

**Influence of the COVID-19 pandemic on Flow-Based Market Coupling**  
International Energy Industry Conference at TU Wien – IEWT 2021

Goal | Analysis | Model | Results | Conclusion

Yash Patel, Mihail Ketov, Huangluolun Zhou and Ninghong Sun

Online, 09 September 2021

## COVID-19 – How performed Flow-Based during the pandemic?

### Global COVID-19 pandemic

- Public measures to limit infections
- ➔ Reduction of economic activities, social routines and electricity demand

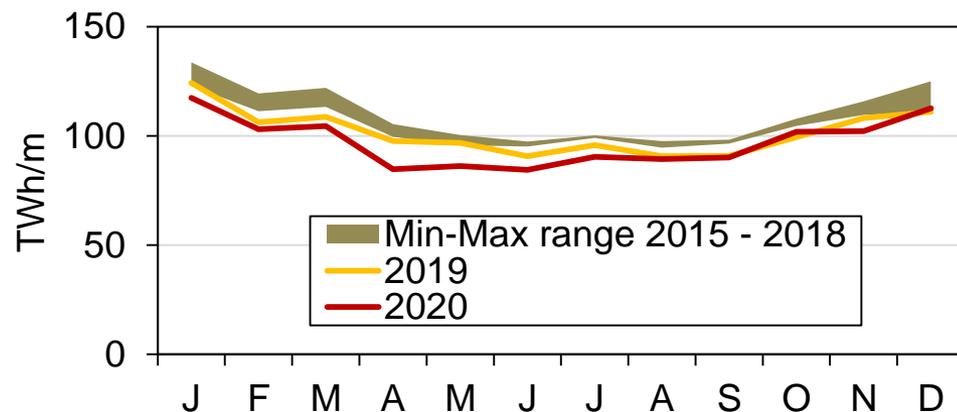
### European electricity exchanges

- Exchanges traded in 27 countries
  - ◆ Im- and exports for security of supply and social welfare maximisation
  - ◆ Central Western Europe (CWE) applies Flow-Based Market Coupling (FBMC)
- Prior to FBMC introductions analysis to ensure positive social welfare gain
  - ◆ Forecasts were based on common market situations
  - ◆ Longer pandemics not considered
- ➔ Performance in pandemic not clear

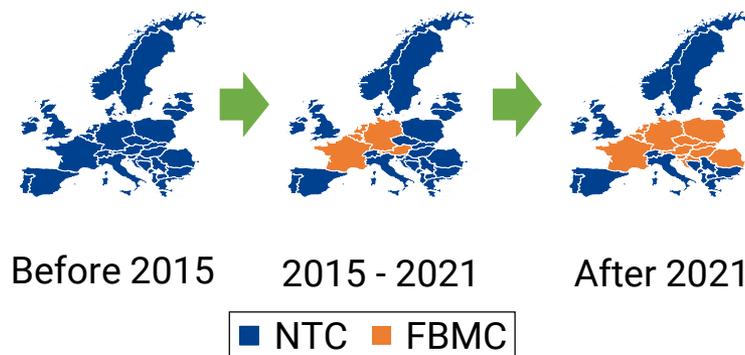
### Aim

Quantitative techno-economic analysis of FBMC during the pandemic

### Vertical grid load in Central Western Europe\*



### Exchange market designs in Europe



\*Source: ENTSO-E Transparency Platform.

## Fuel and emission prices – Drop and return during Covid-19

### Non-COVID in 2019 vs COVID in 2020

- Price decline in the first lockdown at the start of 2020
  - ◆ 19% natural gas price (yearly average)
  - ◆ 34% hard coal price (yearly average)
- ➔ Reduced industrial consumption and electricity pushed prices downwards

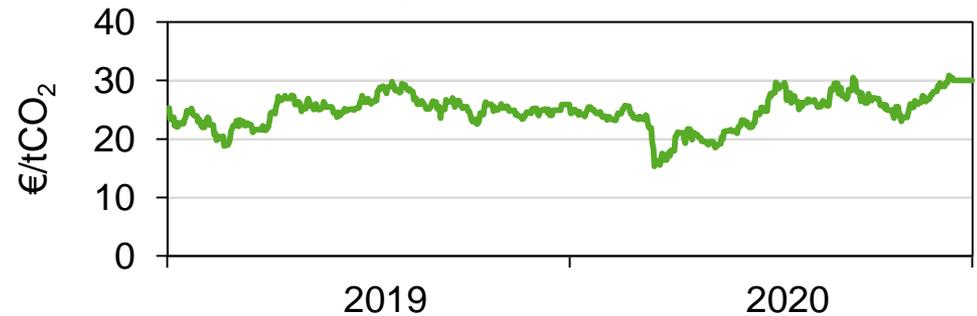
### Pandemic effect

- Relaxation of public measures lead to price rebound behaviour
- Price recovery by the end of the year
- ➔ Pandemic experience reduced market risk and brought price levels back

