WEBINAR:

Electricity market designs for flexibility:

- From zonal to nodal architectures - Findings from first market simulations in the OSMOSE project

27 May 2021

Agenda

- Introduction to OSMOSE WP2
- PART 1: Zonal market architectures:
    a) Study with RTE's PROMETHEUS-ATLAS model
    b) Study with Joint Market Model by UDE
- PART 2: Nodal market architectures:
    a) Study with RTE's PROMETHEUS-ATLAS model
    b) Study with Joint Market Model by UDE
- Conclusions

INTRODUCTION TO OSMOSE WP2

Maxime Laasri, RTE

OSMOSE PROJECT: leveraging flexibilities

Flexibility is understood as a power system's ability to cope with variability and uncertainty in demand, generation and grid, over different timescales.

HOLISTIC APPROACH OF FLEXIBILITY

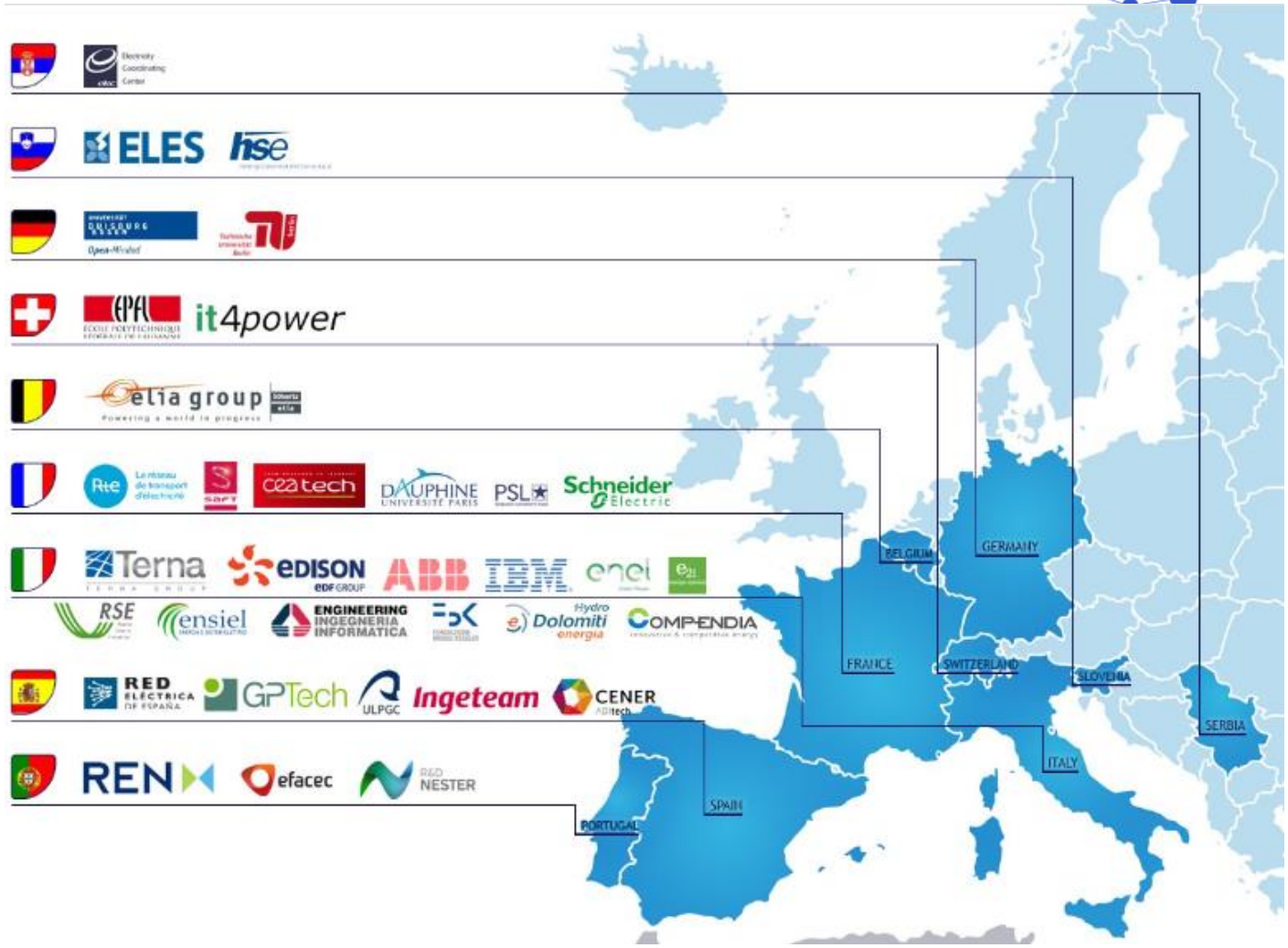
NEW FLEXIBILITY SOURCES

?

