when compared to 2017, high in Q4

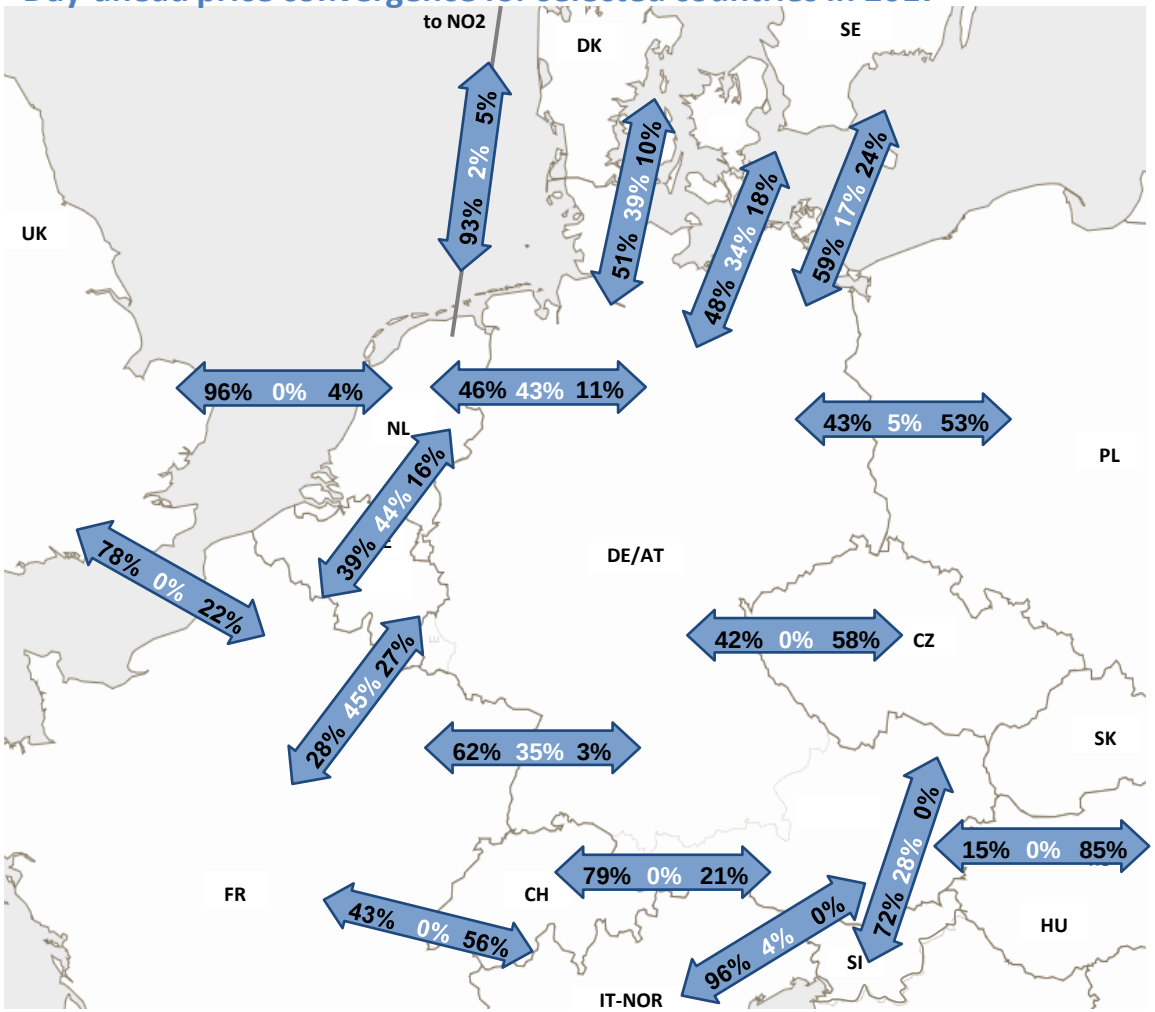


- The figure shows the time distribution of the number of day-ahead price areas in the CWE bidding zones. When there is one price area, full price convergence occurs (all bidding zones have the same price).
- There was full price convergence (1 price area) for 33% of the time in 2018, a small decrease compared to the 34% in 2017. Full price convergence was relatively low in Q2 of 2018 compared to previous years. Contrarily full price convergence was relatively high in 2018 Q4, possibly due to introduction of the minimum Remaining Available Margin (minRAM) mechanism in CWE Flow-Based Market Coupling on 26/4/2018.

DA price convergence 2017

2017: High convergence CWE & DE-DK

Day-ahead price convergence for selected countries in 2017



- Relatively high convergence for CWE countries and DE-DK. Lower convergence between CWE and other countries.
- Centrally located countries that are included in DA market coupling have higher price convergence with each other.
- For some bidding zone borders there is inherently zero or low price convergence as:
  - Grid losses are implicitly included in market coupling (e.g. NL-GB, NL-NO2)
  - For explicit coupled borders, the capacity auction price needs to be added to the DA prices (DE-PL, DE-CZ, AT-CZ, AT-HU, all CH borders).

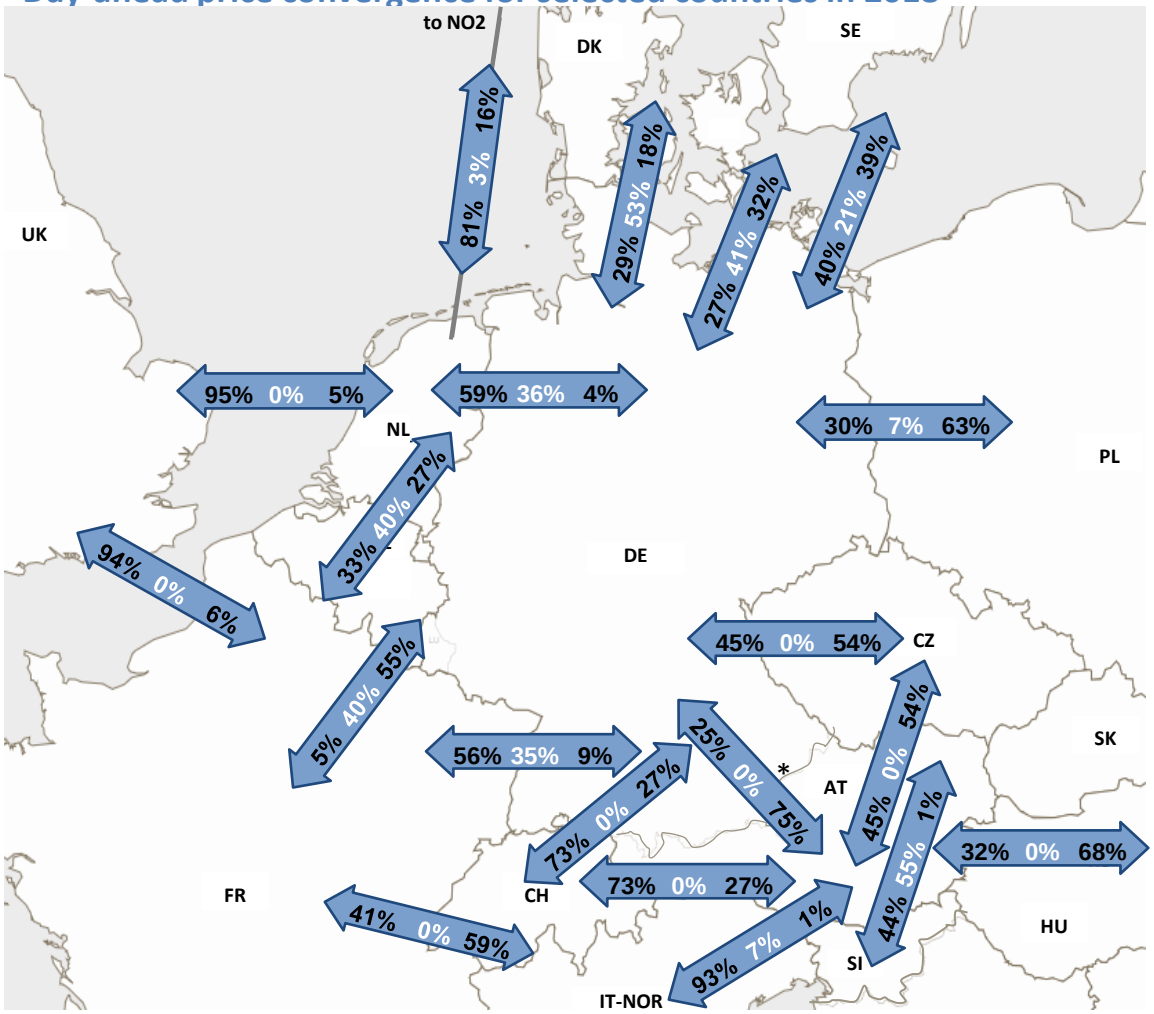
Notes for figure:

