

AMPRION MARKET REPORT 2021

CURRENT TRENDS AND DEVELOPMENTS OF THE MARKET AND GRID SITUATION

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EXECUTIVE SUMMARY

As the energy infrastructure is a key enabler of the European energy transition, transmission system operators (TSOs) play an important role in reaching the European Green Deal objectives as well as in the implementation of a functioning internal energy market. Tackling climate change and achieving climate neutrality by 2050 poses significant challenges for the entire European energy system. On a national level, the German energy system is undergoing an unprecedented transformation. Electricity production from nuclear energy and coal will be phased out while an increasing share of renewable energies is integrated into the system. As generation and consumption in the transmission system must always be in equilibrium in order to keep the network stable, the task of ensuring this is the case will become much more demanding for the transmission system operators. Even in times of such a dynamic and changing environment, TSOs are ensuring a 24/7 electricity supply and are thus enabling the energy transition. Efficient cooperation is a key prerequisite for this. Therefore, TSOs are jointly and cooperatively working around the clock to ensure a secure network, promoting security and cross-zonal trade within the entire European electricity system.

Amprion is - and has been for decades an integral part of this cooperation. We have been engaged in a large number of regional and European system operation, grid planning and market integration initiatives. Our involvement in these initiatives has always been based on a close, trustful and constructive collaboration with our neighbouring TSOs, National Regulatory Authorities (NRAs), ACER (the Agency for the Cooperation of Energy Regulators), power exchanges, a vast

number of market parties and our association ENTSO-E (European Network of Transmission System Operators for Electricity). In a nutshell, close mutual cooperation is in our DNA.

However, 2020 was an unprecedented year in every respect. The effects of the Covid-19 pandemic came along with a particular challenge for our society and for each one of us. Furthermore, the shut-down of public life in large parts of Europe over many months also had a huge impact on the energy sector, resulting in¹:

- · The lowest gross electricity consumption (544 TWh) in Germany since the year 1999²
- The highest share of renewable energies in electricity generation (49%) of Germany ever
- The lowest electricity prices (€32/MWh) since the introduction of Flow-Based Market Coupling (FB MC) in Central Western Europe (CWE) in 2015
- The lowest gas prices (€12/MWh) since 2004³
- The highest electricity imports (31 TWh of day-ahead commercial exchanges) in Germany since the introduction of FB MC in CWE
- The highest price convergence (52% at max. ± €1/MWh) in CWE since the introduction of FB MC in CWE
- The highest amount of hours with negative electricity prices in Germany (298 h) since the introduction of FB MC in CWE

Source: https://transparency.entsoe.eu/

- ² Source: https://de.statista.com/statistik/daten/studie/256942/umfrage/bruttostromverbrauch-in-deutschland/
- ³ Source: https://www.bafa.de/DE/Energie/Rohstoffe/Erdgasstatistik/erdgas_node.html

THE COVID-19 PANDEMIC MADE 2020 AN EXCEPTIONAL YEAR, WHICH IS THEREFORE ONLY PARTIALLY COMPARABLE WITH PREVIOUS YEARS

As these characteristics of the electricity ma ket indicate, 2020 was exceptional. Moreov the impact on the energy sector correspond with general trends and developments in th sector from previous years, which were amp

Future Developments

FUTURE NEED FOR ALTERNATIVES SOURCES WHICH ARE ABLE TO PROVIDE FLEXIBLE CONTINUOUS ELECTRICITY SUPPLY

The future developments in generation adequacy reveal that situations in which Germany will rely on electricity imports from neighbouring countries will occur more often in the long term. This is primarily caused by the nuclear and coal phase-out in Germany. The

ar-	lified by the effects of the Covid-19 pandemic.
er,	This comprises, for example, the increasing
ds	import demands of Germany in relation to
nis	current weather conditions and the solar/wind
p-	power generation.

Current Trends

Trade in CWE and with other neighbouring countries is gaining in importance. Due to decreasing gas prices and the very low total load in 2020, prices in CWE were the lowest and most converging ones since the introduction of FB MC in CWE.

European initiatives and regulations in relation to the green deal are pushing the expansion of renewable and crosssectoral technologies like power-to-gas concepts which contribute to building up a sustainable future power supply in Europe.

Increasingly strong weather-dependent fluctuations of imports and exports, leading to more frequent situations with high import demand as well as situations with high exports.

Offshore energy must be expanded to serve the system. In addition, the integration of wind energy in northern Germany must be ensured, for example with the support of power-togas plants.

withdrawal of the related power plants is not entirely compensated for by the gas-fired or renewable base load capable power generation capacities. Implications on system stability and security must be carefully monitored and evaluated.

LOW NET POSITIONS OF CWE BIDDING ZONES AND INCREASING IMPORT DEMAND IN GERMANY DURING SUMMER 2020

Especially during the summer months, the capability of self-supply of Germany is increasingly dependent on wind power generation, which is statistically lower than in the winter months. In summer 2020, electricity imports of Germany reached nearly 12 GW in several hours. The highest imports in 2020 have taken place from France, the Netherlands, Switzerland and Denmark. Frequently, there were also transit flows monitored from these countries via Germany to Austria, Poland and the Czech Republic. During the winter months, the German balance of trade is generally characterised by exports based on high wind power generation. However, in situations with low wind power generation in combination with a higher average load during winter, Germany will also increasingly rely on imports in future.

LOWEST AVERAGE DAY-AHEAD PRICES AND HIGHEST PRICE CONVERGENCE SINCE INTRODUCTION OF FB MC IN CWE

Due to a combination of low loads across Europe, low gas prices and increasing shares of solar and wind power generation, prices in CWE were the lowest since introduction of FB MC. Moreover, price convergence in CWE reached the highest level ever monitored and indicates a very well-functioning electricity market. However, the general grid situation in 2020 also led to an amplified trend towards hours with negative prices in hours with high power generation of fluctuating renewable energies, which is sign for a lack of flexibility in current power generation.

CONSEQUENCE: AMPRION IS INVESTING 24 BILLION EUROS OVER THE NEXT TEN YEARS

In summary, the results show that the European electricity market is already working quite well and Europe is becoming more and more interconnected. With regard to national energy systems, it is still necessary to ensure a secure, affordable and renewable energy supply for a sustainable future. For this reason, future challenges such as generation and transmission adequacy have to be tackled.

Amprion is very aware of its legal obligations and its role in the European energy system. In order to strengthen electricity trade in Europe and to enable the transition towards a fully renewable and sustainable energy supply, Amprion is substantially investing in expanding and reinforcing the existing transmission grid. In addition, Amprion further increases system planning expertise in the field of efficient and sustainable concepts for the integration of renewable offshore energy and sector coupling with powerto-gas technologies.

INTRODUCTION

This market report provides evidence of the dynamic electricity market environment in which Amprion operates together with many other institutions.

The report highlights the significant mutual benefits resulting from Amprion's strong and steadily enhanced cooperation with TSOs, power exchanges and market parties of the CWE region and beyond.

Energy Markets - The Concept of Energy Time Frames and Flow-Based Market Coupling

Electricity is a commodity for which no efficient storage facility exists, thus it needs to be produced at the point in time at which it is consumed. Trading of electricity takes place before and after this point in time. Figure A in Annex 'Overview Electricity Markets in Europe' gives an overview of the current trading time sequence in wholesale and balancing markets. In sequential order, energy can be traded one or more years before the delivery (forward and futures markets) up to the day after the actual delivery. While in the day-ahead market energy is traded one day before real time, the intraday market enables market participants to correct their nominations closer to the time of delivery. Further information regarding the flow-based market coupling concept can be found via the Amprion homepage (link below).

Further information: https://www.amprion. net/Market/Market-Report/

CENTRAL WESTERN EUROPE (CWE)

In order to achieve the target model of a single European electricity market, local markets have been gradually integrated and coupled at a regional level as from 2006 with the first market coupling of the Belgian, Dutch and French day-ahead markets. The latest major step towards the target model was the introduction of Flow-Based Market Coupling (FB MC) in CWE back in 2015. Currently, TSOs are working on the introduction of FB MC in the capacity calculation region (CCR) Core, which encompasses Eastern Europe in addition to Central and Western Europe.

CWE

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AMPRION

Amprion is one of four transmission system operators in Germany. Our extra-high-voltage network (380 kV and 220 kV) is 11,000 kilometres long and transports electricity across an area that extends from Lower Saxony to the Alps. Around a third of Germany's economic output is generated there. Today, Amprion's grid is interconnected with other transmission grids within Germany and also with the Netherlands, Belgium, Luxembourg, France, Switzerland and Austria. With ALEGrO, the first interconnection between Germany and Belgium has been operational since mid-November 2020.

Core

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OUTLOOK CORE

In terms of market integration, Amprion will continue its strong commitment to the ongoing activities in the capacity calculation regions CWE and Core. The latter will encompass the implementation of a flow-based capacity calculation and allocation at all Core borders for the day-ahead (and at a later stage intraday) time frame and long-term capacity calculation. Concepts of organising and further enhancing cross-zonal redispatch and sharing of the related costs amongst TSOs are currently being developed. We are confident that the current close cooperation amongst all involved TSOs and regulatory authorities will result in adequate and acceptable solutions for all parties involved.

Amprion connects electricity markets across borders

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1. CURRENT TREND IN GENERATION ADEQUACY IN GERMANY

THE DECREASE OF CONVENTIONAL CONTROLLABLE ELECTRICITY PRODUCTION CAPACITY WILL HAVE FUNDAMENTAL CONSEQUENCES FOR THE ELECTRICITY MARKET AND GENERATION PATTERN

In 2020, as in the past years and decades, a continuous balance between electricity supply and demand has always been guaranteed by sufficient conventional electricity generation from coal, nuclear and gasfired power plants. These conventional energy sources have been providing the flexibility of continuously adjusting their generation to the overall demand. The policy trend towards carbon-neutral electricity production has already led to a decrease in conventional generation capacity. This trend will continue and a flexible continuous electricity supply will have to be provided by alternatives sources in the future.