NEW FLEXIBILITY NEEDS

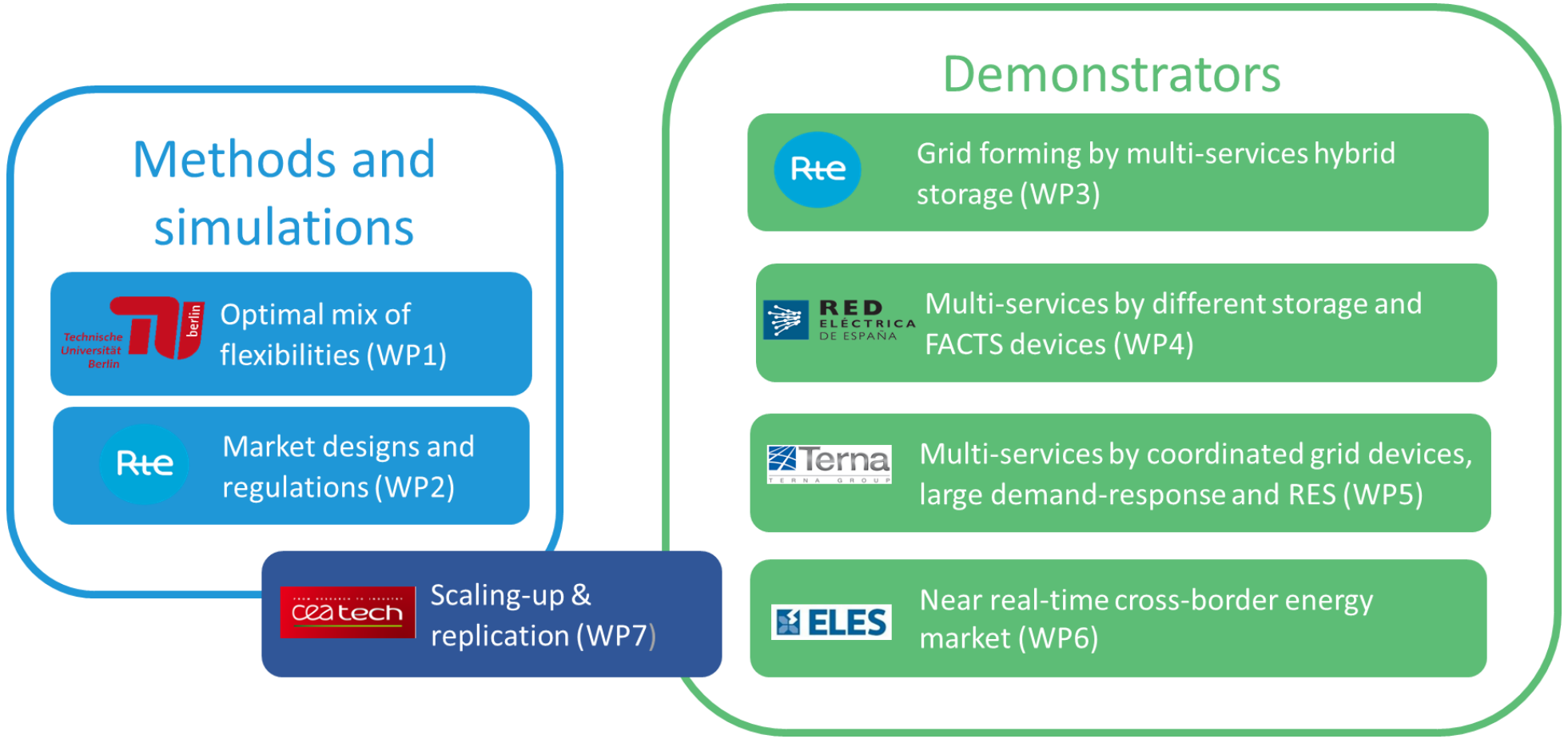
OSMOSE PROJECT: key figures

- ✓ H2020 EU funded
- ✓ 28M€ budget
- ✓ 33 partners
- ✓ Leaders: RTE, REE, TERNA, ELES, CEA, TUB
- ✓ 2018 – 2022



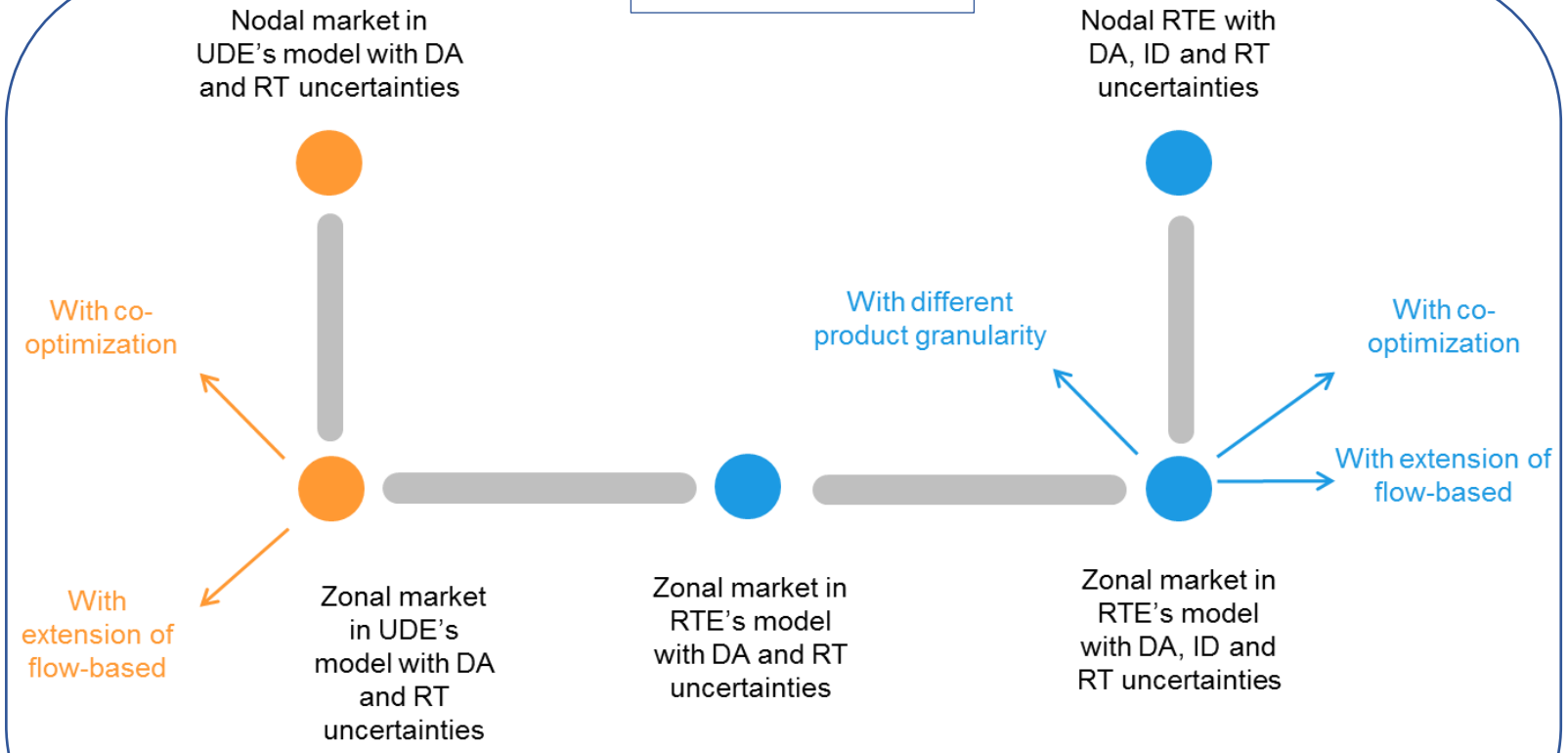
OSMOSE PROJECT: project structure

WP = Work Package



WP2: market designs & regulations

SIMULATIONS



*RT : Real Time ; DA : Day Ahead; ID : intra Day
orange is for CEGrid-JMM model from UDE, and blue is for the PROMETHEUS-ATLAS model from RTE