- DA price convergence in white, black numbers show how often the DA price was higher in that country.
- Percentages do not always count up to 100% due to rounding

DA price convergence 2018

2018: decreased DA price convergence on CWE borders

Day-ahead price convergence for selected countries in 2018



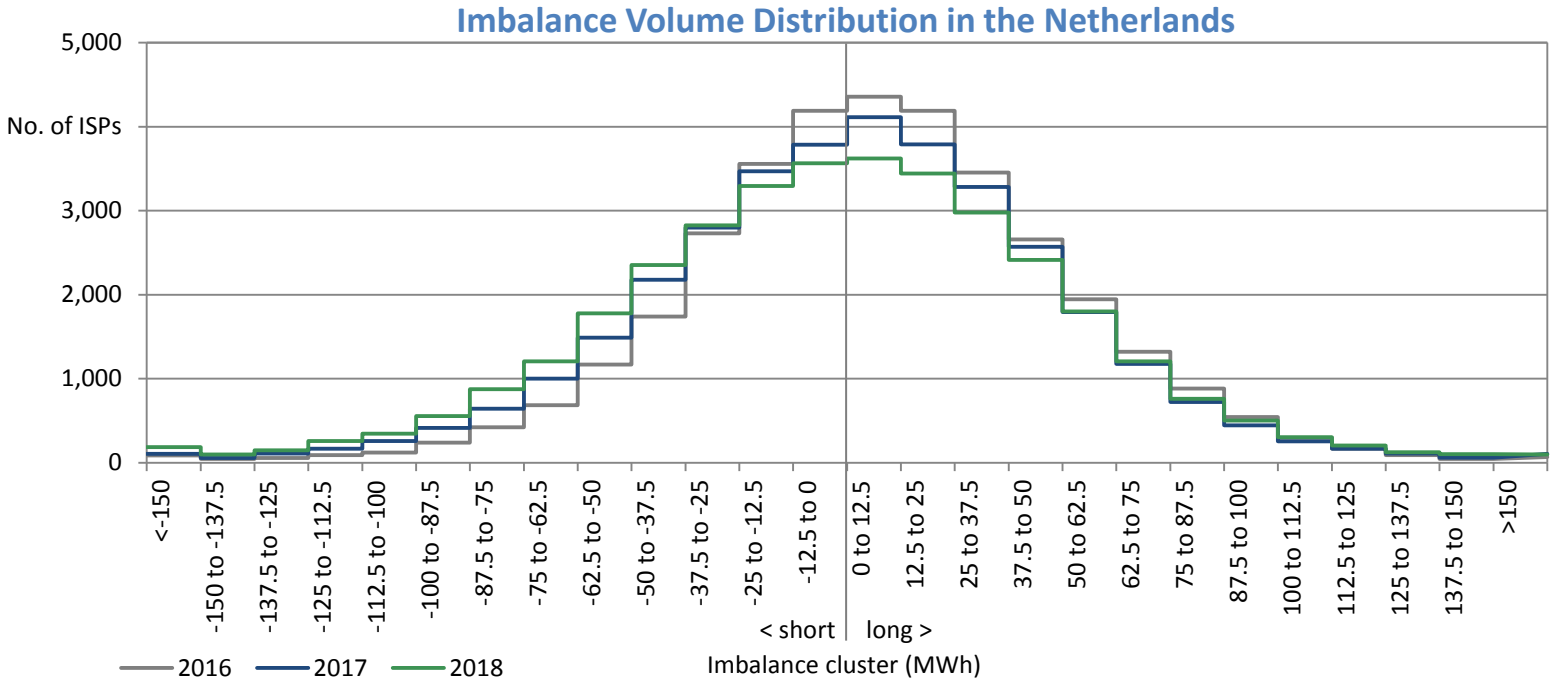
- 2018: convergence decreased on most CWE borders.
- BE prices more often higher than FR (+28 %pp), but more often lower than NL (-6 %pp). FR prices were relatively lower in 2018 than in 2017, resulting to more BE imports from FR. Same effect seen at GB-FR border: more often higher prices in GB (+14 %pp).
- Big increase in AT-SI convergence, due to AT having higher prices after DE-AT bidding zone split.

Notes for figure:

- DA price convergence in white, black numbers show how often the DA price was higher in that country.
- Percentages do not always count up to 100% due to rounding
- * Values for DE-AT border based on October – December (after split).