FUTURE NEED FOR ALTERNATIVES SOURCES WHICH ARE ABLE TO PROVIDE FLEXIBLE CONTINUOUS ELECTRICITY SUPPLY

For the coming years, various European analyses⁴ still show a comparatively high level of security of supply. However, there is a clear trend indicating future import needs in Germany. In the next few years, Germany

Figure 1: Installed power generation capacity in Germany 2015, 2020 and 2025⁶

⁴ E.g. Generation Adequacy Assessment (PLEF); Midterm Adequacy Forecast (MAF) ⁵ See also Amprion Market Report 2020, Chapter 1 Development of the security of supply situation focusing on Germany: Leistungsbilanzbericht of the four German TSOs

⁶ Source: ENTSO-E Transparency Platform, NEP Szenariorahmen (2019) (https://www.netzentwicklungsplan.de/sites/default/files/ paragraphs-files/Szenariorahmen_2019-2030_Genehmigung_0_0.pdf)

might end up in the situation that its electricity demand coverage can, during some hours only be ensured by imports (see in Figure 1 dashed line 'highest peak load')⁵.

Figure 1 indicates the decrease of conventional controllable electricity production capacity with fundamental consequences for the electricity market and generation pattern⁷:

• In 2020 lignite and hard coal together contributed only 24% of net electricity generation, less than wind power (wind offshore and onshore 25.4%). In the past five years, coal-fired power generation has nearly halved (214 TWh in 2015 and 119 TWh in 2020)8. This is a consequence of the coal phase-out in Germany. All coal generation capacities are to be closed by 2038. Tenders are organised in order to determine the coal power plant decommissioning time and compensation payments. Even the modern coal-fired power plants such as the one in Moorburg successfully participated in the first of these decommissioning tenders. This power station will be taken off the grid in 2021 after only five years of operation. Further to these regulatory measures, rising

CO₂ prices and low gas prices are providing incentives not only for hard coal-fired power plants but increasingly also for lignite-fired power plants to leave the market.

- In parallel to the coal phase-out in Germany, nuclear generation capacities will be shut down by the end of 2022, which leads to a further decrease in conventional capacities of 8.1 GW compared to the end of 2020.
- The decreasing share of coal and nuclear energy production will have to be replaced by an increasing share of volatile generation capacities such as wind and solar energy in the coming years. In 2020, the share of electricity generated from renewable energies has already reached almost 50%. Figure 2 highlights the increasing dependency of the German electricity generation on renewable energies and illustrates the monthly average share of renewable energy generation in Germany from 2018 until 2020.

70 electricity 60 50 net o Ŀ. Ш Share Septembe Octobe Novembe Decembe Septer Oction Nover Decem Febru 2019 2018 2020

Figure 2: Share renewable energy generation in Germany 2018-2020⁹

While the overall share of renewable energ generation is constantly increasing, their availability varying significantly depending on daytime, season and general weather conditions. Figure 3 illustrates this by comparing the generation pattern for the day w the hour with the highest share of renewabl energy production in 2020 (84% of net electricity generation on 04 July at 12 a.m.) to the day with the hour with the lowest renewable energy production (14% of net electricity generation on 27 November at 6 a.m.). These values refer to aggregated electricity generation of all renewable ener sources (including wind, solar, biomass, hydro and others). The German energy

⁷ It should also be noted that the graphs on installed capacities (Figure 1) do not take into consideration outages of power plants due to failures or maintenance requirements. The amount of outages depends on the season and historically lies between 10-20% of the installed capacity.

⁸ Source: https://transparency.entsoe.eu/

⁹ Source: https://transparency.entsoe.eu/

¹⁰ Source: https://transparency.entsoe.eu/

У	transition is based mainly on the massive expansion of fluctuating renewable energy
	sources (i.e. wind onshore, wind offshore and
	solar). Considering only these fluctuating
	renewable energy sources, on 04 July at
vith	12 a.m. 74% of net electricity generation
le	and on 27 November at 6 a.m. only 1% was
	generated by wind and solar.
)	
	In addition, Figure 3 shows that situations
	with very low wind and solar power generation
	do not occur only in single hours. Instead,
	they can last for days and even weeks. An
ду	appropriate back-up must be available for such times.

Daytime on 4 July 2020

Figure 3: Days with the lowest and highest renewable power generation in Germany 2020¹⁰

Security of supply has to be ensured at all times, also in situations with low renewable electricity production (e.g. November day in Figure 3 or the investigated week in Chapter 3.2). In such situations flexible gas (hydrogen)fired power stations could in future support electricity generated by renewables. In order to develop the infrastructure required for this purpose, the currently independent grid planning processes of the electricity and gas infrastructure should in future be closely aligned.

Renewable energy plants will also have to contribute to security supply in the future, for example by combining them with flexible storage facilities. Consumer-side flexibility, (aligned with the volatile feed-in of renewable energies) will have to play a stronger role. From 2025 onwards, high electricity demand (peak load indicated in Figure 1 for the reference years 2015 until 2020) can no longer be ensured solely by conventional and controllable power plants.

HIGH LEVEL OF SECURITY OF SUPPLY REQUIRES SUFFICIENT TRANSMISSION CAPACITY OF THE GRID

The previously shown generation adequacy situation does not consider whether the grid is capable of transporting the capacity (transmission adequacy). Current security of supply reports and analyses, in general, do not consider grid-related restrictions. However, insufficient transmission capacity currently requires market interventions on an almost daily basis as described in Chapter 4.1. Grid reserve power plants are contracted and activated for this purpose. Additional grid-relieving measures such as operating equipment for active power flow control has been and will be installed over the next years. However, the potential for further short-term grid optimisation has its limits. An adequate level of transmission capacity can only be ensured by mid and long-term expansion of the transmission grid. Realising the relevant grid expansion projects included in the network development plan and defined in applicable legislation is therefore required and mandatory.

Security of supply has to be ensured also in situations, with low renewable electricity production (e.g. in the investigated week in Chapter 3.2). In such situations flexible gas fired power stations could support electricity generated by renewables. In order to develop the infrastructure required for this purpose, the currently independent grid-planning

processes of the electricity and gas infrastructure should in future be closely aligned.

The European Green Deal accelerates the transformation of the European energy system to enable a fully integrated climateneutral system by 2050. As infrastructure is a key enabler of the European energy transition, European TSOs play an important role in meeting the objectives of the Green Deal and in implementing a functioning internal energy market. Due to the usually high full-load hours of offshore wind farms, this technology is expected to contribute to the overall security of supply more than other renewable energy sources in future by generating electricity on a rather constant level. The grid connection of those offshore wind farms should be located as close as possible to the demand centres in order to provide customers with direct access to electricity supply. For this reason, the offshore grid connection to the shore is just one aspect. It is important to have integrated grid concepts which consider the further transport of the offshore wind power to the regions with high electricity demand. In order to ensure the optimal interlinkage of offshore wind farms a modular offshore grid should be installed in Europe in the long term. See also Chapter 5 of this report for further information on the topic.

ASPECTS OF SYSTEM STABILITY MUST BE CONSISTENTLY TAKEN INTO ACCOUNT **IN SYSTEM DESIGN**

The current electricity system has been reliant on large power stations close to demand centres. Those power stations could provide local ancillary services, i.e. reactive power, and support grid voltage at dedicated locations. With the closure of those power plants this support will no longer be available. Together with the progressive expansion of renewable energies and longer-distance electricity transmission, there is an increased demand for alternative support in the form of new controllable

OUTLOOK IN EUROPE

NOT ONLY IN GERMANY, BUT ALSO IN OTHER EUROPEAN COUNTRIES, A DECREASING TREND IN CONVENTIONAL POWER PLANTS IS VISIBLE

Similar efforts to achieve the Paris Climate Agreement targets and to shut down conventional capacities are being made in other countries across Europe. Exemplarily, France and UK have announced a coal phase-out by the end of 2022 and 2024, respectively, which would reduce conventional generation by 3 GW in France¹¹ and by 5.3 GW in Great Britain¹². Besides that, a nuclear phase-out by 2025 is being discussed in Belgium,

compensation systems. Further information regarding the challenges of voltage control are analysed in Chapter 4.2 of this report.

It is essential that balancing responsible parties provide their contributions to such an overall balanced electricity system. In order to achieve this target, the market framework needs to provide the right incentives for balancing groups to balance their energy injections and withdrawals at all times.

potentially reducing conventional generation by 5.9 GW¹³. In the interconnected European electricity system, such individual changes in the generation capacities in different countries have a substantial impact on the overall European security of supply during scarcity situations. In order to assess the current and future European security of supply situation, Amprion is particularly involved in respective ENTSO-E analyses.

¹¹ See 'France to close Havre coal power plant in April 2021': https://www.reuters.com/article/us-france-electricity-coal/france-to-close-

¹² UK brings forward coal phase-out to 2024: https://www.argusmedia.com/en/news/2064277-uk-brings-forward-coal-phaseout-to-2024 ¹³ See 'Electrabel calls for clarity on Belgian phase-out': https://www.world-nuclear-news.org/Articles/Electrabel-calls-for-clarity-on-

havre-coal-power-plant-in-april-2021-idUSKBN179110

Belgian-phase-out

2. EXTRAORDINARY OCCURRENCES – IMPACT OF COVID-19 PANDEMIC

THE COVID-19 PANDEMIC HAS SIGNIFICANT EFFECTS ON THE ELECTRICITY SYSTEM AND THE ENERGY MARKET

The Covid-19 pandemic made 2020 an exceptional year in terms of many areas of everyday life, including effects on the electricity supply and markets. To give an overview of these extraordinary effects and the resulting lockdown measures, this chapter highlights some key figures.