OBJECTIVES

- ✓ Explore and propose some market-based solutions for the development of an optimal mix of flexibility sources in Europe
- ✓ Create advanced tools and methodologies for market design analysis

PART 1: ZONAL market studies:

a) Study with RTE's PROMETHEUS-ATLAS model

Maxime Laasri, RTE

Modeling a market environment in PROMETHEUS

PROTOTYPING MARKETS AND ENERGY TRANSMISSION FOR A HARMONIZED AND EFFICIENT USE OF THE SYSTEM

ISGAN INTERNATIONAL SMART GRID ACTION NETWORK

LONG-TERM PLANNING

SHORT-TERM DECISIONS

WP1 Current Goals Achieved Scenario

antaressimulator

antaressimulator

antaressimulator

High marginal cost scenario (80% net load forecast quantile of initial study)

Medium marginal cost scenario (direct output of initial study)

Low marginal cost scenario (20% net load forecast quantile of initial study)

Long-term vision (marginal costs, hydraulic reservoir management…)

ATLAS

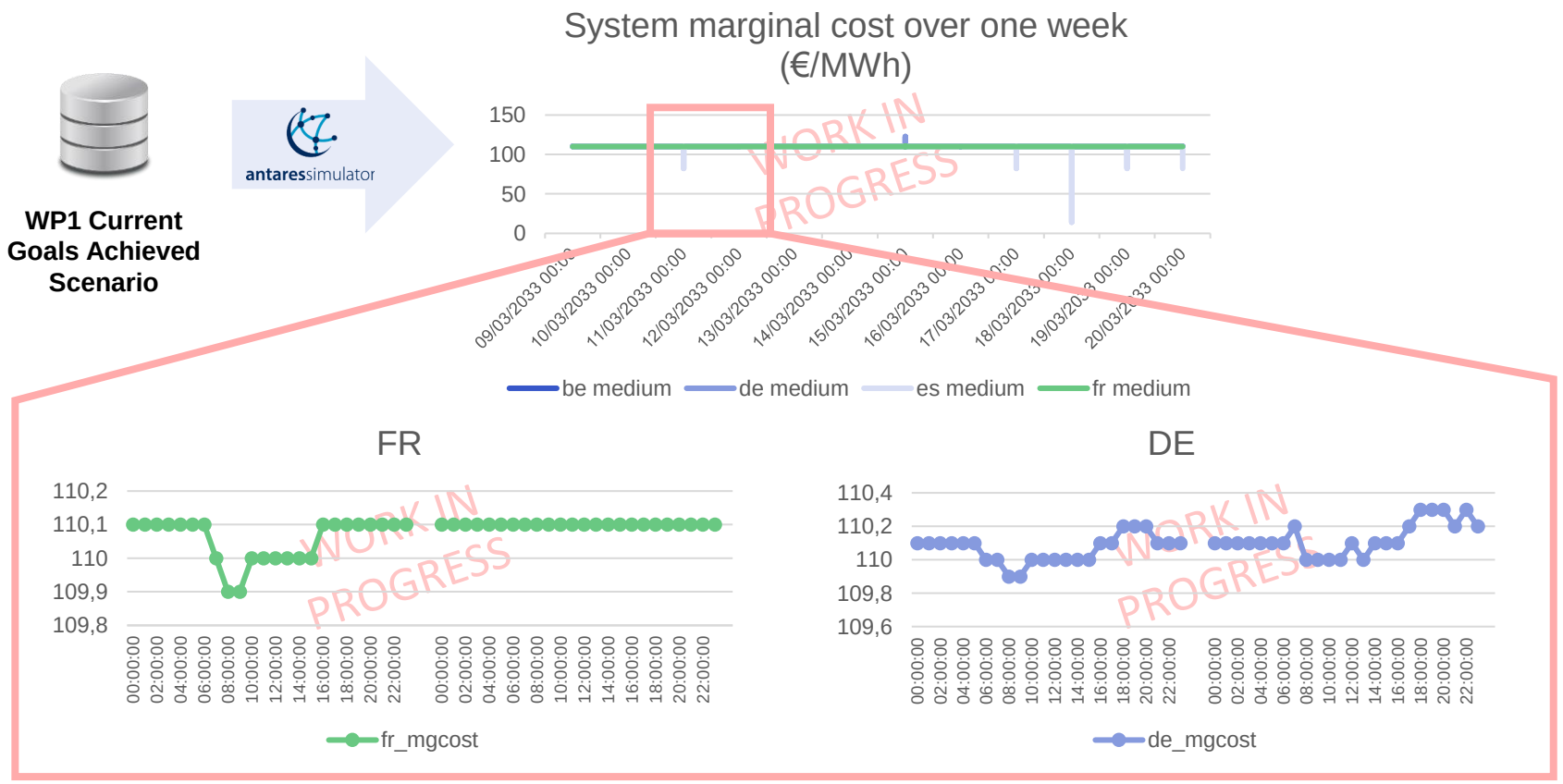
ATLAS is an agent-based model implemented in PROMETHEUS that can simulate complex market environments. It can simulate market participants formulating order books under uncertainty, perform market coupling, and simulate each participant's portfolio optimization.

NB: In this study, market participants are all price takers and submit orders based on their costs only. They are two agents per country: one generation company, and one energy supplier

Antares is an open-source power system simulator developed by RTE. It is embedded into PROMETHEUS, and available as a standalone application: https://antares-simulator.org/