Net imbalance volumes NL

Trend of larger imbalance volumes continues

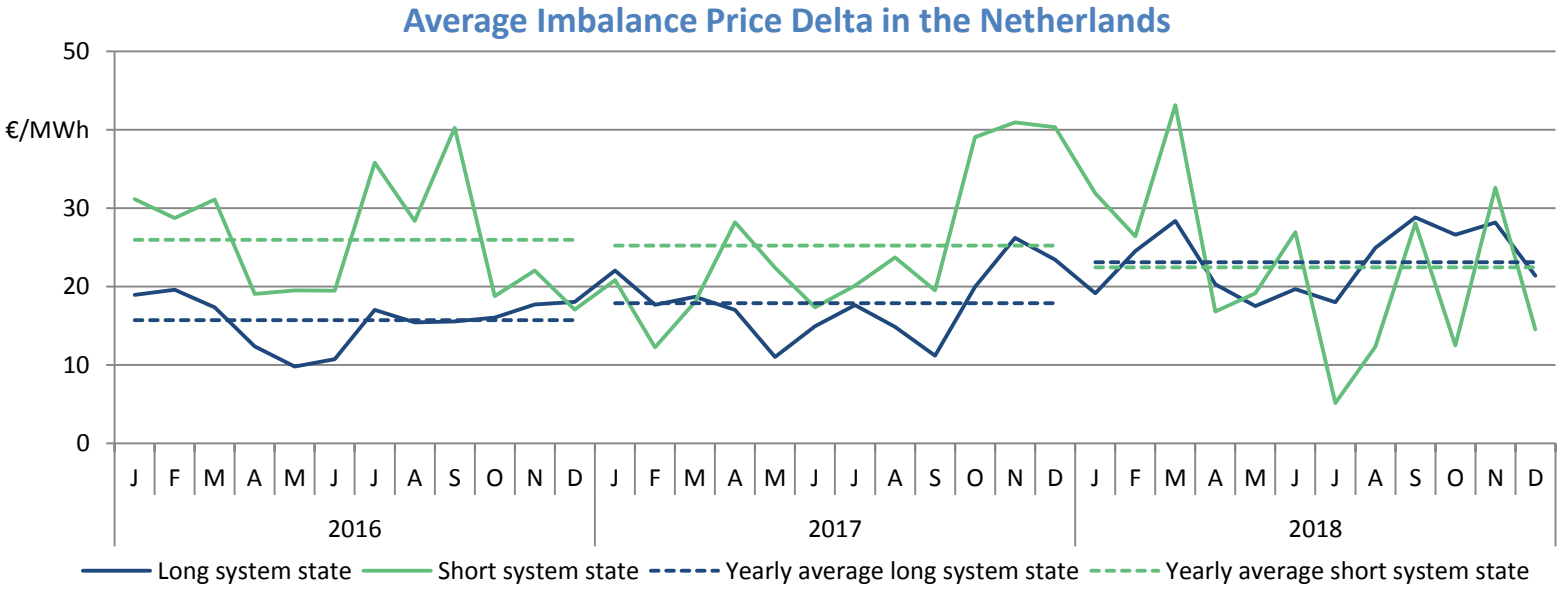


ISPs with dual pricing not included (respectively 7.0%, 7.8% and 6.8% of total ISPs in 2016, 2017 and 2018).

- This figure shows the total number of ISPs per year in which the net imbalance volume fell within a certain cluster of net imbalance volumes.
- Since 2013, a continuing trend is seen: a decreasing number of ISPs with low net imbalance volumes and an increasing number of ISPs with high net imbalance volumes.
- In previous years the graph skewed to the right, meaning that market participants tended to oversupply the system. In 2018, the graph is less skewed and more normally distributed.

Imbalance price delta NL

Yearly average imbalance price delta of short and long system states almost equal in 2018

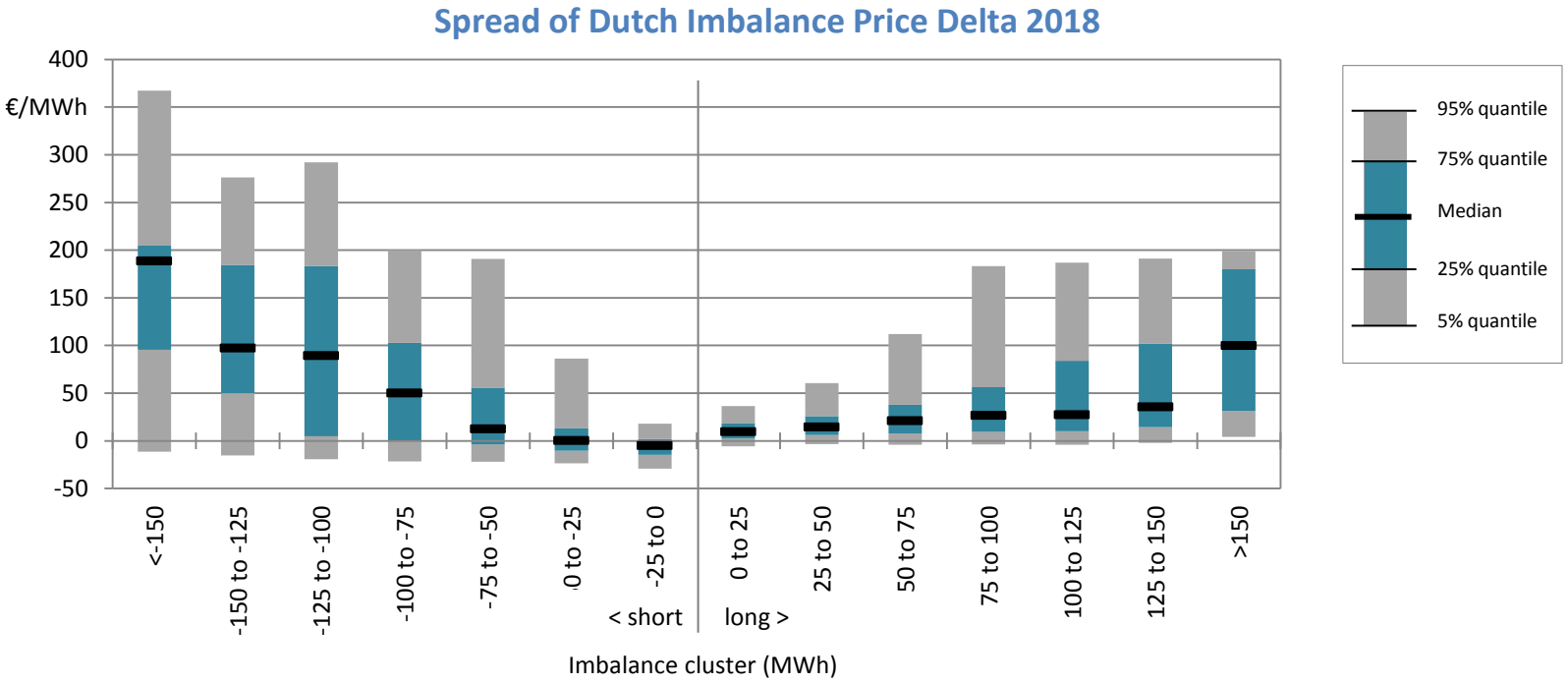


Note: ISPs with dual pricing not included (respectively 7.0%, 7.8% and 6.8% of total ISPs in 2016, 2017 and 2018). The imbalance price delta is calculated differently for a short systems state (imbalance price – DA price) and long system state (DA price – imbalance price), as both systems require different incentives to stay balanced.

- In previous years the average imbalance price delta of a short system state (imbalance shortage) was significantly higher than of a long system state (imbalance surplus). In 2018, the two are almost equal.
- The converging of prices of short and long system states relates to the results from the previous slide, in which 2018 showed a more symmetrical distribution of short and long system state imbalance volumes. Apparently, the incentives to stay balanced in long and short system states have become more equal in 2018.