THE COVID-19 PANDEMIC MADE 2020 AN EXCEPTIONAL YEAR, WHICH IS THEREFORE ONLY PARTIALLY COMPARABLE WITH PREVIOUS YEARS

The lockdown measures across much of Eur ope in the beginning of 2020 had a significa impact on the electricity markets. The actua total electricity demand fell sharply in many countries and in particular also in Germany shortly after the first lockdown, i.e. in the las weeks of March and the months of April and May 2020. Figure 4a shows this substantial change for a representative week in April 202

These clear differences on the demand side persisted during the lockdown period (i.e. in April and May around a 10% decrease in the actual total load). During the summer the actual total load adjusted back to previous years' levels and reached a level comparable to 2019 in August. Over the whole year of 2020, a decrease of 3% in actual total load could be observed for Germany (478 TWh in 2020 compared to 490 TWh in 2019)¹⁴.

r-	Not only the decrease in actual total load but
ant	also a mild winter and an oversupply of gas^{15}
al	resulting in an extreme decrease in gas prices
/	caused a significant change in the generation
	structure. The aforementioned effects result-
st	ed in the following deviations compared to
b	2019: on the one hand, the share of electricity
	generated by lignite reduced by -19%, hard
20.	coal by -27% and nuclear by -14%, but on the
	other hand, an increase in gas by +8%, solar
÷	by +9%, onshore wind by +3% and offshore
n	wind generation by +11% could be observed.
è	Firstly, this can be explained by the sharply
	decreased natural gas prices (-24% compared
	to 2019 and almost -36% compared to 2018).
е	The corresponding merit order shift 'coal-gas
	switch' resulted in lower prices in all countries
	- which also led to more similar prices due to
n	the flattening of the merit order. Secondly,
	the share of renewable energies in net elec-

f Actual total load = actual total load (including losses without stored energy) = net generation - exports + imports - absorbed energy net generation is preferred, however gross generation could be used where it is available with greater precision (Source: ENTSO-E

On an already oversupplied European gas market, new LNG from the USA kept arriving during the winter. According to GIE data, gas storage levels in Europe were 88% full at the beginning of January. At the end of March, storage levels were at 54%.

transparency platform

¹⁵ See 'Der europäische Energiemarkt zwischen Zusammenbruch und schneller Erholung' - EMW - Dr. Philipp Eggert, Trianel; 02.02.2021: Normal would have been around 35%.

tricity generation reached a peak of 49.4% in 2020. Especially wind and solar generation increased significantly. The corresponding shift away from fossil fuels led to a decrease in greenhouse gas emissions of approx. 80 million tonnes of CO_2 -eq and will thus be about 42.3% below the 1990 level¹⁶.

The pandemic and resulting lockdown measures imposed particular challenges on grid operators who had to manage increased volumes of fluctuating renewable energy in a low-demand environment with fewer thermal power plants at the same time. Examples of this are the minimum and maximum shares of renewable energies that occurred in 2020. The range is vast, with 84% on 4 July and only 14% on 27 November (see Chapter 1). Overall, networks coped with the situation well and proved their ability to handle high levels of renewable penetration, which at times crossed 60% in Italy, 70% in Spain and the already mentioned 84% in Germany¹⁷.

The following graphs in Figure 4 (a-e; top to bottom) proves the exceptional effects of the Covid-19 pandemic based on analyses of the example week 6 to 13 April 2020:

- Figure 4a: The actual total load of Germany in 2020 (pink line) decreased significantly compared to the previous years (2015–2019), which are represented by the pink shaded area.
- **Figure 4b:** The power generation pattern in Germany during this week can be characterised by low wind power generation and average PV generation.
- Figure 4c: This situation is reflected by the net positions of France and Germany, which correspond to the overall effects. Figure 4c shows the correlation between the German and France net positions (taking into account

all CWE borders). While Germany was mainly importing during this week, France compensated for this with an average net export position of approx. 7,000 MW. However, at the end of the depicted week (i.e. 12 April), situations occurred in which the reverse situation was visible. On 12 April at 5 a.m. Germany was importing with a net position of -2,400 MW, while France was exporting (net position of +10,200 MW). A few hours later at 1 p.m. the opposite picture emerged: Germany was exporting (net position of +9,000 MW) and France was importing (net position of -1,500 MW). Chapter 3 of this report covers in more detail these strong fluctuations in the net position and the underlying effects.

- Figure 4d: In order to give an overview of how the commercial exchanges behaved during this April week, Figure 4d demonstrates Germany's bilateral commercial exchanges with all neighbouring countries revealing massive transit flows. German imports from France, Denmark and Switzerland are simultaneously offset by exports from Germany to Austria and the Czech Republic.
- Figure 4e: The corresponding day-ahead electricity prices in CWE also show significant fluctuations, with the very low average day-ahead price during the week of only €19/MWh. However, the weekly average day-ahead price in the German bidding zone (€21/MWh) was slightly higher than the average CWE prices, reflecting the strong imports. As a result, the lowest day-ahead prices (€14.4/MWh) were observed in France during this week. Furthermore, the observed price convergence in the week was approx. 35.1% and thus much lower than the average in 2020. This is an indicator for trade limiting network elements and is a result of the exceptional grid situation in Europe based on the national lockdowns.
- ¹⁶ See 'Jahresauswertung Agora Energiewende' in 2020, greenhouse gas emissions decreased. The main reasons for the lower emissions are the economic crisis (low energy demand, lower industrial production, slump in transport demand), higher CO₂ prices in EU emissions trading and a mild winter.

 ${}^{\prime\prime} See https://ec.europa.eu/energy/sites/ener/files/documents/quarterly_report_on_european_electricity_markets_q_2_2020.pdf$

¹⁹ Source: https://transparency.entsoe.eu/

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¹⁸ Share of power generation in the illustrated week: solar 19%, wind onshore 16%, wind offshore 4%, other renewable 16%, nuclear 15%, gas 9%, coal (lignite and hard) 17%

3. MARKET ANALYSIS 2020

LOW ELECTRICITY DEMAND AMPLIFIES MARKET TRENDS FROM 2019.

This chapter seeks to analyse and explain our main observations and the key trends in the electricity wholesale market in 2020. With our control area located in the heart of CWE, our market monitoring is focussed mainly on this region, where Amprion provides fundamental contributions to European electricity trade and FB MC. Since the go-live of the ALEGrO cable in November 2020, which represents the first interconnection between the German and Belgian transmission grid, Amprion is now interconnected with every foreign TSO in CWE. This particular role in Germany and CWE requires our strong commitment to CWE and the overall European electricity market.

EXPORTS AND IMPORTS IN CWE

We analyse electricity exports and imports by monitoring the day-ahead net positions of all bidding zones in this region. In general, these net positions show the difference between all flows out of a particular bidding zone (exports) or into a particular bidding zone (imports) at one particular point in time. A positive net position indicates a (net) exporting bidding zone, while a negative net position shows a (net) importing bidding

zone. In order to show the main effects of the electricity wholesale market, our analysis is focussed on flows which are exchanged between bidding zones the day before the actual production and consumption takes place. These flows are determined by the dayahead market which is where currently the major part of electricity trading takes place. Figure 5 illustrates the moving weekly average of CWE net positions in 2019 and 2020.

(considering all country borders except DC interconnectors, moving weekly averages)

LOW NET POSITIONS OF CWE BIDDING ZONES AND INCREASING IMPORT DEMAND **IN GERMANY DURING SUMMER 2020**

In both years, the net position of the Germ Luxembourgian (DE-LU) bidding zone is consistently high during winter months and low during summer months. In 2019, the lo German power generation was especially compensated for by the French (FR) bidd zone with an average net position of arour +6,400 MW from July till October 2019 (fo

Germany's past high net exports of 36.8 TWh in 2019 have decreased by 39.3% to 22.3 TWh in 2020. These German net imports are composed of imports which have increased to 30.9 TWh (+36.8%) in 2020 and exports which have decreased to 53.2 TWh (-10.3%). As already in 2019, Germany has been a net importer during several weeks in the summer time from May to October.

In order to provide more details of the market behaviour in particular export and import situations, the following Chapters 3.2 & 3.3

Explanation: One representative Lockdown week (6 to 13 April), one representative import week (13 to 20 July) and one representative export week (14 to 21 December) were analysed in detail.

Figure 5: Comparison of day-ahead net positions in CWE in 2019 and 2020²⁰

ian/	comparison: the average net position of
	DE-LU was around +400 MW in this period).
d	However, summer months in 2020 stand
W	out due to comparatively low net positions
	not only in Germany, but in particular also
ng	in France (e.g. average net position of FR:
nd	+750 MW, DE: -300 MW from July till October
or	2020).

. decrease of net exports of Germany in 2020.

will focus on one representative import week in July and one representative export week in December (cf. Figure 5).

²⁰ Source: https://transparency.entsoe.eu/

FOCUS SUMMER 2020 -3.2 **GERMANY BECOMING A NET IMPORTER**

As in the summer of 2019, also in the summer months of May, July and August 2020, Germany was importing significantly from France, Netherlands, Switzerland and Denmark. For a better understanding of this phenomenon, Figure 6 provides some insights into one of these weeks, from 13 to 20 July 2020, in which Germany relied heavily on imports.