Primary results of long-term planning simulations

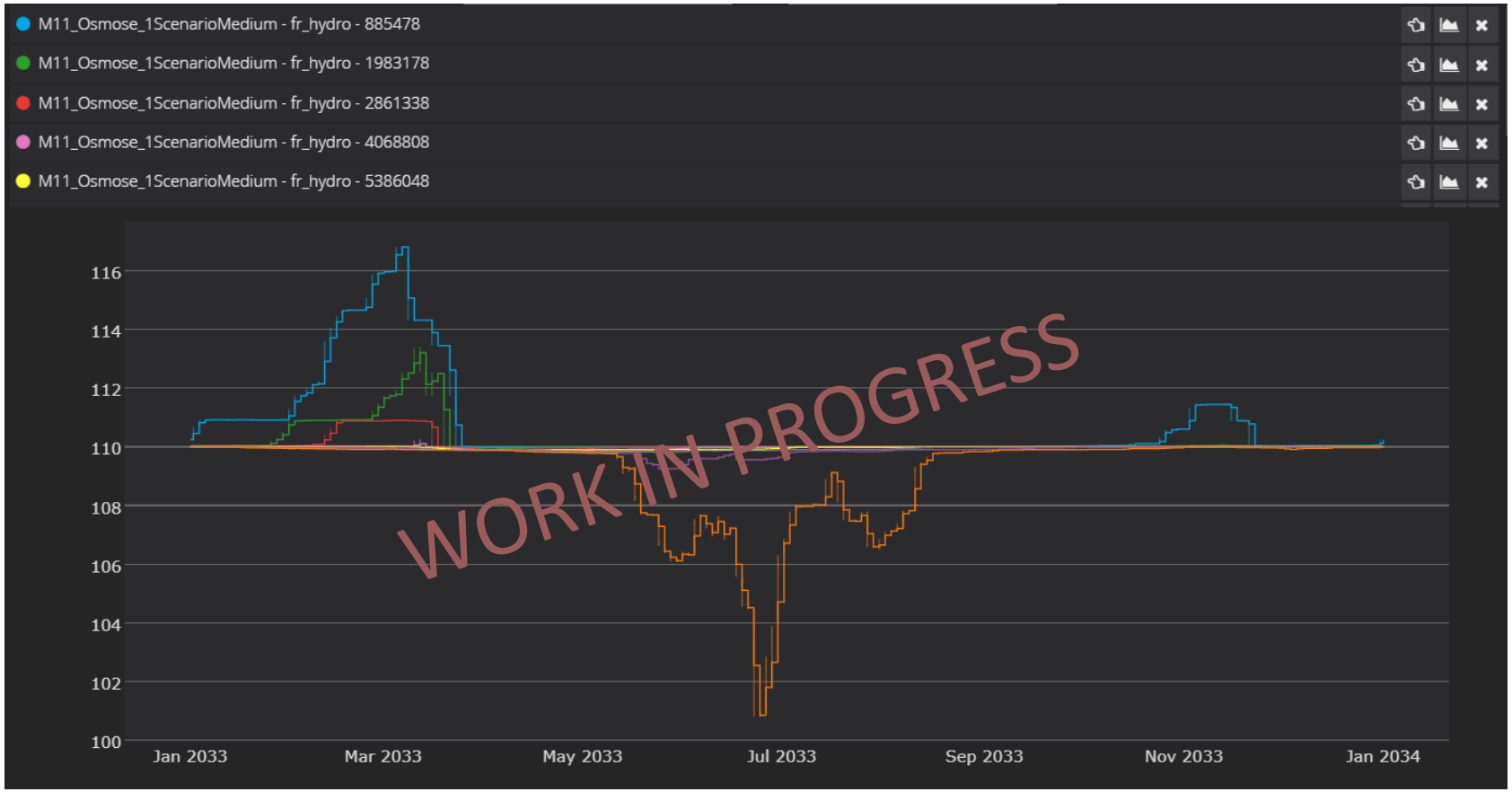
- The study comprises the same 33 countries as in WP1, and the same grid assumptions, taken from e-Highway
- The number of thermal clusters and the stratification of their variable costs has a direct impact on the system's marginal cost
- NB: variable costs in these first runs are different from UDE's values. Final runs will use the same values



Short-term water values

- Water values are close to the system's overall marginal cost for average storage levels
- We observe the expected seasonality for high and low storage levels: water gains value around the winter but looses value in the summer

Hourly water values over one year in **FRANCE** (€/MWh)