Imbalance price delta spreads

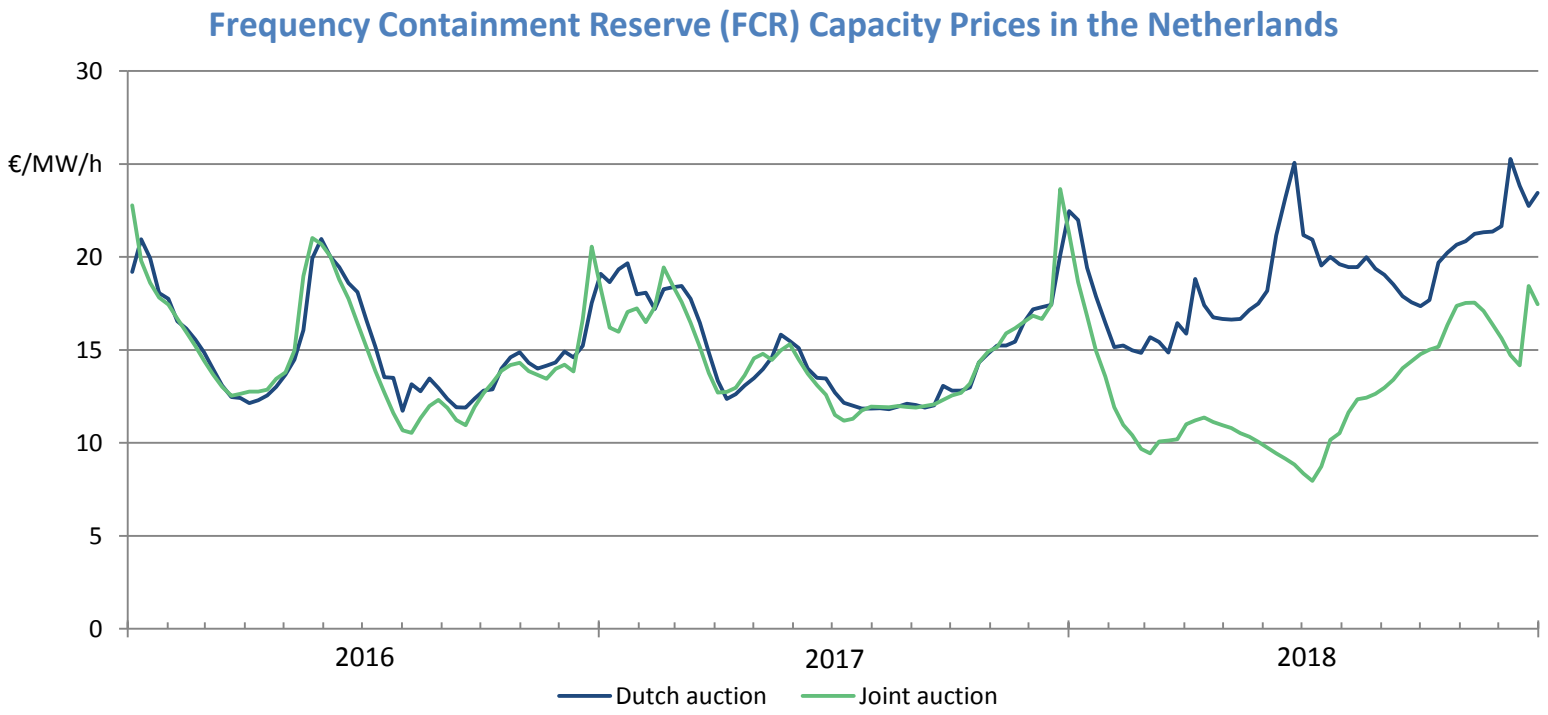
Higher prices at higher imbalance volume clusters



- The figure shows the spread or variability in imbalance price delta for certain imbalance clusters.
- The spread is higher at larger imbalance volume clusters, which corresponds to the principle that the incentive to stay balanced or to help restore the system is larger with larger system imbalance volumes.
- As was the case last year (see TMR 2017), the imbalance price spread includes negative values in most imbalance clusters. This can be attributed to the depressing price effect of IGCC (cooperation between TSOs to exchange imbalance volumes in opposite directions).

FCR prices in the Netherlands

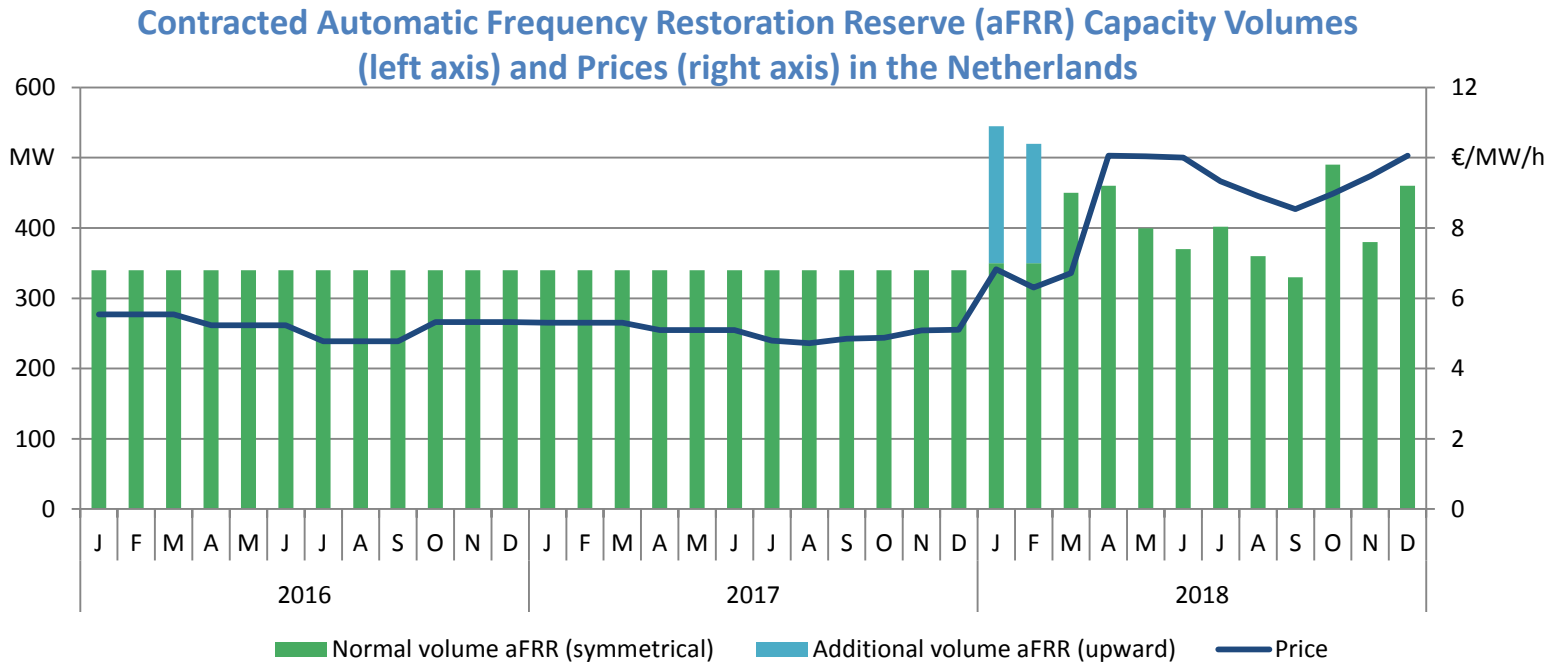
Larger differences between the Dutch and joint auctions