HIGH IMPORTS FROM FRANCE, NETHERLANDS, SWITZERLAND AND DENMARK **DURING SUMMER 2020**

In order to explain market behaviour in such situations, the following reflects the interdependencies between load, generation, day-ahead wholesale prices as well as imports and exports.

The graph at the top shows the total actual grid load in Germany which has been slightly lower than in the last years. In nearly every hour, the load in 2020 has been lower than the lowest value of this hour in comparable calendar weeks from 2015 to 2019 (grey shaded areas, on average: -5%). This is still a result of Covid-19 pandemic and the related restrictions in Germany.

While low loads are usually related to a surplus in generation, this has not been the case due to comparatively low generation of wind power and below-average PV generation. For comparison, the hourly wind generation of onshore plus offshore power plants in Germany during this week was on average at 3,100 MW²¹. Despite usually high PV generation in July, on 15 and 16 July 2020 also the PV generation was comparatively low with an hourly average generation of around 8,100 MW²².

The gap between demand and comparatively low generation from wind and PV has been

filled partly by coal and gas power generation²³. Furthermore, net imports have reached a level of on average 4,200 MW per hour²⁴. Figure 6 shows that the CWE net position of DE-LU during this week remains negative (importing), except for a few hours on Monday, Saturday and Sunday around noon. When taking a look at the day-ahead scheduled commercial exchanges at all country borders (beyond CWE only), it becomes obvious upon which countries Germany has been relying. With a total amount of 461 GWh, the highest net imports have come from the Netherlands with a 4,500 MW peak, followed by France (276 GWh total, 5,700 MW peak), Denmark (218 GWh total, 1,900 MW peak) and Switzerland (119 GWh total, 2,800 MW peak).

Although trading volumes in CWE have been high, the average day-ahead wholesale prices were just slightly above average at around €35/MWh in CWE²⁵ with a high degree of price convergence of around 75%²⁶. Consequently, there were only 47 limiting CNECs (critical network elements and contingencies) monitored in CWE over the whole week, which have limited trade in CWE. Furthermore, none of those CNECs refers to internal network elements of Amprion

- ²² Peak overall PV production in 2020: 30,300 MW, peak generation during the particular week 15,100 MW
- ²³ Average generation from lignite plus hard coal power plants was around 12,900 MW and natural gas power generation was around 8.600 MW

²⁴ Which sum up to 708 GWh over the whole week

- ²⁵ Maximum: €58.7/MWh in DE-LU at 16/07/2020 10 a.m.: minimum: €15.0/MWh in BE at 20/07/2020 12 a.m.
- ²⁶ In 74.5% of hours the maximum price deviation is below ±€1/MWh in CWE and the maximum deviation is ±€10.9/MWh reached on 20/07/2020 at 12 a.m.
- ²⁷ Source: https://transparency.entsoe.eu/

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3.3 FOCUS WINTER 2020 -WIND POWER AS MAJOR DRIVER FOR EXPORTS

As in 2019, in January, February and December of 2020 trade in CWE was significantlyaffected by net exports from Germany. In contrast to the summer months, a surplus in wind power generation during the winter months has been a key driver for these net exports. Figure 7 provides an overview of one of these characteristic exporting weeks from 14 to 21 December 2020.

HIGH WIND GENERATION LED TO HIGH EXPORTS DURING WINTER 2020

The total actual grid load in Germany during this period is depicted in the graph at the top of Figure 7. In 2020, it was on a level comparable previous years, slightly below the average of 2015 to 2019. The effects of the restrictions related to the Covid-19 pandemic, which have been even more restrictive than during the summer months, are not as obvious then during the lockdown from March to May. On average, the load in December 2020 has just been 0.2% lower than in December 2019.

The second graph in Figure 7 shows a surplus in generation related mainly to high wind power generation, while PV generation is commonly low during winter months. The hourly wind generation of onshore plus offshore power plants in Germany during this week was 19,000 MW²⁸ on average. For comparison, the hourly average photovoltaics generation was just around 1,200 MW²⁹.

Due to the higher average load of 57,300 MW compared to only 51,100 MW in the summer week from Chapter 3.2, combined coal and gas power generation was even higher during this week (average generation from lignite plus hard coal power plants was around 17,600 MW and natural gas power generation was around 7,500 MW).³⁰ This high surplus of supply resulted in net hourly exports of 6,700 MW on average which add up to 1,128 GWh over the whole week. Figure 7 shows that the CWE net position of DE-LU during this week remained positive (exporting), except for a few hours on Wednesday morning and on Sunday around noon. By far the highest net exports in this week went to Austria (837 GWh at 5,800 MW peak), followed by France (286 GWh total, 4,500 MW peak). Due to the overall high wind power generation in northern Europe Denmark has additionally been exporting to Germany (333 GWh in this week with a 2,700 MW peak).

Compared to other weeks of the year, trading volumes in CWE were relatively high and the average day-ahead wholesale prices were significantly above average at around €42.7/MWh³¹ in DE-LU. Moreover, price convergence was rather low during the whole week at around 23%³². This was a result of high loads and a generation shift to northern Germany and Denmark due to high wind power generation, which led to 444 limiting CNECs over this week. The share of internal network elements of Amprion was 7.2% with 32 monitored CNECs.

²⁸ With a peak at 36,000 MW. The average wind power generation over December 2020 was around 15,600 MW in contrast to 20,400 MW in 2019.

²⁹ With a peak at 10,500 MW

³¹ Maximum: €76.1/MWh in AT on 17/12/2020 at 6 p.m.; minimum: €0.0/MWh in DE-LU on 21/12/2020 at 11 p.m.

³³ Source: https://transparency.entsoe.eu/21/12/2020 at 11 p.m.

Figure 7: Example winter week with net exports of Germany³³

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³⁰ Please note: the peak load in the winter week was 71.5 GW whereas the peak load in the summer week (chapter 3.2) was 67.0 GW.

³² In only 22.9% of hours it the maximum price deviation below ±€1/MWh in CWE and the maximum deviation is ±€22.6/MWh reached on 21/12/2020 at 11 p.m.

INCREASING TREND OF PRICE CONVERGENCE IN CWE

As explained in Chapter 2, the Covid-19 pandemic led to a 3.2% decrease in the total actual load in Germany. The share of renewable energies in power generation increased to 49.3% compared to 2019 and natural gas prices sank by -26%. Similar effects can be seen in other European countries. All of these factors led to a significant decrease in average day-ahead prices in CWE from around €39.5/MWh in 2019 to just €32/MWh in 2020, continuing the trend of decreasing prices since 2018. Furthermore, the span between the average prices of CWE bidding zones decreased as well, from €3.2/MWh in 2019 to €2.7/MWh in 2020. In both years, the average day-ahead prices in DE-LU were the lowest in CWE of €37.7/MWh in 2019 and €30.5/MWh in 2020. The highest prices in 2019 were observed in NL of €41.2/MWh. In 2020, the highest prices were observed in AT of €33.1/MWh. The development of day-ahead prices in CWE is summarised in Table 1.

LOWEST AVERAGE DAY-AHEAD PRICES AND HIGHEST PRICE CONVERGENCE SINCE INTRODUCTION OF FB MC IN CWE

Bidding zone	2016	2017	2018 (DE-LU-AT)	2018 (DE-LU)	2019	2020
AT	-	-	-	59.91	40.05	33.14
BE	36.61	44.58	49.94	71.06	39.34	31.88
DE-LU	-	-	-	52.59	37.66	30.47
DE-LU-AT	28.98	34.18	41.72	-	-	-
FR	36.74	44.96	45.97	62.72	39.45	32.20
NL	32.24	39.30	49.80	60.60	41.19	32.24

Table 1: Day-ahead average price levels in CWE (in €/MWh)³⁴

The highest CWE day-ahead prices in 2020 were monitored on 21 September at 7 p.m. of €200.0/MWh in all CWE bidding zones. The lowest price was monitored on 13 April at 2 p.m. of -€115.3/MWh in BE. For comparison, the highest price in 2019 was €121.5/MWh in whole CWE and the lowest was -€500/MWh in BE.

Although such an extremely negative price as in 2019 did not occur in 2020, the overall amount of hours with negative prices increased by 41% to 298 h. The amount of hours with at least six continuous hours with

negative prices increased as well by 56% to 192 h. Again, this trend can be attributed to an increasing share of fluctuating renewable energies paired with a low load in 2020 due to the Covid-19 pandemic.

In the case of sufficient cross-zonal exchange capacities, no price differences between CWE bidding zones should occur. If commercial exchanges are limited by transmission constraints, prices between CWE bidding zones diverge. Accordingly, price convergence is an indicator of the level of market integration in the CWE region.

The reduction of price differences within a region is one of the main targets of market coupling. Sufficient cross-zonal transmission capacities are a crucial prerequisite for achieving price convergence (i.e. where price differences equal zero).

The steady increase of hours with full price convergence in CWE provides evidence of the significant contribution of CWE TSOs in making transmission capacity available to the market, thereby achieving a cost-efficient balancing of supply and demand across the region³⁵.

An overall increasing trend for price convergence in CWE is observed (cf. Figure 8). Wh the full price convergence in CWE reached 49% in 2019 for a maximum price span of ±€1/MWh, a further increase to 52% has bee observed in 2020.

... increase in hours with full price convergence in CWE in 2020.

In order to provide a more detailed evaluation of the CWE electricity market efficiency, different price deviation thresholds and combinations of bidding

³⁵ Other fundamental factors also significantly impact the market and prices as well. Examples are in particular the considerable changes in the generation mix described in this report (i.e. the decommissioning of conventional generation units and the increase of renewable energy production).