Short-term water values

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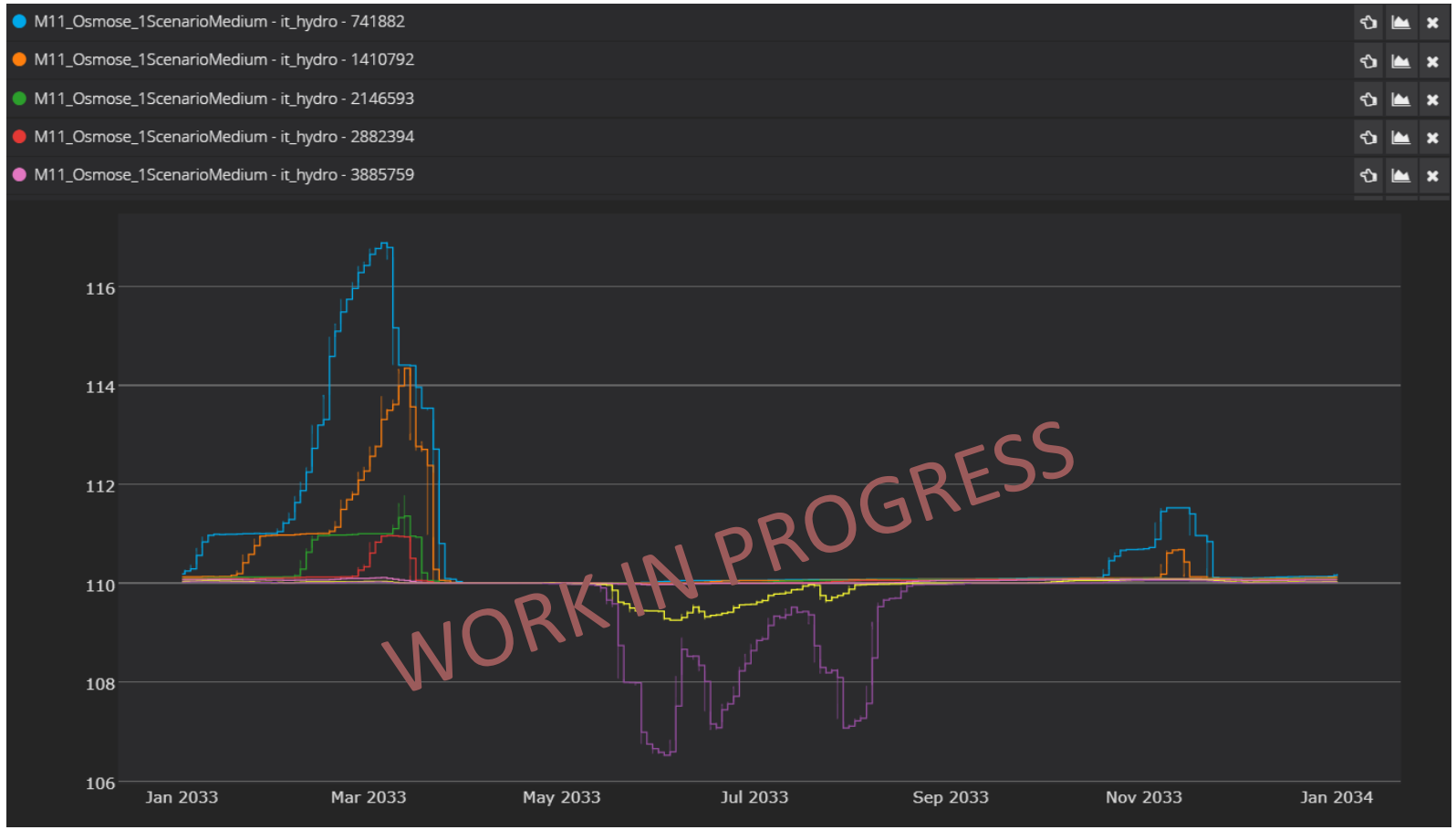
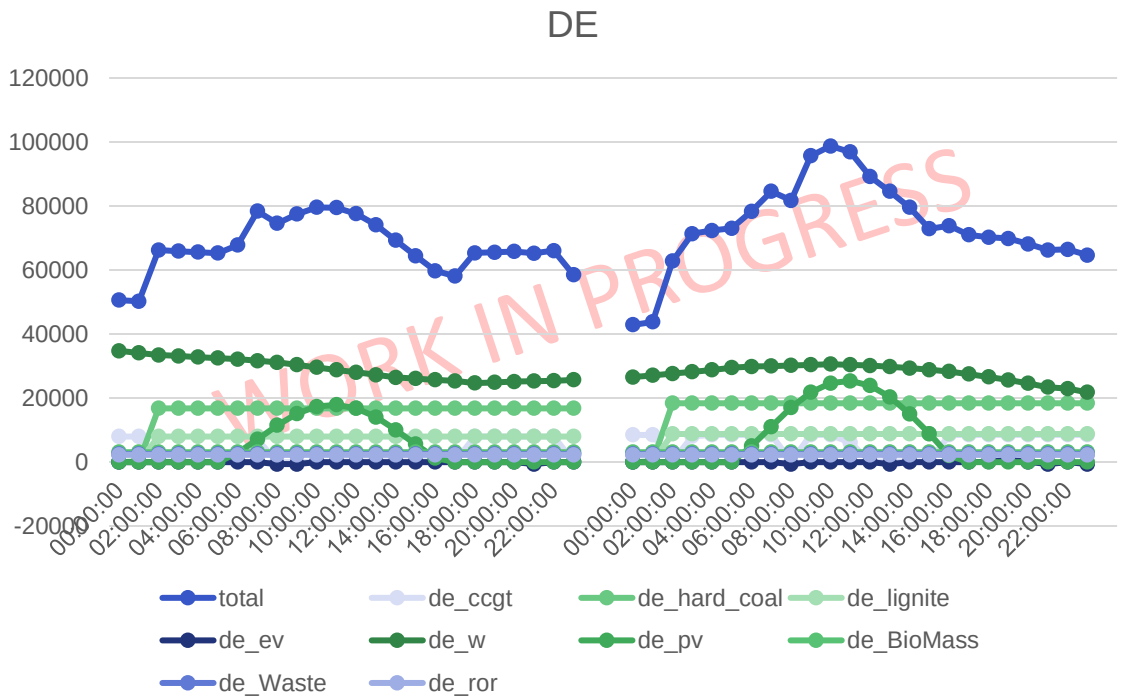
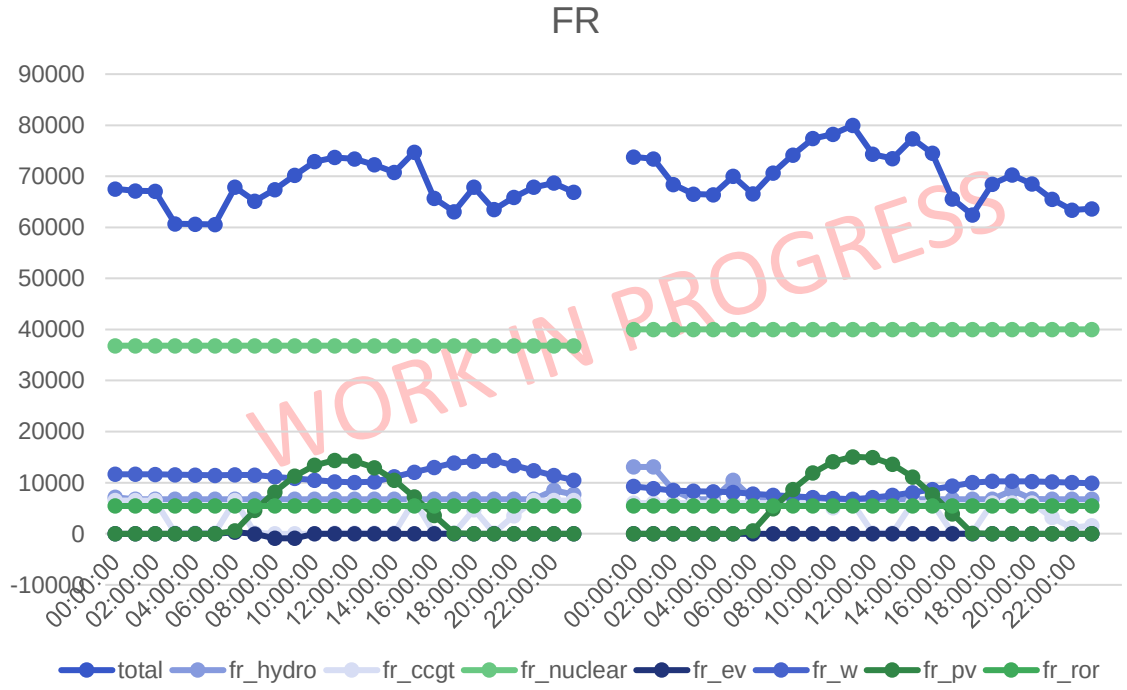
Hourly water values over one year in **ITALY** (€/MWh)