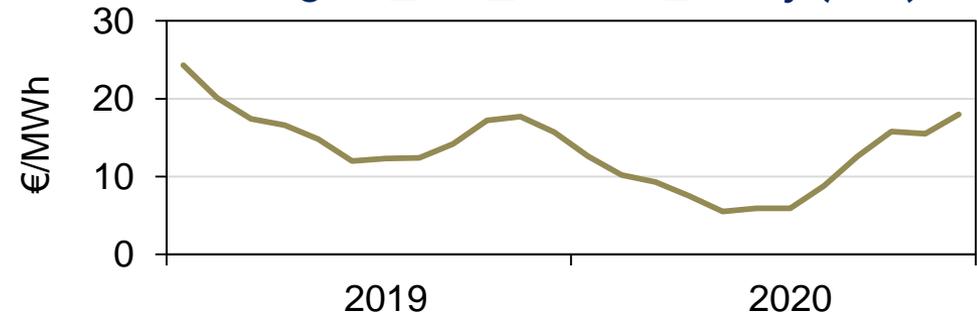
### Effect on electricity markets

- Generation cost of system mainly due to thermal power plants
- ➔ Lower fuel and emission prices reduced electricity generation cost

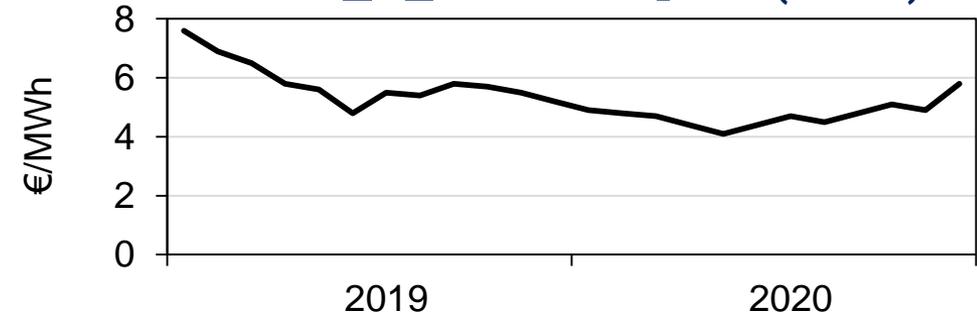
### Emission: European Union Allowance (EUA)\*



### Natural gas: Title Transfer Facility (TTF)\*



### Hard coal: All Publications Index (API#2)\*



\*Source: Energate market data.

## FBMC domain – Commercial exchange capacities raised due to less grid utilisation

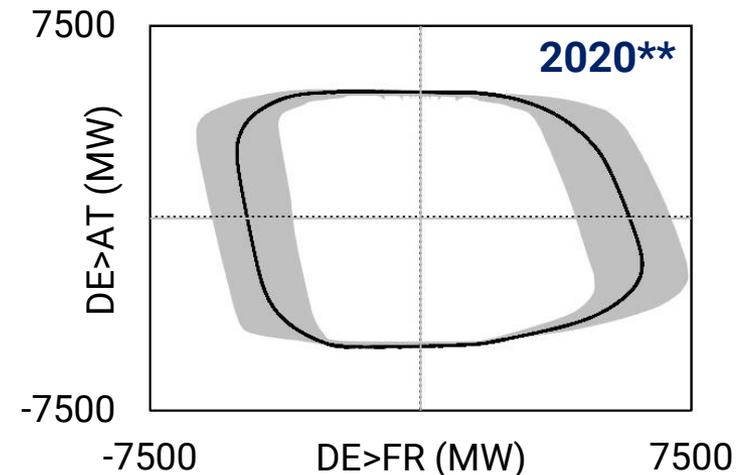
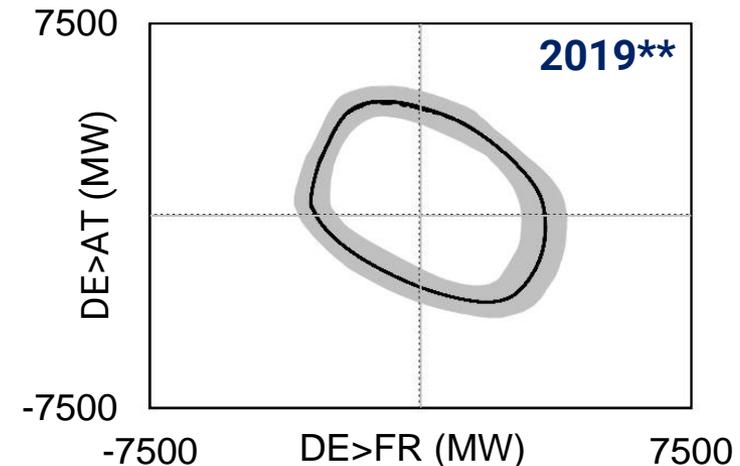
### Historical flow-based restrictions