³⁶ Source: https://transparency.entsoe.eu/

³⁴ Source: https://transparency.entsoe.eu/

-	zones have been further investigated in Figure 8.
hile	Both full price convergence in all five bidding
	zones and partial price convergence in only
	two to four bidding zones has been assessed.
en	The results show that the level of convergence
	has raised in every category compared to
	2019. In case of increasing threshold levels
e	from ±€1/MWh to ±€5/MWh, the hours of full
e	price convergence in all five bidding zones
	increase to 75.2%. For three out of five bidding
	zones already 77.5% of the hours converge
	below or equal to ± €1/MWh and in 97.3% of
	the hours below or equal to \pm €5/MWh.

It is difficult to quantify the impact of the individual factors for this convergence rate as they cannot be analysed on a stand-alone basis³⁷. The provision of an adequate transmission capacity level by TSOs does, however, positively impact the price convergence rate and hence market integration.

EXCURSUS ON EU TRANSMISSION CAPACITY TARGET: GERMAN ACTION PLAN AND **70% TARGET**

Transmission capacity targets are one of the core elements of a piece of recently released legislation called 'Clean Energy for All Europeans Package' (CEP)³⁸ which entered into force on 4 July 2019. One of its main provisions is that at least 70% of the capacity of internal and cross-zonal critical³⁹ network elements has to be made available for cross-zonal electricity trading from 1 January 2020⁴⁰.

Germany, as well as Poland, the Netherlands, Romania and Austria, will not implement this 70% target immediately. These countries have opted for an exemption clause, a so-called 'Action Plan'41. This Action Plan sets capacity targets which will start at a lower level and successively increase to 70% by 31 December 2025. Table 2 shows this increasing path (the linear trajectory).

	% of	f the capaci	ty of critica	l network el	ements (CN	ECs)	
	2020	2021	2022	2023	2024	2025	From 31/12/2025
German CNECs in Core	11.5	21.3	31.0	40.8	50.5	60.3	70.0

Table 2: Percentage of the capacity of critical network elements (CNECs) for Germany in the CCR Core

In addition to the 11.5% capacity target for 2020, Amprion has guaranteed the 20% minimum capacity introduced in the CWE region in April 2018 in compliance with system

security standards. Amprion has been able to fulfil both capacity targets on all CNECs at all times during 2020.

³⁷ Instead, they have to be considered in the complex environment of changes, not only in the transmission capacity between bidding zones, but also with regards to changes in CO2 and fuel prices as well as RES infeed, plant availabilities, electricity demand and weather conditions

³⁸ Regulation (EU) 2019/943

³⁹ A transmission network element is called "critical" when it is considered relevant for the European Market Coupling

⁴⁰ cf. Article 16(8) of Regulation (EU) 2019/943

⁴¹ cf. Article 15 of Regulation (EU) 2019/943

DO CEP MINIMUM TARGETS FOR CROSS-ZONAL TRADING CAPACITY CREATE VALUE FOR EUROPE?

Providing a sufficient and appropriate level of transmission capacity for European electricity trading is an essential joint European energy policy goal. Amprion shares and fully supports this target of further market integration. Yet the currently applied general target values may require some further analytical assessment.

In particular, the consideration of the follow ing three economic principles seems to be beneficial:

- Minimum capacity targets have an effect only if their application leads to a provision of additional virtual trading capacity on network elements which are limiting the electricity market.
- In such cases, value is created only if the welfare gains due to increased cross-zona trading do outweigh the redispatch costs to cope with the overloads resulting from providing virtual trading capacities to the market.
- Minimum capacity targets can only serve a transitionary solution, while target-orien ed investment into network infrastructure is the superior way in the long run.

On a yearly basis, ACER releases a market monitoring report on the appropriateness o transmission capacity provision to the European market⁴². This report questions wheth the transmission capacity provided by Euro pean TSOs in 2020 was sufficient, in particu with regard to the 70% capacity target. Wh this apparent shortcoming of transmission capacity provision can be explained by som specific analytical assumptions which ACER has taken⁴³, ACER's report also explicitly

of electricity exchanges with non-EU countries; exclusive focus only on some particularly low-margin network elements infrastructures', ACER Market Monitoring Report 2020 on page 23

Our analysis has shown the increasing price convergence in CWE where during the year 2020 in 52% of all hours a full price conver- gence (± €1 /MWh) was achieved (cf. Figure 8 on page 27). Together with a further 13% of all hours with at least moderate price convergence (± €3/MWh), the CWE market was nearly unconstrained during 65% of all hours (cf. Figure 8 on page 27).This existing high price convergence rate has been achieved by providing the 20% minimum capacity target applied in the CWE region as well as the 11.5% minimum capacity tar- get included in the Clean Energy Package. Providing additional transmission capacity in compliance with the linear trajectory values indicated in Table 2 would increase price convergence levels even further. Such an increase would, however, require the use of costly remedial actions, a subject which will be discussed in the subsequent chapters. Ultimately, this also raises the question of the efficiency of such additional costly remedial measures, since their costs would have to be compared to the achievable gains and bene- fits, i.e. further increasing price convergence.	/-	excludes full (100%) price convergence as a target of European market integration ⁴⁴ .
This existing high price convergence rate has been achieved by providing the 20% minimum capacity target applied in the CWE region as well as the 11.5% minimum capacity tar- get included in the Clean Energy Package. Providing additional transmission capacity in compliance with the linear trajectory values indicated in Table 2 would increase price convergence levels even further. Such an increase would, however, require the use of costly remedial actions, a subject which will be discussed in the subsequent chapters. Ultimately, this also raises the question of the efficiency of such additional costly remedial measures, since their costs would have to be compared to the achievable gains and bene- fits, i.e. further increasing price convergence.	n	Our analysis has shown the increasing price convergence in CWE where during the year 2020 in 52% of all hours a full price conver- gence ($\pm \in 1/MWh$) was achieved (cf. Figure 8 on page 27). Together with a further 13% of all hours with at least moderate price convergence ($\pm \in 3/MWh$), the CWE market was nearly unconstrained during 65% of all hours (cf. Figure 8 on page 27).
fits, i.e. further increasing price convergence.	as ht- of er o- ular ile	This existing high price convergence rate has been achieved by providing the 20% minimum capacity target applied in the CWE region as well as the 11.5% minimum capacity tar- get included in the Clean Energy Package. Providing additional transmission capacity in compliance with the linear trajectory values indicated in Table 2 would increase price convergence levels even further. Such an increase would, however, require the use of costly remedial actions, a subject which will be discussed in the subsequent chapters. Ultimately, this also raises the question of the efficiency of such additional costly remedial measures, since their costs would have to be compared to the achievable gains and bene-
	2	fits, i.e. further increasing price convergence.

⁴² Report on the result of monitoring the margin available for cross-zonal electricity trade in the EU in the first semester of 2020 ⁴³ E.g. focus only on the day-ahead timeframe without consideration of long-term, intraday and balancing capacity; no full consideration

44 Reaching full price convergence [i.e. 100% of all hours] is not an objective as such, because it would require overinvestment in network

In Flow Based Capacity Calculation arrangements, transmission capacity is provided in the form of CNECs. Depending on the market direction, only some of these CNECs will actually limit the electricity trading. Such limiting elements are called active (limiting) constraints.

Figure 9 shows how often an internal network element of Amprion has actually been such an active constraint, limiting CWE trades during one month as a share of all limiting network elements within this month. The grey area indicates all active cross-zonal constraints for the CWE borders as well as other internal network elements from other TSOs. From 2016 to 2019, Amprion managed to reduce the share of the internal network elements contributing to the limitation of CWE trade continuously, from 39% of all

active constraints in 2016 down to around 8% in 2019. As Figure 9 shows, this trend changed slightly in 2020. The share of Amprion's internal network elements has increased again up to 14% over the whole year. Moreover, the total amount of monitored CNECs in 2019 limiting trade in CWE was the lowest since 2015⁴⁵ and increased by around 25% in 2020. The latter is again at least partially related to the extraordinary occurrences in 2020 and the Covid-19 pandemic, which led to an exceptional grid situation.

Figure 9: Share of Amprion's market-constraining internal network elements, i.e. relative frequency of active critical branches by monthly average^{46, 47}

⁴⁵ The total amount increased from around 5,700 in 2016 up to 7,500 in 2018 and dropped by 35% to 4,900 in 2019. In 2020, there was again an overall increase by circa 25% up to 6,100 monitored trade limiting CNECs

⁴⁶ In order to show the frequency of active CBs (critical branches) over time, the percentages per month have been calculated applying a scaling to 100% for all months. Accordingly, the number of active constraints in one month (labelled as 100%) does not necessarily correspond to the number of active constraints of another month (also labelled as 100%).

⁴⁷ The general information about the critical branches can also be downloaded via the Utility tool available at JAO, see https://utilitytool.jao.eu/

DESPITE THE SLIGHT INCREASE IN AMPRION'S LIMITING NETWORK ELEMENTS, PRICE CONVERGENCE INCREASED

This becomes obvious when taking a look at price convergence in the previous Chapter 3.4. Although there was an increase in active (limiting) constraints, price convergence increased by 3%. In consequence, the trade limiting CNECs in 2020 occurred in a more concentrated way in specific hours than in previous years, which can also be attributed to the singularity of 2020.

As Figure 9 shows only the share of Amprion's limiting network elements of all active constraints, this does not reflect the time of occurrence and potential concentrations of CNECs in specific hours of the year. For that reason, Figure 10 depicts the share of hours in which cross-zonal and internal network elements constrained the CWE trade in 2020. There is a differentiation between hours in which only internal network elements of one TSO or only interconnectors have affected trade in CWE.