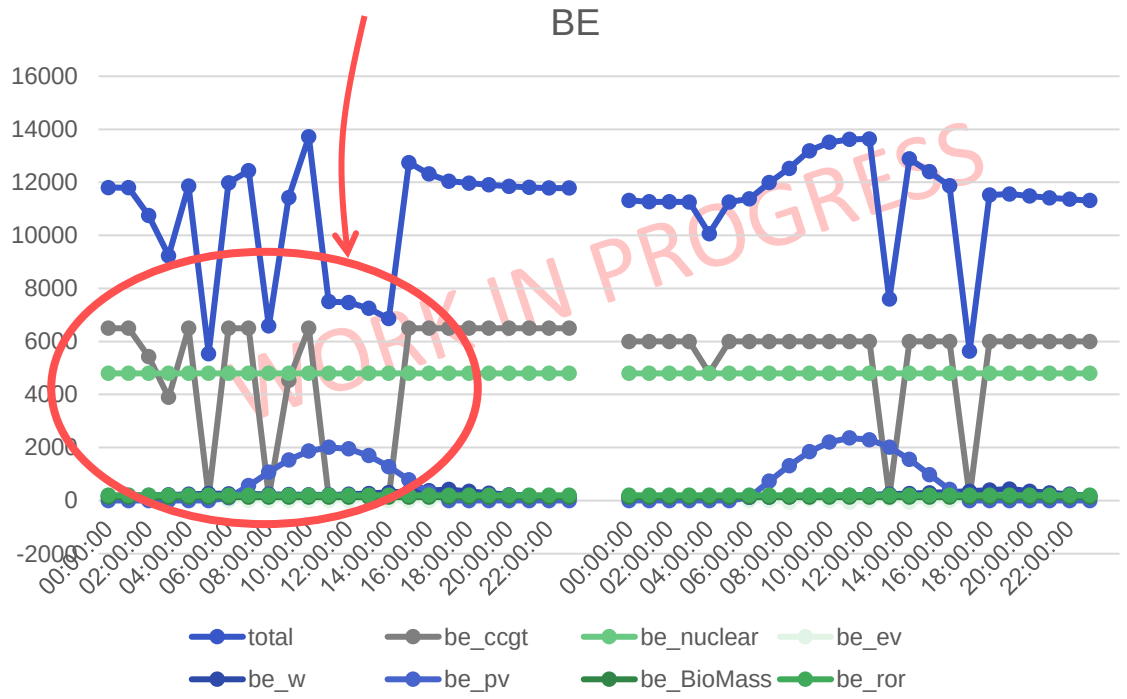
Cleared quantities on 11/03 and 12/03 DA market

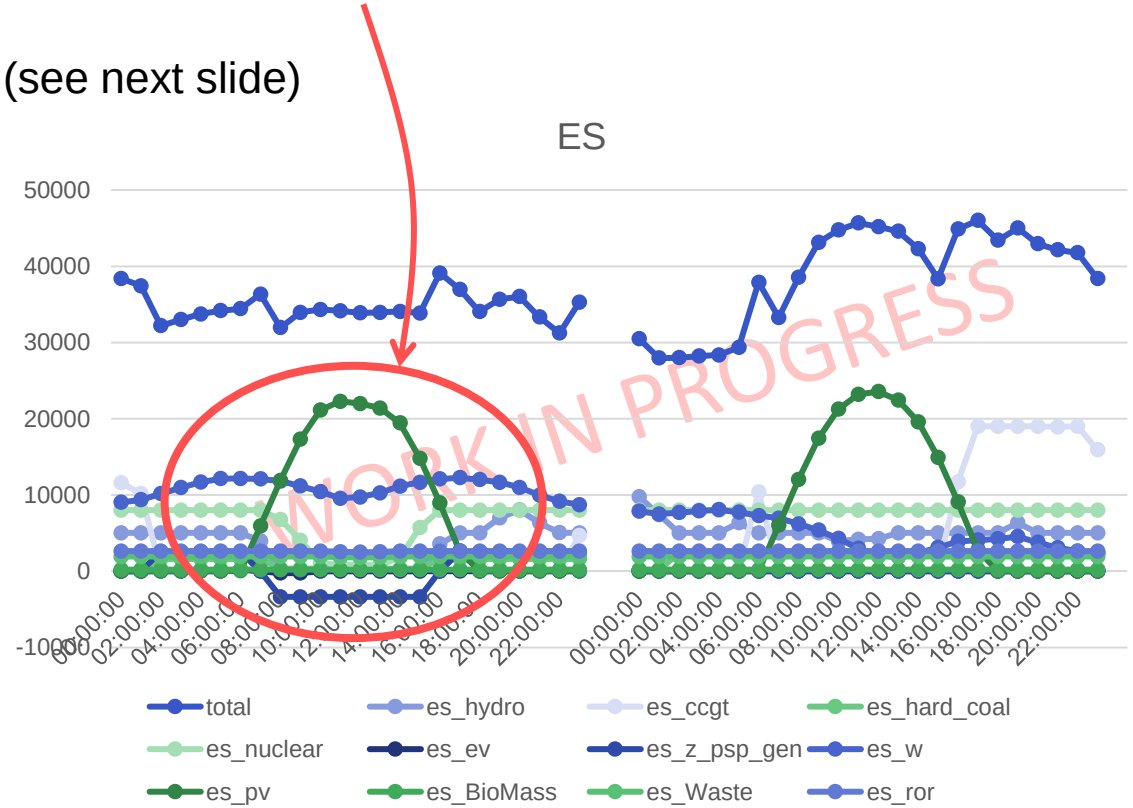




Cleared quantities on 11/03 and 12/03 DA market

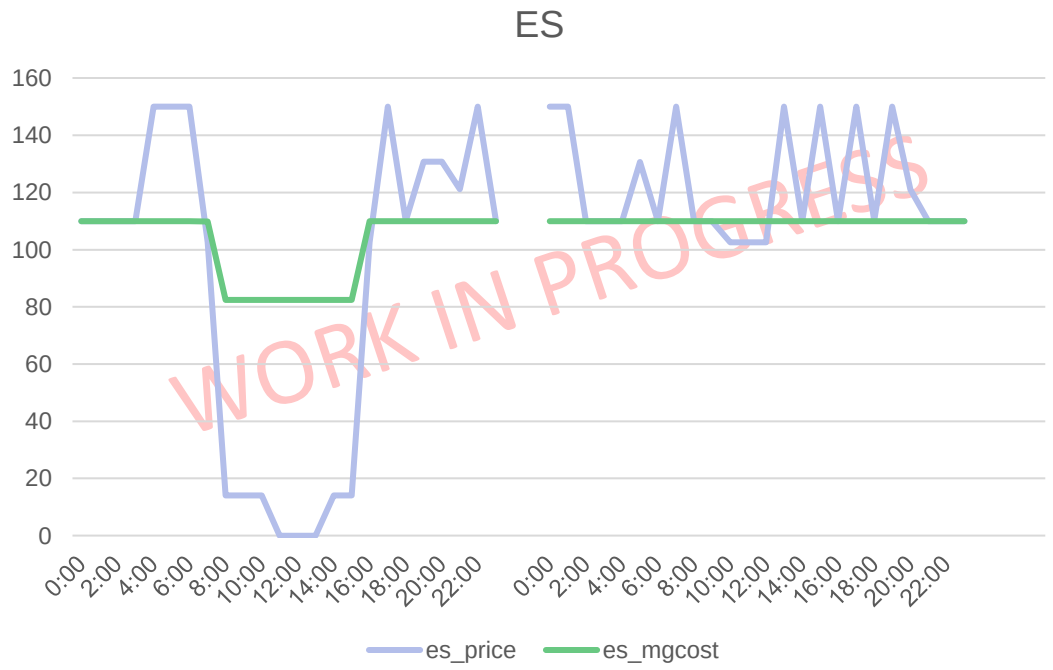
- High renewable penetration entails power stations being out-of-the-money, and opportunities for electric vehicles charging
- CCGT provide flexibility to the market, with its own cost (see next slide)