- Whereas in previous years the prices of the Dutch FCR auction and the joint auction are close together, the prices are diverging in 2018 with higher prices in the Dutch auction.
- Per January 2018 a higher amount of mFRRda capacity is procured in the Netherlands (see slide 39). This likely increased the value for capacity products for ancillary services in general, lifting the FCR prices in the Dutch auction above the FCR prices in the joint auction.

aFRR in the Netherlands

Higher prices for aFRR in 2018



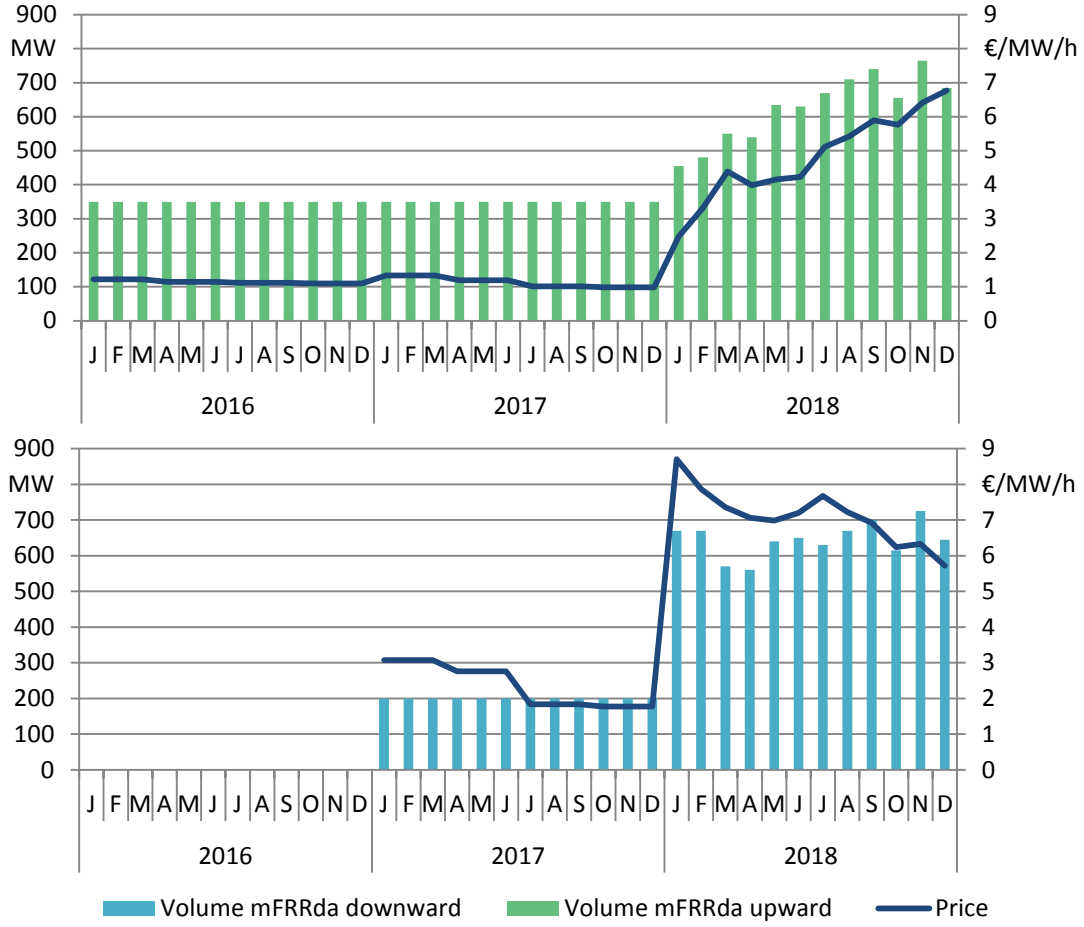
* The price (€/MW/h) for normal aFRR (symmetrical) is divided by two to enable comparison with additional aFRR (upward)

- Since 2018, a fixed amount of capacity for aFRR and mFRRda (see next slide) combined is contracted, instead of fixed amounts for aFRR and mFRRda products separately. Therefore, 2018 shows more variation in aFRR volumes. In January and February 2018, a shortage of offered upward FRR capacity led to the organisation of an additional tender. Both aFRR and mFRRda were allowed in this tender, and aFRR turned out to be the most economically attractive option.
- aFRR prices were relatively high in 2018, mostly due to a tighter balancing market caused by increased amounts of contracted mFRRda (see next slide).

mFRRda in the Netherlands

Higher prices for mFRRda in 2018

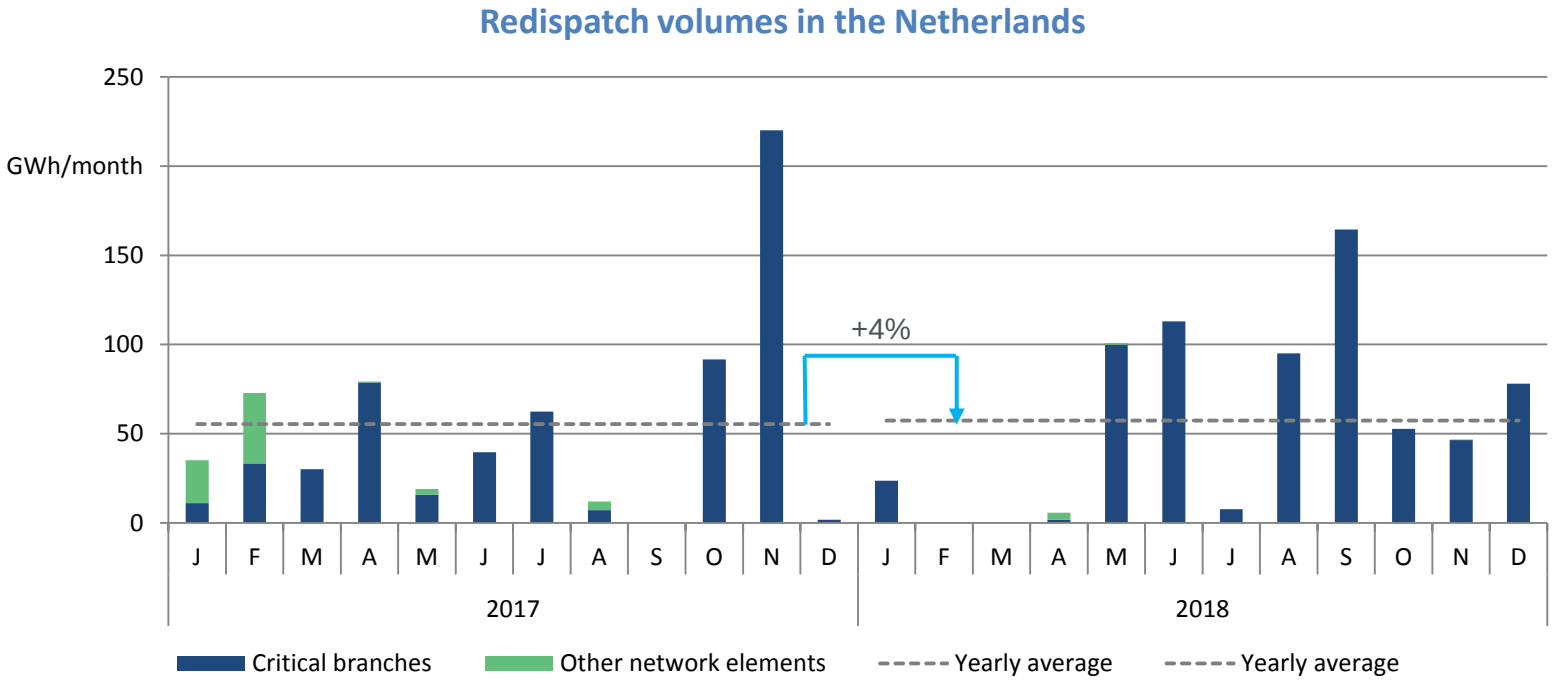
Manual Frequency Restoration Reserve directly activated (mFRRda) Capacity Volumes (left axis) and Prices (right axis) in the Netherlands