Figure 10: Share of active constraints in the CWE domain per TSO control area and cross-zonal elements in 2020^{48,49}

As already seen in 2019, also in 2020 the distribution between cross-zonal and interr network elements limiting the CWE domain

⁴⁸ Please note that allocation constraints are not considered. ⁴⁹ The general information about the critical branches can also be downloaded via the Utility tool available via JAO, see https://utilitytool.jao.eu/

	was fairly equal. While cross-zonal constraints
nal	limited the CWE trades to 46%, internal net-
n	work elements counted for 54%.

Figure 11: Location of major active critical branches in FB MC of Amprion in 2020 as a share of hours per year in which a sufficient capacity for cross-zonal trade is reached The geographical location of the limiting Amprion elements in 2020 is shown in Figure 11.

With regard to internal elements, a particular focus lies on the north-western area of the Amprion grid, which is influenced mainly by north German wind generation. In the last Amprion Market Report⁵⁰, we showed that, in particular, the so-called 'Emsland transmission lines' were affected by the high wind power generation in northern Germany. In March 2019, the dynamic line rating (cf. Chapter 5) was introduced on these lines between TenneT DE and Amprion, resulting in a much lower need for redispatch measures and fewer limitations of trade in CWE in 2020.

Now, the remaining limiting network elements in this area are located near the DE-NL border around Gronau. The location of those limiting constraints indicates that congestion within Amprion is caused mainly by on- and offshore wind as well as the import-export situation. Other major constraints can be found at the

⁵⁰ Available at: https://www.amprion.net/Strommarkt/Marktbericht/

south-west border to the French control zone (Vigy lines) and located close to Frankfurt (around Buerstadt). In case of the Vigy lines, the monitoring results of 2020 show that these lines solely constrain trade in import situations from France to Germany. Such effects can be related to specific locations of power plants, for example if power plants are located close to the border or cross-border lines like the Vigy lines.

Lower exports have led to a lower utilisation of Amprion's transmission grid and therefore also to a lower restriction of the CWE trades. This finding is confirmed by the comparison of one particular week in July in which Germany was importing (Chapter 3.2) and a week in December in which Germany was continuously exporting (Chapter 3.3). The comparison shows that price convergence was higher in import situations where no Amprion CNECs were active and limiting CWE trade. During the characteristic export week, 32 internal Amprion CNECs were constraining the CWE market for 7.2% of the time.

3.6 EXCURSUS: INTRODUCTION OF THE BALANCING ENERGY MARKET

Balancing service providers are offering two different, but closely connected, services to the grid: Balancing capacity and balancing energy. Balancing capacity is basically the 'promise' to be able to increase or decrease the generation on short notice, if this is necessary to balance the power system. The balancing energy is the amount of energy which is then actually activated on short notice for balancing purposes. So far, there has been a common market for balancing energy and capacity in Germany – and only accepted balancing capacity bids were allowed to offer balancing energy as shown in Figure 12. Since November last year, there have been six separate auctions for balancing energy every day – in which all balancing service providers could offer balancing energy, independent of their balancing capacity bids. Balancing service providers that have been awarded on the balancing capacity market have to participate in the balancing energy market at least with the procured volume. At the same time, the price limit for balancing energy was increased from €9,999/MWh to €99,999/MWh.

Figure 12: Process flow chart of balancing energy market introduced in 2020

As the separation of the markets should increase the competition on the balancing energy market, lower balancing energy prices were expected. So far, the opposite has been observed: The liquidity in the market remained low and the prices for balancing energy increased significantly. Apparently, the intraday wholesale market is currently more profitable than the (intraday) balancing energy market, causing the low liquidity in the latter market segment. Since mid-January, the old price limit of €9,999/MWh has been reintroduced, and so far also the price level for balancing energy seems to return to the price levels before the introduction of the balancing energy market. With the separation of the balancing energy and balancing capacity market, Amprion and the other German TSOs are pursuing the way towards the target market described in the European guideline for electricity balancing. The next steps towards this goal will follow this year: The European aFRR (automatic Frequency Restoration Reserve) collaboration PICASSO will be connection-ready towards the end of 2021/early 2022. Consequently, German TSOs will introduce 15-minute balancing energy products, increasing the number of daily balancing energy auctions from 6 to 96.

4. GRID OPERATION ANALYSIS 2020

INCREASING OPERATIONAL CHALLENGES DUE TO HIGHER SHARES OF FLUCTUATING RENEWABLE ENERGIES

In Chapter 3, the impact of transmission capacities on the electricity market has been analysed and described. The actual availability of these transmission capacities has to be ensured in real-time grid operation which is discussed in this Chapter 4. The overloading of grid elements and critical voltage situations have to be avoided by applying remedial actions, i.e. changing the grid topology and taking redispatch measures.

REDISPATCH

The generation of electricity at particular locations in the grid causes electrical load flows. In the event such load flows exceed the technical limitations on particular network elements, the power generation pattern has to be changed. This process is called redispatching, where TSOs must reduce power generation at dedicated locations in the grid

IN 2020, REDISPATCH VOLUMES AND COSTS IN GERMANY WERE AT A RELATIVELY **STABLE LEVEL AND COMPARABLE TO 2019 VALUES**

In 2020, there were not any extraordinary re dispatch volumes in Germany. They increas slightly in comparison to 2019 where volum were particularly low⁵². The latest observed trend of rising redispatch volumes and cost in 2020 is inconspicuous. The main reason the increase is the higher infeed of renewabl into the grid in combination with transits to southern Germany and other European countries, which leads to high load flows an

in order to alleviate the power flow on constrained network elements⁵¹. The two main driving forces of the German redispatch are wind infeed and the load as well as the supply situation in the south of Germany with significant power flows into this southern area.

re-	congestions. For the Amprion grid operation,
ed	congestions on the northern transmission
nes	lines (e.g. Emsland transmission lines, which
ł	are very sensitive to wind power generation
ts	in northern Germany as shown in Chapter 3.5)
for	play a significant role.
es	
	Figure 13 illustrates the monthly redispatch
	volumes and costs for Germany with a focus
nd	on the Amprion share for the years 2018, 2019

st In order to keep electricity generation and demand in balance, power generation has to be increased in other less constrained areas.

⁵² The reasons for the low redispatch volumes in 2019 (among others: low CO₂ price as well as high non-availability of offshore converter stations and as a result lower offshore wind infeed with correspondingly congestion of e.g. the 'Emsland transmission lines') were analysed and summarised in Chapter 4.2 of the previous Amprion Market Report from 2020 (https://www.amprion.net/Market/Market-Report/Market-Report-2020/).

and 2020. For the whole of Germany as well as for Amprion, a moderate increase in redispatch volumes can be observed. Within this moderate increase, for Amprion the volume of voltage-induced redispatch, which increased

tenfold in 2020⁵³, deserves particular attention. An explanation of voltage induced redispatch and the associated effects and challenges of voltage control is provided in the following Chapter 4.2.

Amprion Other DE TSOs

Figure 13: Total monthly redispatch volumes and costs⁵⁴ for Germany (including RES curtailment)55

⁵³ Already in 2019 the volume of voltage induced redispatch of Amprion increased sixteen times compared to 2018.

⁵⁴ Volumes are presented according to the instructing principle (i.e. in which control area power plants have been started in order to cure redispatch. Amprion does not instruct RES curtailment and this data is therefore missing in the volumes for Amprion Costs are presented according to the requester principle (i.e. what costs did incur in order to cure the requested redispatch).

⁵⁵ Disclaimer: The data shown in the graph may differ from RD figures published elsewhere (e.g. EMFIP report), as other sources sometimes contain assumptions for additional costs that have not yet been invoiced. The graph published here contains only the additional costs actually invoiced

SYSTEM OPERATION FACES INCREASING OPERATIONAL CHALLENGES REGARDING VOLTAGE CONTROL DUE TO BOTH HIGH AND LOW VOLTAGE LEVELS AS WELL AS **VOLTAGE FLUCTUATIONS**

as such situations with unexpected voltage fluctuations. On the one hand, this effect is driven by high power-flow transits, especially in a north-south direction, which lead to high grid utilisations associated with high reactive power demands. On the other hand, major power plants are operating for fewer hours, especially in situations where high wind power infeeds cause power-flow transits in a northsouth direction. Other major power plants are going to be removed from the system and will be decommissioned. Thus, these power plants are no longer available for reactive power compensation and the total reactive power reserves of the system decrease. The resulting reactive power demands have to be compensated for by remaining active power plants or reactive power compensation units in order to maintain a constant voltage level within the operational limits. A lack of reactive power can lead to a decreasing or increasing voltage level outside the operational limits, which might, in the worst case, result in a voltage collapse.

The aim of the voltage control is to maintain grid voltages within the operational voltage limits of 390-420 kV for the 380 kV level and 220-245 kV for the 220 kV level. Stable voltage in the grid is one necessary basis for the effective and efficient regulation of the power flow. Thus, voltage control means keeping the electrical network in a stable and operable condition as well as keeping electrical losses to a minimum. For this purpose, system control centres must control the reactive power infeed of power plants and operates additionally with different grid-related measures, such as tap changing of transformers, operation of reactive power compensation units, power plants or converters, topology changes or switching off low-loaded lines. If these measures are not sufficient, market-related measures such as a voltage-related redispatch might be activated. During recent years, system operation has faced increasing operational challenges in terms of voltage control due to situations with persistent high or low voltage levels as well

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High voltage levels:

An increasing number of periods with high voltage levels occur especially in offpeak situations such as weekends or holidays. Due to the decrease in load caused by the Covid-19 pandemic, this effect became particularly apparent during the Easter holidays 2020 (09-14 April 2020).