- Commercial exchange capacities increased with physical similar grid
- Example: Germany-Austria
  - ◆ Absolute capacity rise
  - ◆ Variability of capacity reduced
  - ◆ FBMC domain shape closer to Net Transfer Capacity (NTC) in 2020
- ➔ German-Austrian exchange less dependent on German-French in 2020

### Less line utilisation in base case

- Less electricity consumption in 2020 compared to 2019
  - ◆ Increase of average Remaining Available Margin (RAM)
  - ◆ Physical limits reached with higher commercial flows in 2020
- ➔ Pandemic effects led capacities to rise

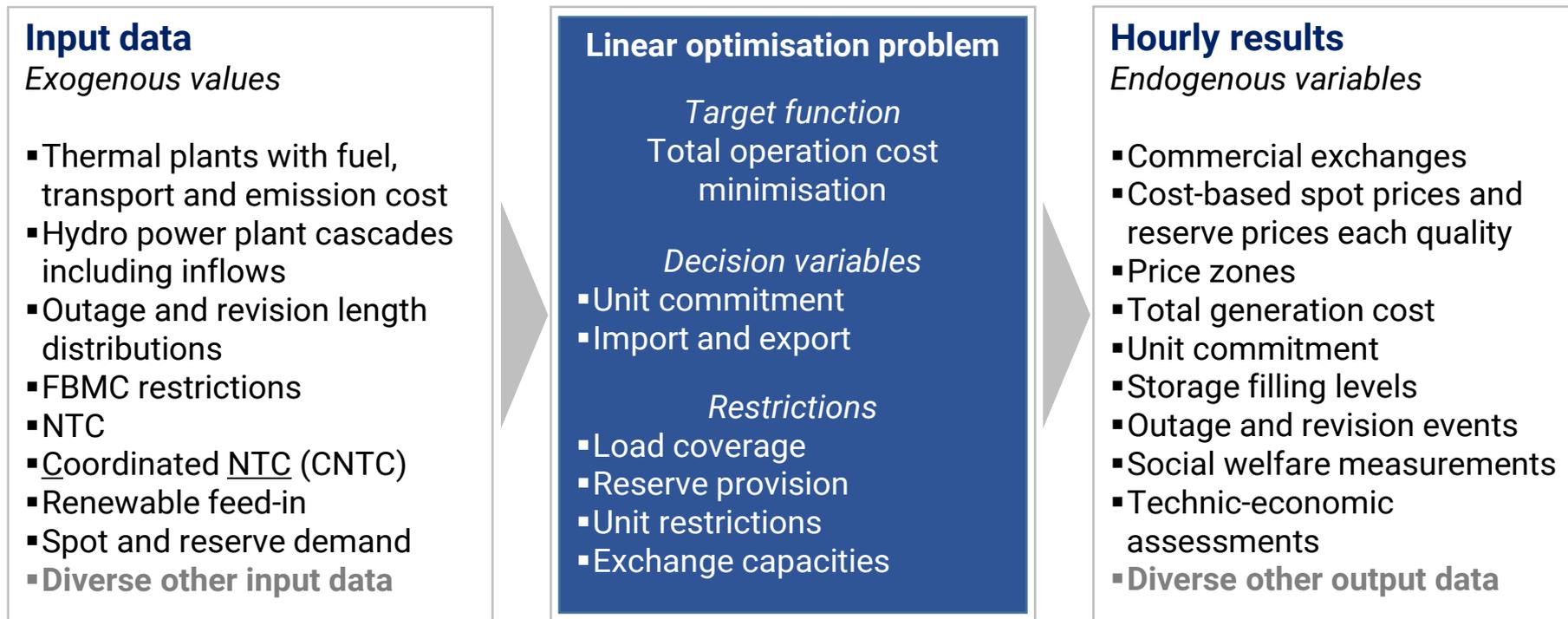
### Exemplary average flow-based domain\*



\*Methodology: Average restrictions calculated based on intersecting points of all hourly feasible domains of a year and the origin.