- For the balancing product mFRRda, upward and downward capacity is contracted separately.
- The increase in contracted mFRRda volumes is a direct result from new requirements in the EU Electricity Balancing Guideline that came into force in 2018.
- In 2016, downward mFRRda was not yet contracted in the Netherlands. In anticipation of the EU Electricity Balancing Guideline, TenneT started contracting downward mFRRda in 2017.
- The higher amounts of contracted volume has led to a tighter market in 2018, and to increased prices for all balancing products.

Redispatch volumes NL

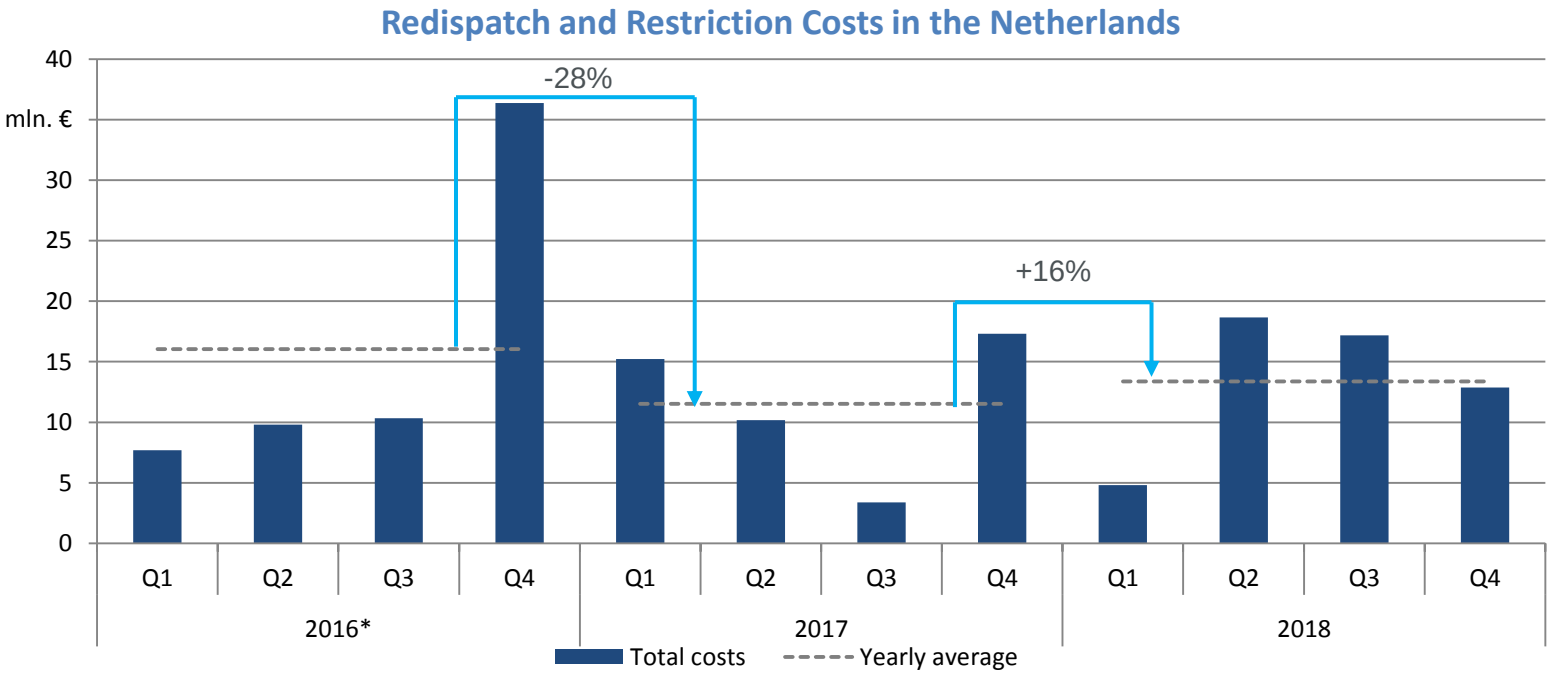
Redispatch mostly required on critical branches



- Critical branches are lines that are included in CWE flow-based market coupling, as they significantly impact and are impacted by CWE cross-border exchanges. Redispatch takes place to ensure that grid operation remains within operational security limits.
- An increase in redispatch application is seen following the implementation of a 20% minimum remaining available margin (minRAM) in the CWE Flow-Based Market Coupling methodology on 26/4/2018.
- Average redispatch volumes increased slightly in the Netherlands from 55.3 GWh/month in 2017 to 57.4 GWh/month in 2018 (+4%)