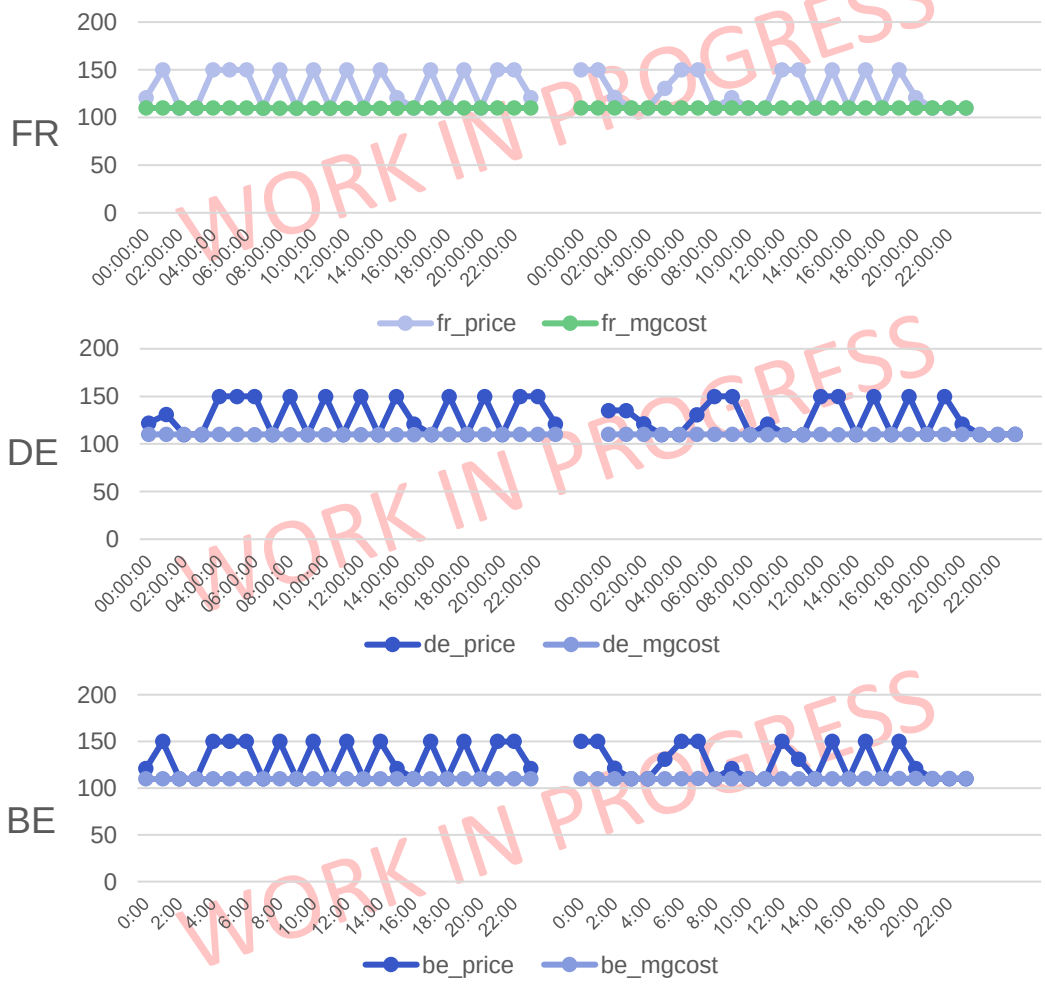
Clearing prices on 11/03 and 12/03 DA market

- As expected, day-ahead prices are more volatile than the marginal cost due to the simulated market environment (constrained market orders add complexity and rigidity compared to a pure and perfect competition-based system optimization)
- The depth of price drops induced by solar power peaks can be radically different from one day to the next, as illustrated for Spain
- Prices are also impacted by the level of stratification in thermal units' variable cost



Clearing prices on 11/03 and 12/03 DA market

- Day-ahead prices are sometimes continuously higher than the marginal cost anticipated during long-term planning (see France, Germany, and Belgium, almost always in the same price group as the grid is unconstrained on these days)



PART 1: ZONAL market studies:

b) Study with the Joint Market Model

Prof. Dr. Cristoph Weber, Florian Boehnke

Agenda

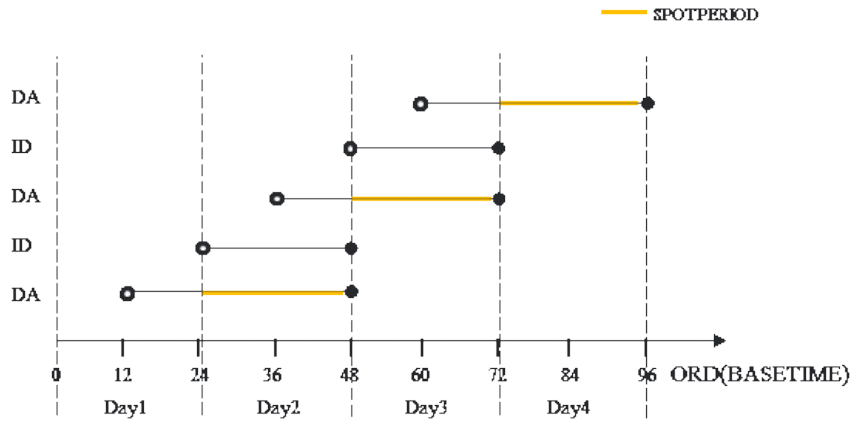
- Introduction of the Joint Market Model (JMM)
- Preliminary Results
  - Zonal Market Studies