\*\*Source: Joint Allocation Office (JAO).

## Market simulation – Yearly Europe-wide implicit day-ahead market clearing



### Assumptions

#### ○ Market approximations

- ◆ Perfect competition
- ◆ Perfect foresight
- ◆ Level playing field

#### ○ Exchange assumptions

- ◆ Post-processed FBMC exchanges via a quadratic optimization
- ◆ NTC exchanges directly used

➔ Simultaneous capacity allocation in a hybrid NTC, CNTC and FBMC market model

## Scenarios – NTC vs FBMC for 2019 and 2020 to assess market coupling design

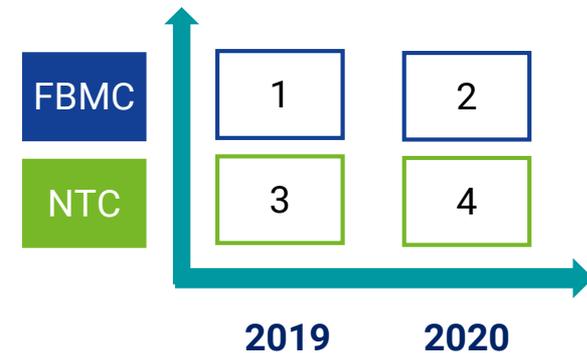
### Input data sources

- Hourly load and feed-in of renewable energy sources from ENTSO-E
- Power plant data base from Maon
- Exchange capacities
  - ◆ FB domains (approximately 1.3 million restrictions) from JAO
  - ◆ NTC for CWE generated from FB domain for every hour
- ➔ 8760 coupled consecutive hours and 5000 units endogenously modelled

### Modelled region

- Bidding zones in CWE connected with 14 other bidding zones
- Net position of CWE interdependent with net position of surrounding area
- ➔ Simulating the Single Day-Ahead Coupling (SDAC) region to capture the interdependencies

### Four simulation scenarios



### 50 modelled bidding zones



## Spot prices – Multiple higher influence of COVID than FBMC

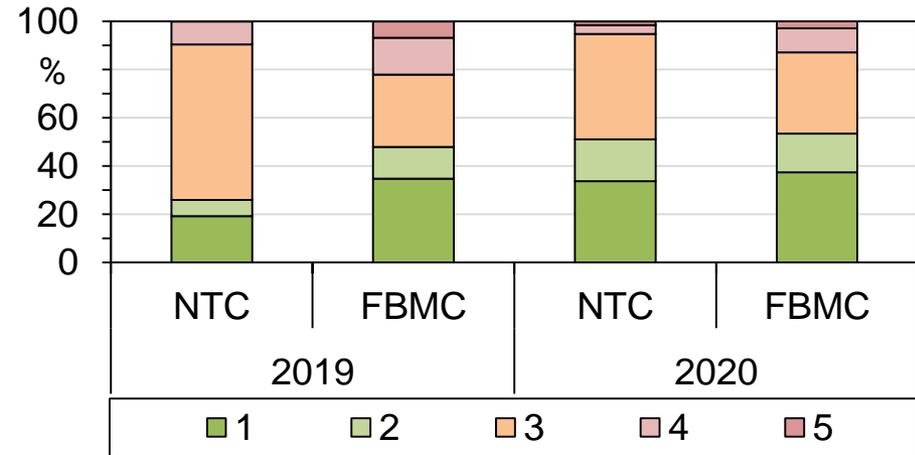
### CWE price convergence

- FBMC leads to higher price convergence indicating greater interconnector utilisation
- Higher capacities in COVID times led to greater price parity
- ➔ High-load situations (2019) with FBMC as the superior coupling design