Redispatch costs NL

Costs for congestion management up in 2018

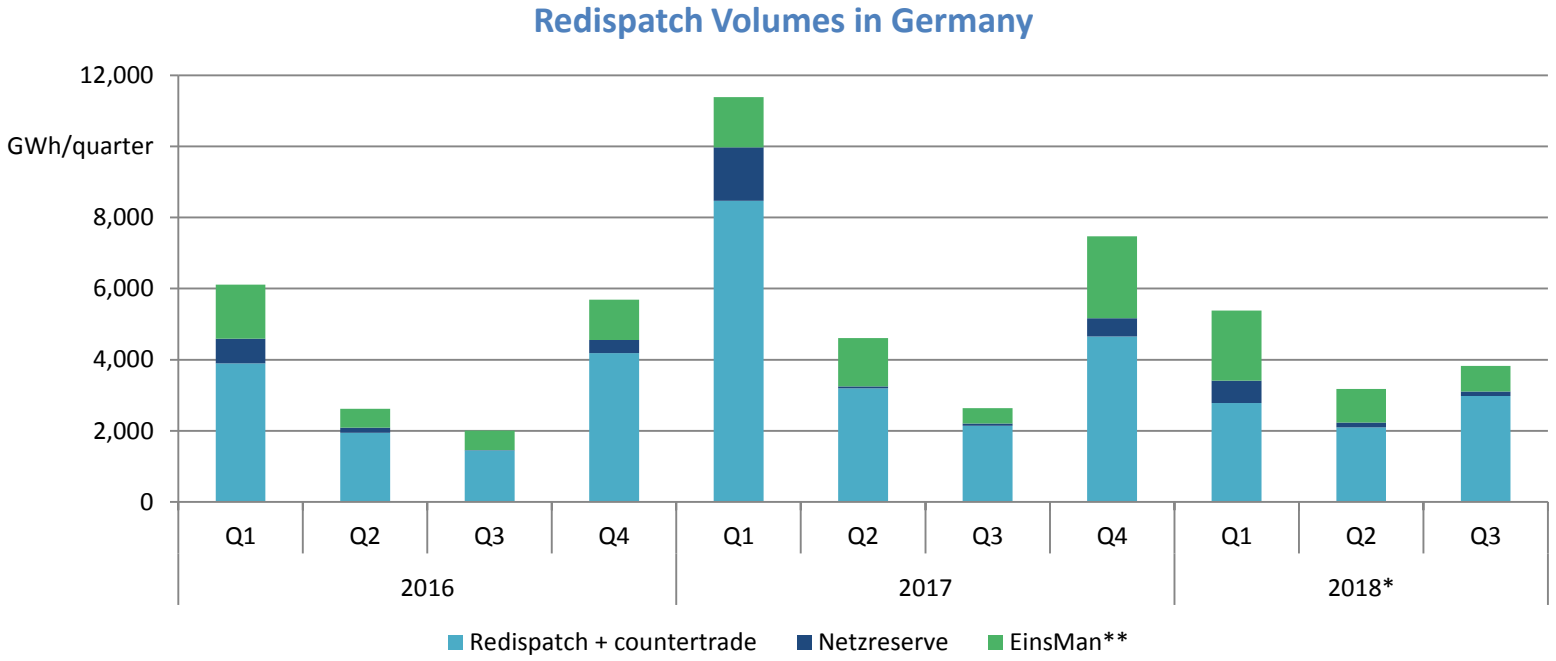


* For 2016, the distinction between redispatch and restriction costs was not available, and costs for 2016 are thus reported as total costs.

- This figure shows redispatch and restriction costs in the Netherlands. Restriction concerns contracts with market parties to withhold a share of production for a certain period. Total costs increased from €46.1 million in 2017 to €53.3 million in 2018. Costs were significantly high in Q4 2016, mainly induced by high electricity generation volumes in the Netherlands and congestion issues in the Eemshaven, where almost all plants were generating electricity to enable exports to Belgium and France. This has been largely resolved by a temporarily line between substations Eemshaven and Eemshaven Oudeschip. After a reduction of average costs in 2017 over 2016 (-28%), costs rose again in 2018 by 16%.

Redispatch volumes DE

Congestion in the German grid mostly solved by conventional redispatch + countertrade

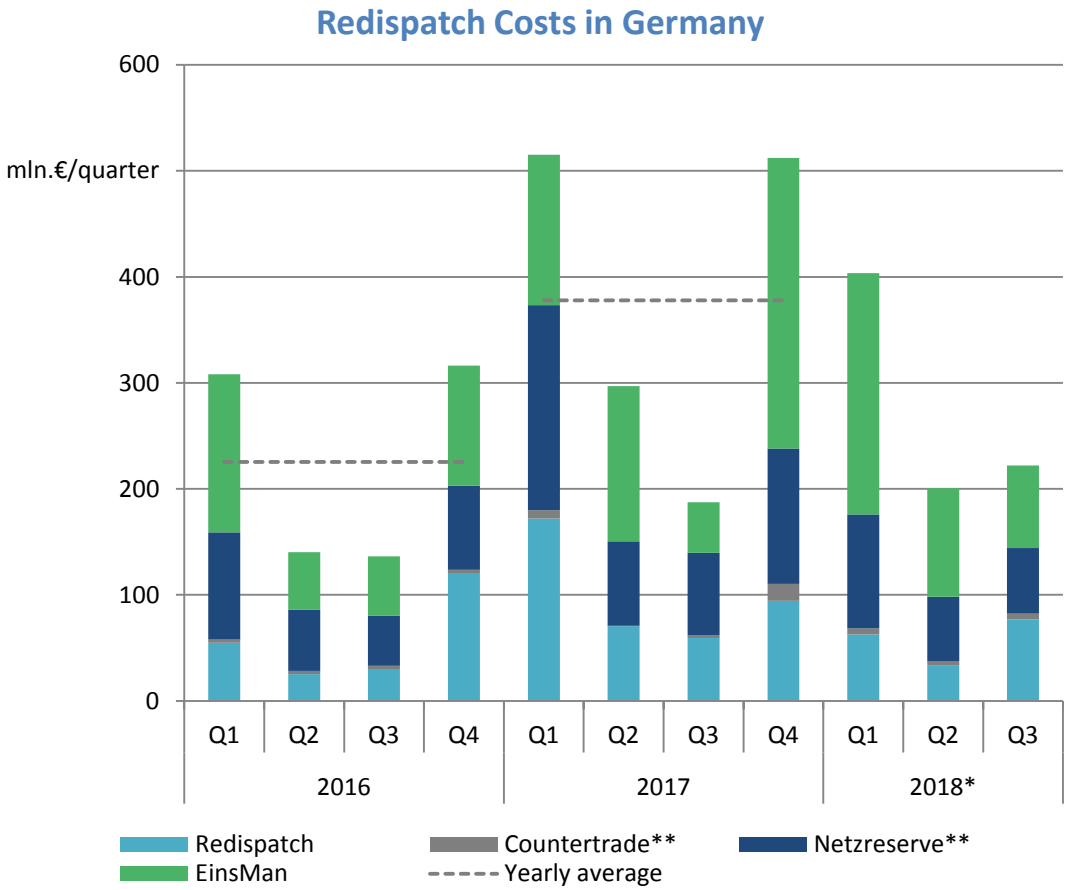


* For 2018 only costs for the first three quarters were available. ** EinsMan volumes exist only of downward adjustments.

- Conventional redispatch in combination with countertrade is the most common process used for solving congestion in the German grid.
- For the first three quarters of the 2018, the use of grid reserves decreased significantly compared with the first three quarters of 2017, especially because there were less congestion management measures required in Q1.

Redispatch costs DE

Redispatch costs slightly down in Q1-Q3 2018



* For 2018 only costs for the first three quarters were available. ** Countertrade costs for 2016 and Netzreserve costs for all years were given as yearly aggregated values. Therefore, costs have been equally divided over the four quarters.

- In 2017 total redispatch costs amounted to €1,511 million, of which €999 million in the first three quarters of the year. Costs in the first three quarters of 2018 amounted to €826 million. Redispatch costs decreased in 2018 compared to the first three quarters of 2017.
- The year 2017 saw high redispatch costs, fueled by a cold winter and high wind feed-in because of stormy weather. 2018 had more moderate weather conditions, but an increased share of renewables.
- Redispatch costs are higher in winter months, due to generally more stressed grid conditions.
- When compared to the previous slide, redispatch measures show the lowest costs per GWh, and EinsMan the highest.