During this period, a large part of the available reactive power from power plants and reactive power compensation units within the control area of Amprion were activated in order keep the voltage within the operational limits. Another tool of system operation that was used in this situation is the switching off of low loaded lines. This measure allows to decrease the system voltage, since the charging capacity of switched off lines is omitted and the increasing power flow on remaining overhead lines results in an increasing inductive power demand. During this specific situation up to 18 low-loaded lines with a total length of more than 1,000 km were put out of operation for reactive power compensation purposes. At this point all grid-related measures had been activated considering the n-1-criterion

and the local stability of power plants. Despite the utilisation of comprehensive countermeasures, the voltage band was occasionally exceeded at individual points of the grid which clearly shows the need for reactive power compensation units at the transmission grid level.

Low voltage levels:

Figure 14 shows the voltage profiles exemplary for 27 July 2020. During this day a high infeed from wind power plants in northern Germany caused high power transits from north to south. At approximately 6 p.m., system operation had already activated reactive power reserves based on the wind forecast in order to raise the voltage level in advance. In the following hours, the increasing north-south transits due to the increasing wind power infeed caused the voltage to decrease. As a consequence, system operation increased the voltage level again by activating additional reactive power reserves. However, due to the high grid utilisation, the voltage level remained relatively low and volatile, especially in the southern part of the grid (e.g. Hoheneck).

Figure 14: Voltage profiles during high north-south power transits on 27 July 2020

Voltage fluctuations:

Another challenge regarding voltage contro is voltage fluctuations, which are related to the simultaneous change of infeed from gen eration units and which have occurred more frequently in the last years. This effect can b related to, for example, market incentives fo directly marketed generation units or restric tions of operating hours due to noise protec tion. Figure 15 shows three example situation in which a voltage drop of up to 5 kV within few minutes occurred, when several wind power plants in northern Germany started their operation at 6 a.m. due to noise protec tion restrictions during night-times. In such situations, dynamic reactive power reserves

Amprion approaches the challenges regardir voltage control in different ways. By develop ing new methods for predicting the reactive power demand of the future system, new reactive power components and their location can be planned at crucial points in the grid in advance. Up to the year 2023, Amprion is planning to build 22 new reactive power con pensation units with a total capacity of almost 5,200 MVAr. In addition, Amprion works on a system for dynamic security assessments

	are essential to limit the voltage fluctuations.
bl	Thus, system operation keeps dynamic re-
	active power reserves available at all times.
۱-	The increasing number of similar situations
è	and their rising impact on the system show
be	the increasing need for dynamic reactive
or	power reserves at the transmission grid level.
C-	Furthermore, beside these non-fault effects,
<u>)</u> -	the impacts on the reactive power demand and
ns	voltage due to grid faults need to be taken into
	account anytime. Here reactive power reserves
	are also needed to handle grid faults and to
	support a return to a stable operation point.
-	That is why the system operator not only
	keeps dynamic power reserves for power flow
;	fluctuations, but also for possible grid faults.

Figure 15: Voltage fluctuations related to the simultaneous change of infeed from generation units

ng	which allows real-time voltage stability
o-	assessments during system operation and
	the determination of operational counter-
	measures. Moreover, new curative measures
on	for stabilising the voltage level in emergency
	situations are developed and implemented.
	All these actions will contribute towards main-
n-	taining a stable system operation in the future
ost	as the number and impact of the previously
	described situations increases.

5. FUTURE DEVELOPMENTS

FOR THE TRANSFORMATION OF THE EUROPEAN ENERGY SYSTEM, NEW CONCEPTS FOR THE INTEGRATION OF RENEWABLE OFFSHORE ENERGY AND SECTOR COUPLING ARE NECESSARY

Further development and improvement of the existing electricity grid is the core business of TSOs, and in particular, an increase in transmission capacity, a reduction in congestions and an enhancement of trading capabilities. In 2021 and beyond, Amprion will support cross-zonal trading by taking several additional measures.

The previous chapters have illustrated the main CWE market trends and Amprion's operational activities in supporting current and future market integration. This section provides a short summary of Amprion's planned future grid reinforcements and expansions. Strengthening our grid is an essential prerequisite for integrating renewables and alleviating the transmission constraints described in Chapter 3.5 and 3.6 which will accommodate further domestic and European electricity exchange. In the longer term, our plans will also pave the way for a fully integrated carbon-neutral energy system by 2050 which is envisaged by the European Green Deal.

REINFORCEMENT AND EXPANSION OF THE EXISTING POWER GRID

Since 2015, Amprion received the permit granting for about 530 km of transmission lines. Furthermore, 457 km of the transmission lines that Amprion has to build based on the EnLAG⁵⁶ and BBPIG⁵⁷ have already been built by the end of 2020. Amprion is supporting the market by strengthening and extending its grid infrastructure by more than 1,500 km in the next ten years. Two of Amprion's light house projects are HVDC (high-voltage direct current) links from Emden in northern Germany to Osterath in western Germany and from Osterath to Philippsburg in southern Germany. These projects are known as the A-Nord project and the Ultranet project - one of the future cornerstones of the German transmission grid. Both projects are included in relevant legislation⁵⁸. While the A-Nord project is planned as an underground cable system, the Ultranet project is planned as a hybrid system using the same pylons for DC lines in parallel to the already existing AC lines.

Considering the future developments in the German and European energy system up to 2030, the national grid development plan 2019 identified the need for an additional DC corridor from northern Germany to western Germany by 2030 (Corridor B - North). Amprion has already started the initial steps to develop this corridor, and the project is also included in the relevant legislation⁵⁹. In the recent national grid development plan 2021, the need for one further DC corridor from northern Germany to the Frankfurt Area has been identified (Corridor B - South). Figure 16 shows all the planned DC projects of Amprion. These projects will support the German and European energy transition by effectively integrating the massively expanding wind power generation in northern Germany (as shown in Chapter 3.3) into the grid. In total, Amprion is planning grid investments of 24 billion euros over the next decade.

⁵⁶ EnLAG = Energieleitungsausbaugesetz

⁵⁷ BBPIG = Bundesbedarfsplangesetz

⁵⁸ The Federal Requirements Plan Act which lists the transmission projects that are legally defined through the German parliament. The German TSO are obliged to implement these projects.

⁵⁹ The update of the Federal Requirement Plan Act in 2021

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AMPRION IS CONTRIBUTING TO THE TRANSFORMATION OF THE EUROPEAN ENERGY SYSTEM BY EXPANDING AND REINFORCING THE EXISTING TRANSMISSION GRID AND VIA NEW CONCEPTS FOR THE IN-TEGRATION OF RENEWABLE OFFSHORE ENERGY AND SEC-TOR COUPLING WITH POWER-TO-GAS TECHNOLOGIES.

This figure is only schematic and conceptual. It does not necessarily correspond to any concrete grid planning.

AMPRION MARKET REPORT 2021 Figure 16: Amprion's overall concept for the integration of offshore energy and power-to-gas ----- Offshore connection HVDC lines Offshore grid Amprion AC grid Offshore wind power **Onshore wind power** 凸 PtG plant FUTURE DEVELOPMENTS | 43

INTEGRATION OF THE ALEGRO DC-INTERCONNECTOR AS A MILESTONE IN ADVANCED AND FUTURE MARKET COUPLING

The integration of our ALEGrO project has marked a milestone for the CWE Market Coupling and further increases the trading possibilities in CWE as mentioned in Chapter 3.5. The first day of commercial operation was for business day 18 November 2020 (allocation day 17 November 2020). ALEGrO represents the first connection between

Belgium and Germany and will play a major role in bringing the European electricity market closer together. Spanning a distance of 90 km, the high-voltage underground cable uses HVDC transmission technology and strengthens the security of supply in both countries and beyond. It is capable of carrying around 1,000 megawatts (MW) of power.

FURTHER DEVELOPMENT OF THE DYNAMIC LINE RATING

Further to building new infrastructure, Amprion is continuously optimising the use of its existing grid. For this purpose, we have introduced dynamic line ratings on several of our transmission lines, allowing higher electricity transmission under favourable weather conditions, i.e. low temperatures⁶⁰. This measure allows for an increase in thermal limits of more than 20%, in particular during cold weather conditions which are usually associated with a high demand for electricity. In addition to the practical implementation of the network elements, the legal requirements according to §43f EnWG must be fulfilled. Especially different measures are necessary to keep voltage inductions into parallel infrastructures (e.g. gas pipelines) below certain threshold values.

Amprion's dynamic line rating concept has been applied particularly to those network elements which have been constraining the CWE FB MC (cf. Figure 11 on page 32). In March 2019, the concept was introduced on the Emsland transmission lines (Dörpen - Hanekenfähr) between TenneT DE and Amprion which have been a major bottleneck in the market (cf. Chapter 3.5. on page 30 to 33). This route also forms the crucial connection of the offshore HVDC converters in Dörpen to the AC grid in North Rhine-Westphalia. By increasing the maximum transmission capacity of the Emsland line by 25%, the need for redispatching has been significantly reduced, increasing the opportunities for offshore wind infeed in this area.

In order to further improve the impact of the weather-dependent operation of overhead lines on capacity and redispatch reduction, the next phase of the dynamic line rating concept has already been initiated. For this purpose, Amprion plans to install 200 weather stations by the end of 2022. Their measurements will allow for a better parameterisation of network models applied in operational congestion management processes.