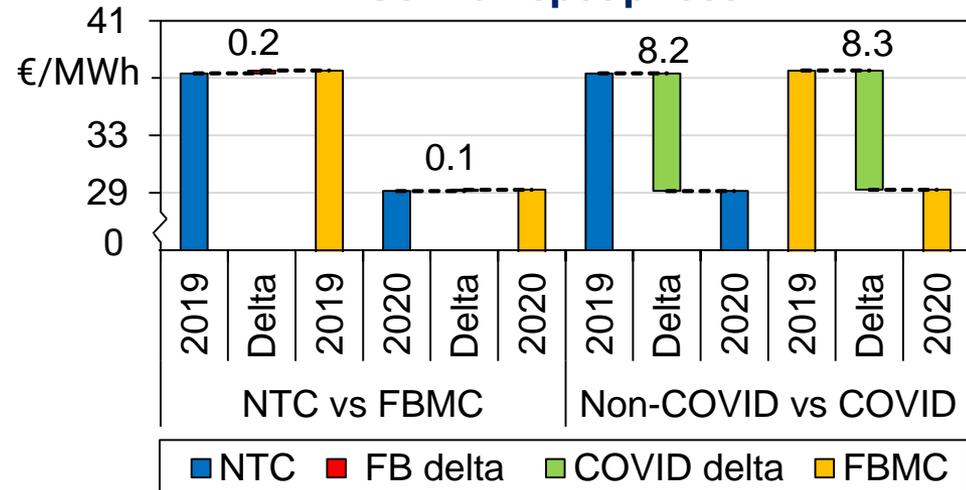
### German spot base prices

- Prices do not differ significantly between NTC and FBMC
- Pandemic year reduction was 8 €/MWh and market design difference at approx. 0.2 €/MWh
- ➔ Lower demand and fuel prices during pandemic led to reduction of base spot prices in Germany by over 20%

### Number of price zones in CWE\*



### German spot prices



\* Methodology: Bidding zones with price deltas within the range of 1 €/MWh is considered to be one price zone.

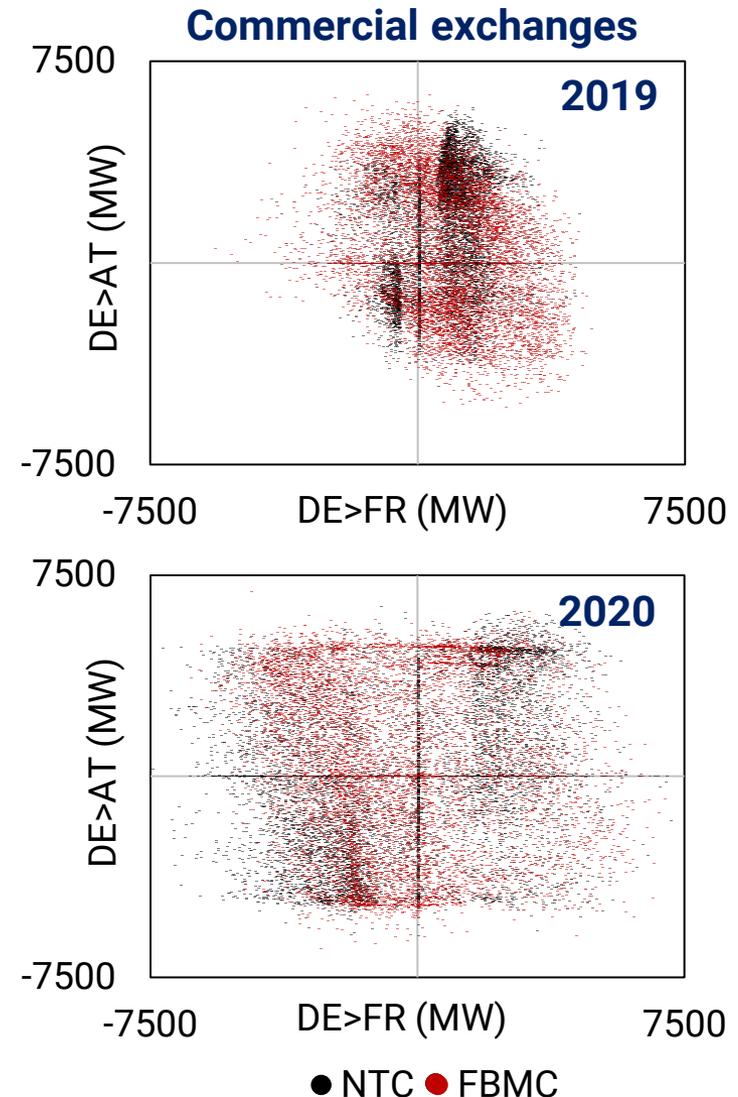
## Cross-border exchanges – Commercial exchange flexibility higher with FBMC

### Domain edge

- Higher commercial capacities in 2020
  - DE>AT more often at edge during 2020 due to missing domain variability
  - NTC flows display sharper boundaries
    - ◆ NTC exchanges only consider flow limits of one commercial line
    - ◆ FBMC exchanges consider flow limits of all critical lines within the region
- Greater exchange magnitude and variability for FBMC in both years

### Domain center

- FBMC exchanges more often near the vertical axis than NTC
    - ◆ Multi-lateral influences in FBMC
    - ◆ NTC does not reach FBMC flexibility
- Lower exchange magnitude in FBMC allows higher utilisation of other lines
- FBMC enables greater economic gains