Annex (1/3)

	Day-ahead average price 2017	Day-ahead average price 2018	Day-ahead median price 2017	Day-ahead median price 2018	Physical import 2017	Physical import 2018	Physical export 2017	Physical export 2018	Net export position 2017	Net export position 2018
	€/MWh	*€/MWh*	*€/MWh*	*€/MWh*	*TWh/year*	*TWh/year*	*TWh/year*	*TWh/year*	*TWh/year*	*TWh/year*
AT	34.2	46.3	33.8	46.5	31.0	29.4	23.3	19.0	-7.7	-10.4
BE	44.6	55.3	39.4	52.6	14.2	21.6	8.2	4.3	-6.0	-17.4
CH	45.9	52.2	41.2	51.4	36.0	30.3	30.0	31.6	-6.0	1.3
CZ	36.5	46.0	35.0	46.1	15.1	11.6	28.1	25.5	13.0	13.9
DE	34.2	44.5	33.8	45.1	28.1	31.5	83.4	82.6	55.4	51.1
DE-AT	34.2	41.7	33.8	36.4	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
DK1	30.1	44.1	30.1	44.2	15.3	15.6	10.6	10.4	-4.7	-5.2
DK2	32.0	46.2	30.6	45.5						
EE	33.2	47.1	30.8	46.2	2.3	3.4	5.1	5.2	2.7	1.7
ES	52.2	57.3	51.0	60.0	23.8	24.0	14.6	12.9	-9.2	-11.1
FI	33.2	46.8	30.8	46.1	22.6	23.4	2.1	3.4	-20.4	-20.0
FR	45.0	50.2	40.1	49.9	21.1	13.4	60.8	76.0	39.6	62.6
GB	51.7	64.9	49.8	63.0	19.8	22.7	3.5	2.2	-16.3	-20.5
HR	60.0	52.0	47.8	51.8	12.2	12.7	4.8	6.5	-7.4	-6.2
HU	50.4	51.0	46.4	50.1	19.8	18.6	6.9	4.3	-12.9	-14.3
IE	45.7	61.9	42.1	58.9	1.1	1.6	1.8	1.6	0.7	0.0
IT-CNOR	54.1	61.1	50.0	60.8	42.9	47.1	5.2	3.2	-37.8	-43.9
IT-CSUD	51.6	60.9	48.8	61.0						
IT-NOR	54.4	60.7	50.0	60.4						
IT-SARD	51.5	60.7	48.8	60.9						
IT-SICI	60.9	69.5	56.6	63.8						
IT-SUD	49.8	59.4	48.2	60.1						

Annex (2/3)

	Day-ahead average price 2017	Day-ahead average price 2018	Day-ahead median price 2017	Day-ahead median price 2018	Physical import 2017	Physical import 2018	Physical export 2017	Physical export 2018	Net export position 2017	Net export position 2018
	€/MWh	*€/MWh*	*€/MWh*	*€/MWh*	*TWh/year*	*TWh/year*	*TWh/year*	*TWh/year*	*TWh/year*	*TWh/year*
LT	35.1	50.0	31.8	47.9	11.9	12.8	3.2	3.2	-8.7	-9.6
LV	34.7	49.9	31.7	48.0	4.1	5.1	4.1	4.3	0.1	-0.8
NL	39.3	52.5	36.9	50.9	22.5	26.8	18.8	18.6	-3.8	-8.2
NO1	29.0	43.7	29.0	43.9	5.9	8.1	20.7	18.0	14.8	9.9
NO2	28.8	43.2	28.9	43.6						
NO3	29.5	44.1	29.1	44.9						
NO4	25.7	43.7	25.0	44.7						
NO5	28.8	43.0	29.0	43.7						
PL	36.7	52.0	34.4	48.9	13.3	13.8	11.0	8.1	-2.3	-5.7
PT	52.5	57.5	51.1	60.0	5.5	5.7	8.2	8.3	2.7	2.7
SE1	30.8	44.2	30.0	44.8	13.8	14.2	33.0	31.6	19.2	17.3
SE2	30.8	44.2	30.0	44.8						
SE3	31.2	44.5	30.0	44.9						
SE4	32.2	46.4	30.2	45.4						
SI	49.5	51.2	47.0	50.6	9.1	8.9	9.6	9.3	0.4	0.4
SK	40.9	48.5	36.5	47.4	15.6	12.5	12.5	8.7	-3.0	-3.8

Annex (3/3)

		2016		2017		2018		
		NL	DE	NL	DE	NL	DE	Source
Yearly average weighted intraday price	€/MWh	34.6		40.6		53.1		[1]
Intraday volumes CrossBorder	GWh/year	542.1		901.9		1,213.0		[1]
Intraday volumes Spot	GWh/year	367.9		580.8		995.4		[1]
Yearly average hard coal price (API#2 OTC)	€/MWh.th	7.6		10.7		11.2		[2]
Yearly average natural gas price (TTF OTC monthly)	€/MWh.th	14.0		17.4		22.0		[2]
Yearly average carbon price (EEX futures)	€/tCO2	5.3		5.8		15.4		[2]
Yearly average Clean Dark Spread base	€/MWh	11.1	8.6	9.8	6.8	13.4	6.8	[2, 3]
Yearly average Clean Spark Spread base	€/MWh	6.9	4.5	7.3	4.4	8.6	2.0	[2, 3]
Yearly average Clean Spark Spred peak	€/MWh	12.2	8.6	12.5	9.5	14.3	6.7	[2, 3]
Yearly consumption	TWh/year	114.5	538.5	115.0	538.6	116.5	538.4	[4]
Average imbalance price delta long system	€/MWh	15.7		17.9		23.1		[3, 5]
Average imbalance price delta short system	€/MWh	26.0		25.2		22.5		[3, 5]
Yearly average FCR price Dutch auction (symmetrical)	€/MWh/hour	15.0	#N/A	14.9	#N/A	19.1	#N/A	[6]
Yearly average FCR price Joint auction (symmetrical)	€/MWh/hour	14.8		14.6		12.8		[7]
Yearly average aFRR price (asymmetrical)	€/MWh/hour	5.2		5.1		8.9		[7]
Yearly average mFRRda upward price (assymetrical)	€/MWh/hour	1.1		1.1		4.8		[7]
Yearly average mFRRda downward price (assymetrical)	€/MWh/hour	#N/A		2.4		7.1		[7]
Redispatch volumes	GWh/year	#N/A	16,426	664	26,101	688	#N/A	[7, 8]
Redispatch costs	mln.€/year	64.2	889.1	46.1	1,511.5	53.5	#N/A	[7, 8]

1) APX; 2) energate; 3) MRC Market Coupling; 4) ENTSO-E Power Statistics; 5) TenneT NL; 6) regelleistung.net; 7) TenneT NL; 8) Bundesnetzagentur

Colophon

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TenneT is a leading European electricity transmission system operator (TSO) with its main activities in the Netherlands and Germany. With approximately 22,000 kilometres of high-voltage connections we ensure a secure supply of electricity to 41 million end-users.

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