⁶⁰Lower temperatures generally allow higher electricity transmission since the sag of overhead lines reduces. This allows for an increase in the maximum permissible power flow on a critical network element (Fmax) which is derived from the maximum current on a critical network element (I_{max}). Imax is the physical (thermal) limit of the critical network element, which depends on installed components (conductor, bundle, instrument transformer, etc.) and the weather conditions

INNOVATIONS IN OFFSHORE RES INTEGRATION

We have shown the already existing high market impact of wind power generation (cf. example week described in Chapter 3.3). There are ambitious plans to extend this wir power generation further, both on a nationa and European level, and in particular target at offshore wind. For an efficient and flexible utilisation of this wind power generation an integrated offshore and onshore system needs to be established stepwise. This futur system will be a combination of offshore connection systems, partly up to the domest load centres, as well as national and international offshore HVDC corridors. The diver sity of such a setup needs to be considered within a modular structure and implemented

MULTI-SECTORIAL PLANNING SUPPORT

Our market analysis has shown that there are times with excessive renewable energy production, while at other times, renewable production falls short of the demand for electricity (cf. example days described in Chapter 1). This trend will increase with a higher share of renewable electricity generation. In particular, at times when, in future, demand falls short of excessive renewable electricity production, sector coupling technologies come into play. Sectors that were previously decoupled could then be connected and form an integrated energy system. Such an integrated system needs a holistic system planning process that combines the current individual planning processes for energy infrastructure in a multi-sectoral way to ensure an affordable, effective and efficient energy transition in line with the European climate goals.

Beyond conventional grid planning, within ENTSO-E Amprion has therefore developed the concept of Multi-Sectorial Planning Support (MSPS) together with several European partners. This holistic approach will link the nowadays separated planning processes of electricity and gas infrastructures. It will start with the identification of joint scenarios followed by economic and technical assessments aimed at finding different pathways to find a cost-efficient overall 'one system' solution.

	stepwise. Existing national and international
	planning processes still play a role in this con-
	text. They will be implemented autonomously
nd	but in close cooperation by all European
ıl	partners. Only such a consideration of existing
ed	domestic plans and processes will ensure,
	simplify and accelerate the implementation of
n,	both European and domestic offshore wind
	power targets. Amprion is a partner in the
e	Eurobar Initiative, where we are developing
	such concepts and are making them a reality
tic	with our European partners. Eurobar is follow-
	ing the idea that interfaces will be standard-
-	ised for the upcoming generation of offshore
	connection technologies - making them
d	'offshore grid ready'.

In light of long lead times (several years) from the planning processes to the realisation of infrastructure, the approach should be implemented as soon as possible. This implementation of a synchronised planning process should take place both on European and national level.

In terms of power-to-gas facilities, their location determines how energy is transported - in the form of electricity or gas. As both ways result in different costs, the location of those facilities has to be considered in the planning processes. Furthermore, Amprion has developed a flexible operational strategy. At any given point in time, the strategy would determine the use of green electricity either as electricity consumption or the production of hydrogen (electricity-gas switch). Together with our project partner OGE (Open Grid Europe), Amprion has furthermore set up the 'hybridge' project to develop the power-to-gas technology to an industrial scale. The aims of the 'hybridge project' are a combination of the technology scale-up and its system-supportive operational use. We have pushed the project to a level that we could enter the permission phase. However, without a clear regulatory basis from politics we cannot realise the project.

6. CONCLUSION AND OUTLOOK

THE CURRENT DYNAMIC DEVELOPMENTS IN THE ELECTRICITY SYSTEM AND MARKET WILL CONTINUE OVER THE NEXT DECADES

This Market Report provides evidence of the dynamic electricity market environment in which Amprion operates together with many other institutions. It starts with an illustration of current and future changes in the electricity production pattern. The year 2020 was an exceptional year in many respects, with the outbreak of a global pandemic probably having a significant impact on the entire electricity system. The lockdown measures across much of Europe at the beginning of 2020 had significant impacts on the electricity market. The effects, such as a significan drop in energy demand and further changes in the generation mix, have been analysed and presented at the beginning of this repor All further analyses and comparisons with previous years are therefore characterised b the partly overlapping effect of the Covid-19 pandemic. Nevertheless, some effects have further intensified in 2020 and in particular the increasing German imports in the summe months should be noticed. The net position the DE-LU bidding zone is consistently high (exporting) during winter months and low (in porting) during summer months. As in 2019, Germany became a net importer in several weeks during the summer-time from May to October 2020. Some very specific situations (for example, high German imports in the su mer) are analysed in detail in the report. The German net position is strongly dependent on the wind and solar infeed and shows rapi changes even within a few hours of a day.

The current dynamic developments will pers into the future. To accommodate the changing generation pattern, to facilitate the integration of renewables into the system and to ensure the physical transmission of increasing mark

9	flows across Germany and Europe, Amprion is continuously enhancing and optimising its
У	grid. The new interconnector ALEGrO went
n	operational at the end of 2020. Since the
	go-live of ALEGrO, which represents the first
	interconnection between the German and
he	Belgian transmission grid, the Amprion grid is
	now interconnected with every foreign CWE
	TSO. This special role in Germany and in CWE
	is accompanied by our significant commitment
	to the European electricity market.
nt	The European Green Deal accelerates the
S	transformation of the European energy system
	to enable a fully integrated climate-neutral sys-
rt.	tem by 2050. As infrastructure is a key enabler
	of the European energy transition, European
ру	TSOs play an important role in meeting the
9	objectives of the Green Deal and in implement-
	ing a functioning internal energy market.
er	The role and capacity of the electricity grid
of	as the backbone of the decarbonisation of
	all energy sectors is becoming increasingly
m-	important. By promoting the integration
,	of renewables and enabling the integration
	of new clean energy technologies to plug
	into the energy system - including offshore
S	renewable energy and hydrogen – the
ım-	power grid is crucial to a reliable, affordable
9	and sustainable energy system.
id	Decarbonisation by 2050 requires the
	planning of tomorrow's infrastructure and
	development of sustainable concepts already
sist	today. With a view to making our transmission
ng	network fit for purpose and future-proof, we
ion	at Amprion think in the long term, take innov-
5	ations into account and adapt our system
ket	planning in a continuous and flexible manner.

In order to secure a balanced and stable electricity system across Europe, strengthening, reinforcing and optimising the electricity grids are crucial prerequisites for a successful and efficient integration of renewables. For this purpose, Amprion is planning grid investments of 24 billion euros over the next decade. Achieving this goal requires local acceptance for the timely implementation of infrastructure projects and an adequate regulatory framework for investments, as well as investment certainty. A legislative and regulatory (financial) framework that actively supports the development of European energy infrastructure is therefore essential and should be promoted through the TEN-E revision.

The envisaged expansion of renewables will not be sufficient by itself and the electrical energy system of today will have to be enhanced. More flexibility, for example through seasonal storage and innovative concepts such as sector coupling and integration, is needed to make the energy system fit for purpose and decarbonised for the future. Here the TSOs can also be important enablers and market integrators for the energy transition process, using such instruments in a targeted and thus efficient manner. An increasingly coupled and integrated energy system would be a strong support for achieving decarbonisation targets in other sectors (buildings, heat, transport and industry). This requires coherent infrastructure planning at national, regional and European level. The European grid should be jointly planned in the future by the electricity and gas TSOs.

Security of supply, sustainability and costs must be reconciled. In order to ensure a further reduction of CO_2 emissions in line with the EU targets, while maintaining Europe's security of supply and industrial competitiveness, cross-sectoral approaches and technology diversity and neutrality, as well as flexible regulation are required. Since innovation requires the timely setting of a stable framework and the right incentives, an appropriate legal framework needs to be set up.

LIST OF ABBREVIATIONS

ACER	Agency for the Cooperation of	Fmax	Maximum
	Energy Regulators	Fref	Reference
aFRR	Automatic Frequency	FRM	Flow Relia
	Restoration Reserve	HVDC	High-Volta
ALEGrO	Aachen Liège Electricity Grid	ID	Intraday
	Overlay	Imax	Maximum
СВ	Critical Branch		Network E
СВСО	Critical Branch Critical Outage	LTA	Long-Term
CCR	Capacity Calculation Region	MAF	Midterm A
CEE	Central Eastern Europe	NRA	National R
CEP	Clean Energy Package	PST	Phase Shif
CNE	Critical Network Element	PTDFs	Power Trai
CNEC	Critical Network Element and		Factors
	Contingencies	RAM	Remaining
CWE	Central Western Europe	RE	Renewable
DA	Day-Ahead	RES	Renewable
ENTSO-E	European Network of	SIDC	Single Intr
	Transmission System Operators	TEN-E	Trans-Euro
	for Electricity		Energy
EU	European Union	TSO	Transmissi
FB MC	Flow-Based Market Coupling	XBID	Cross-Bor

max	Maximum Allowable Power Flow
ref	Reference Flow
RM	Flow Reliability Margin
IVDC	High-Voltage Direct Current
D	Intraday
max	Maximum Current on a Critical
	Network Element
.TA	Long-Term Allocation
1AF	Midterm Adequacy Forecast
IRA	National Regulatory Authority
PST	Phase Shifter Transformer
PTDFs	Power Transfer Distribution
	Factors
RAM	Remaining Available Margin
RE	Renewable Energy
RES	Renewable Energy Sources
SIDC	Single Intraday Coupling
EN-E	Trans-European Networks for
	Energy
SO	Transmission System Operator
(BID	Cross-Border Intraday Project

CONTACT

Lena Breuer

Amprion GmbH Economic Grid Management International Affairs Robert-Schuman-Straße 7 44263 Dortmund, Germany

MarketReport@amprion.net

FURTHER INFORMATION IS AVAILABLE AT

www.amprion.net/Market/Market-Report/

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Amprion GmbH Phone +49 (0) 231 584 914 109 Fax +49 (0) 231 584 914 188 Email info@amprion.net

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Dr Peter Lopion

Amprion GmbH Economic Grid Management International Affairs Robert-Schuman-Straße 7 44263 Dortmund, Germany

MarketReport@amprion.net

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Amprion GmbH Robert-Schuman-Straße 7 44263 Dortmund Germany

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