## Social welfare indications – FBMC reduces generation costs especially in CWE

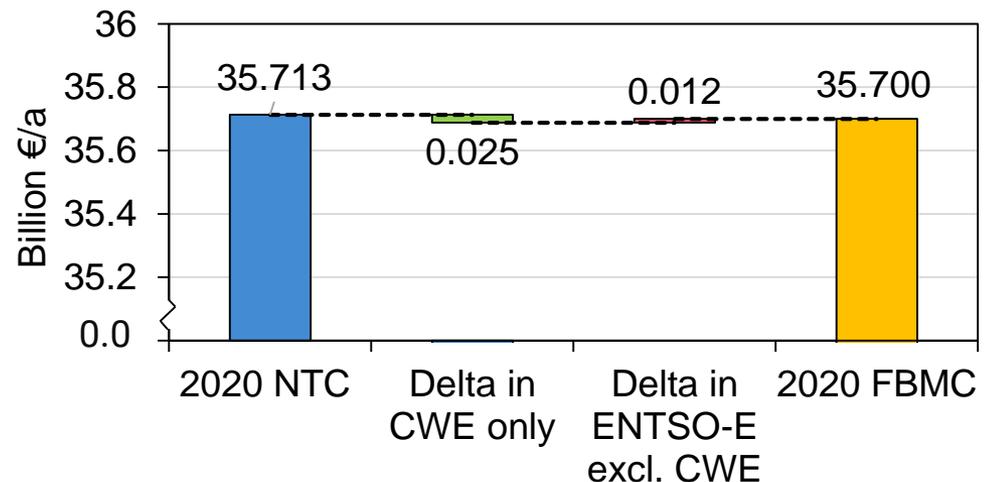
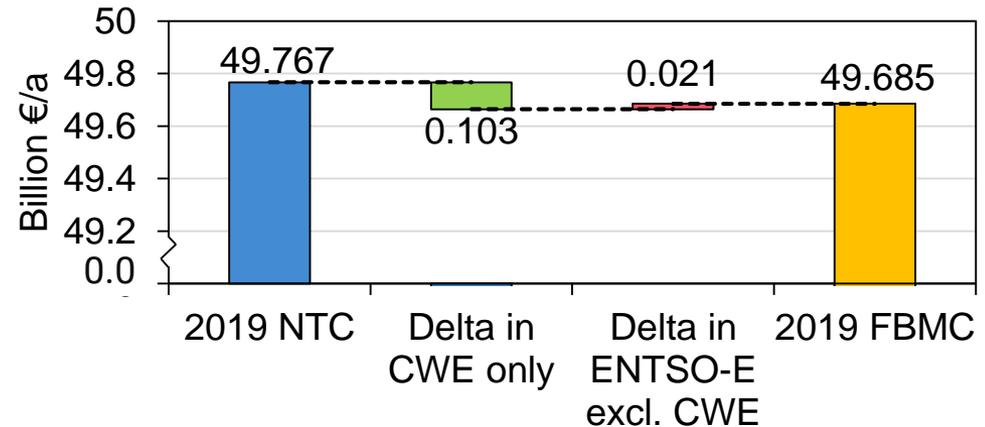
### FBMC vs NTC

- More flexible exchanges due to FBMC reduce cost in CWE, but lead to lower export to non-CWE
- To compensate missing electricity supply, non-CWE cost rises
- ➔ Cost increase outside CWE lower than cost reduction within CWE (FB region)
- ➔ Overall lower total costs

### COVID vs non-COVID

- Difference of approx. 14 billion €/a
- In higher load scenario (2019), FBMC yields greater gains
- ➔ Load has multiple higher influence on cost than exchange design
- ➔ FBMC leads to higher social welfare for the overall system during non-COVID as well as COVID year

### Total generation cost



## Key take away – FBMC superior to NTC for pandemic and non-pandemic times

### Goal

- Quantitative techno-economic analysis of FBMC behaviour during long lasting pandemic

### Analysis

- Drop for fuel and emissions price in first lockdown and return afterwards
- Higher commercial exchange capacities during COVID-19

### Model

- Simulating all bidding zones in SDAC with a hybrid NTC, CNTC and FBMC model

### Results

- Significant higher price convergence for FBMC in comparison to NTC
  - Spot price difference by market design at 0.2 €/MWh and by COVID-19 at 8 €/MWh
  - Reduction of 14 billion €/a in total generation costs during pandemic
- ➔ FBMC emerges as the better approach of the two during normal time as well as for a global pandemic

# **MAON**

Maon GmbH | Bismarckstraße 10-12 | 10625 Berlin

Yash Patel, M.Sc.  
[yp@maon.eu](mailto:yp@maon.eu)

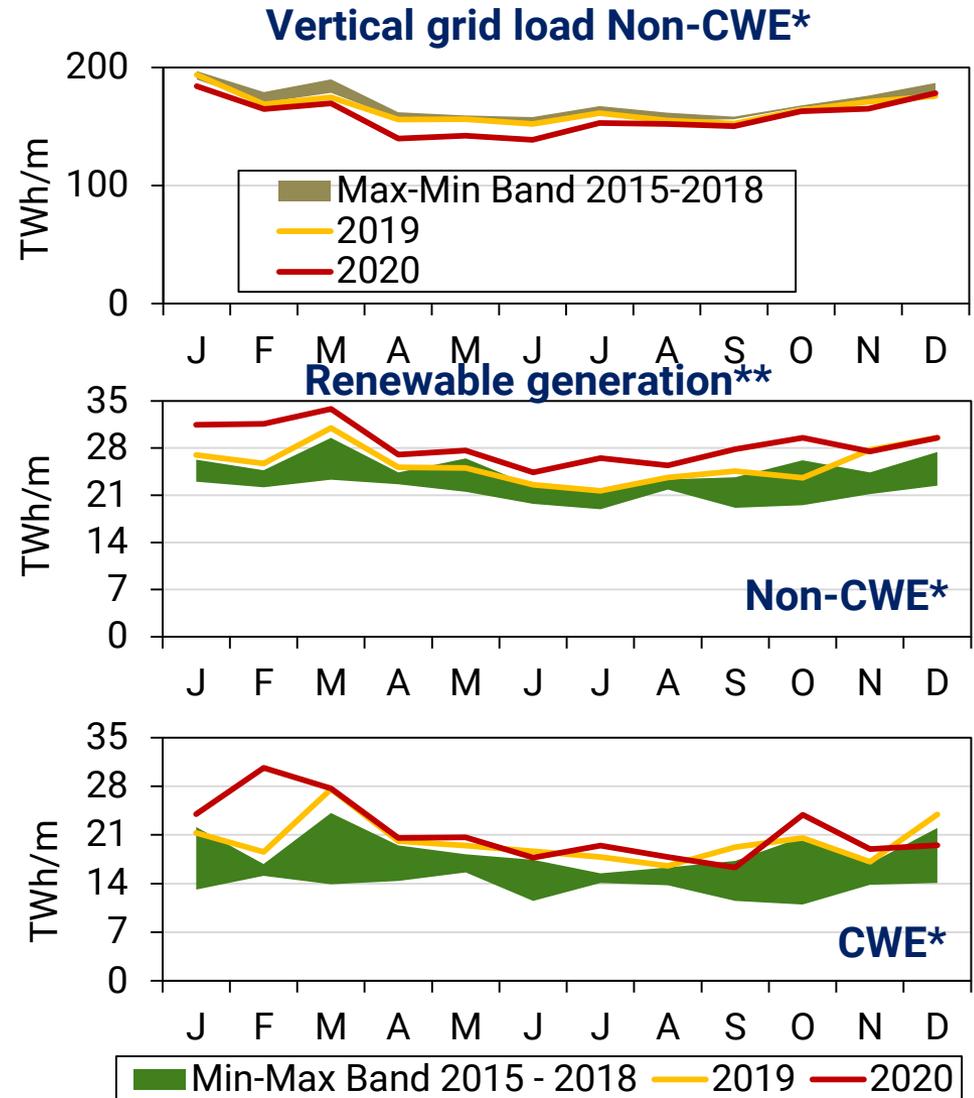
## COVID-19 – Lower demand with higher renewable generation

### Demand

- Non-CWE experience similar effect in grid load as CWE
- ➔ CWE to non-CWE exchanges will be affected

### Variable renewable generation

- Generation amount increased for CWE and non-CWE for 2019 and 2020
- Installation of new capacities led to higher output compared to historical years
- ➔ This will push the prices even downwards



\*Source: ENTSO-e

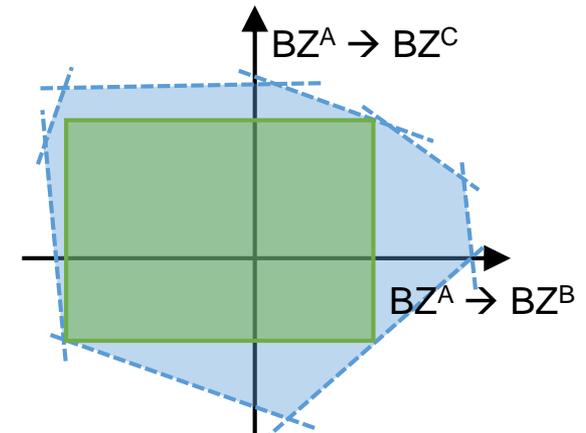
\*\* Solar, wind onshore, wind offshore

## NTC estimation – Technically feasible NTC domain for each hour

### Methodology

- Estimation of hourly NTC value using FB domain
- Multi-lateral dependences taken into consideration
- Maximize individual exchange values
- ➔ Technically feasible NTC values for all valid lines in the CWE region

### Exemplary estimation



- Net Transfer Capacity (NTC)
- - - Flow-Based Market Coupling (FBMC) restriction
- Bidding Zone (BZ)

\*Source: ETNSO-E Transparency Platform.

## Model validation – Model mimics reality

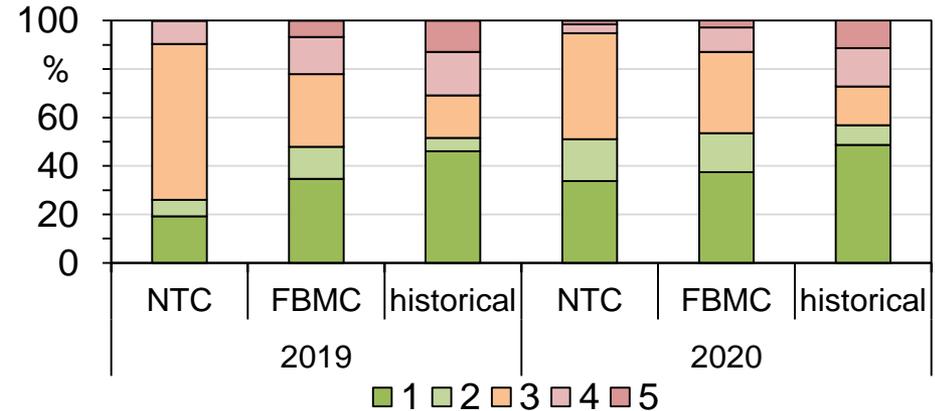
### Historical price convergence

- FBMC simulation output and historical values closely related
- 2020 in reality also showed higher price convergence
- ➔ Due to lack of perfect foresight, the historical values show higher price convergence than model outcome

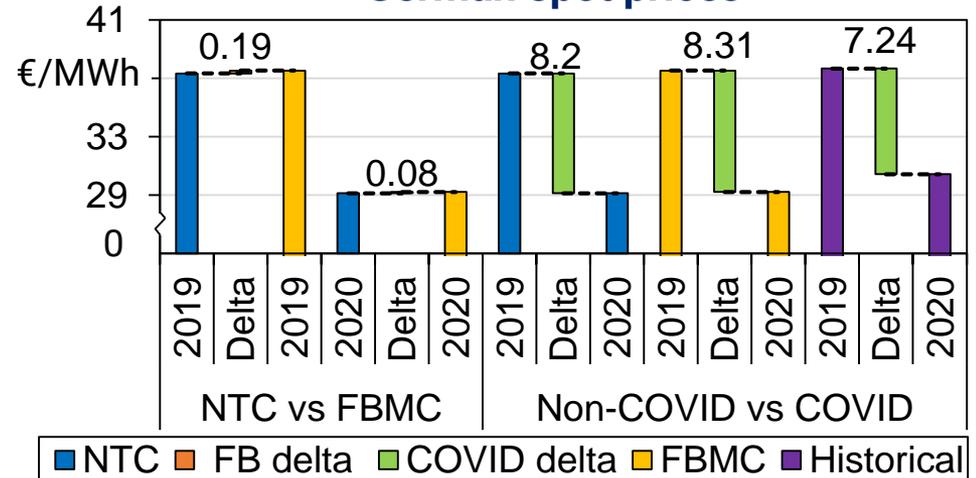
### German spot base prices

- Price difference in reality is about 7 €/MWh between the years

### Number of price zones in CWE\*



### German spot prices



\* Source: JAO

## FB congestion – Higher grid utilization during pandemic

### Flow on critical elements

- Congestion hours on critical network elements or contingencies are represented in the plot
- JAO only published names starting from 2<sup>nd</sup> October 2019
- ➔ FBMC advantage of using actual grid elements enables in identifying major grid bottlenecks

### Grid utilization

- Highest congestion between Germany and France for 2019, while it is between Germany-Netherlands for 2020
- Spread out congestion in COVID times
- ➔ Flow on the critical elements increased despite of higher flow capacities during 2020

### 4<sup>th</sup> Quarter congestion map