Market Design Studies
Modelling Landscape – Joint Market Model (JMM)

- Modelling of power plant operation and market outcomes (unit commitment)
- Starting point: with well-functioning competition the market outcome corresponds to the outcome of a central optimization (fundamental model)
- Objective function minimizes variable generation costs
- Two-stage optimization approach for modelling of forecast errors and redispatch
- Modelling of different markets:

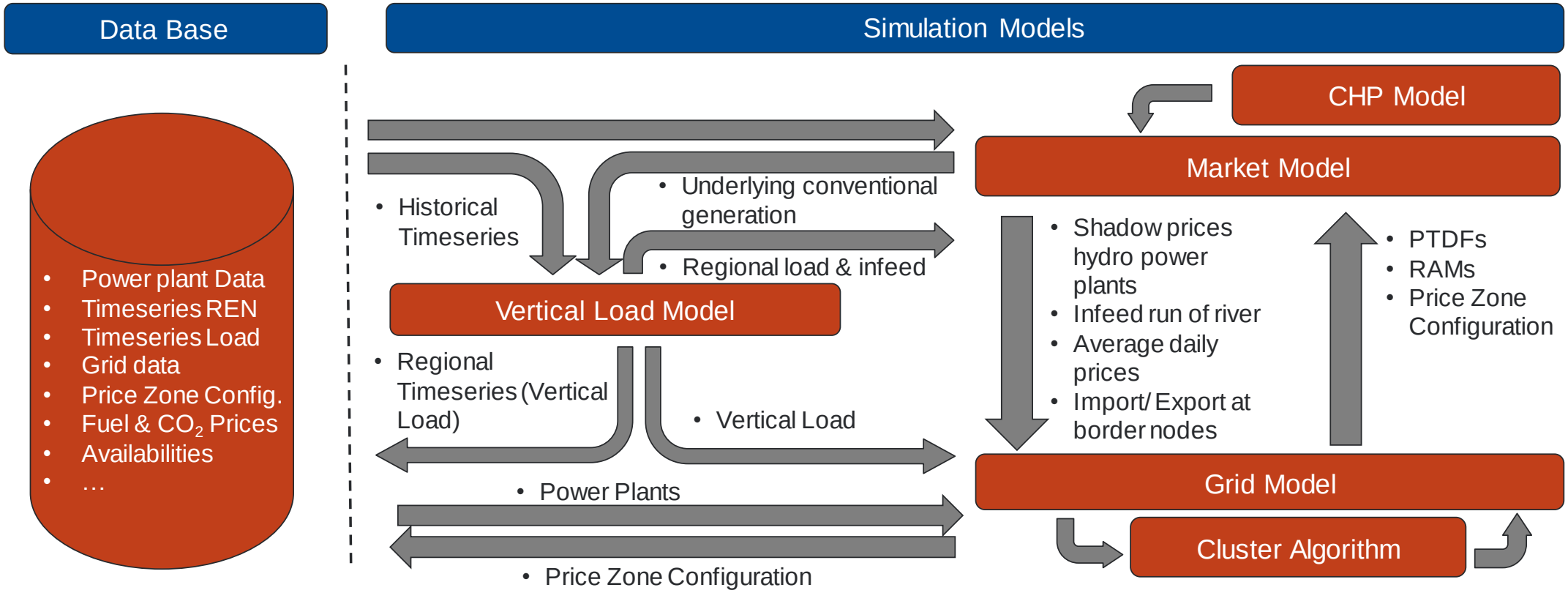
  day-ahead, intraday, balancing, heating markets
- Detailed formulation of technical restrictions
- Geoscope: Europe

Geoscope



Rolling Planning Approach

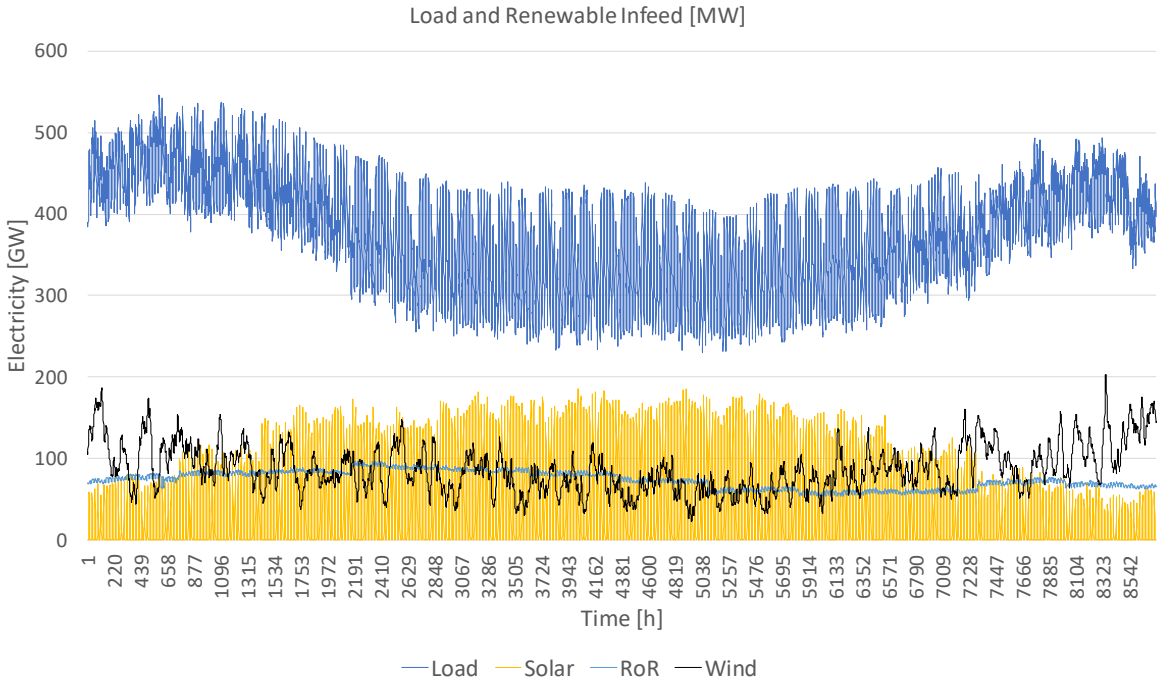
Market Design Studies
Modelling Landscape – Joint Market Model (JMM)

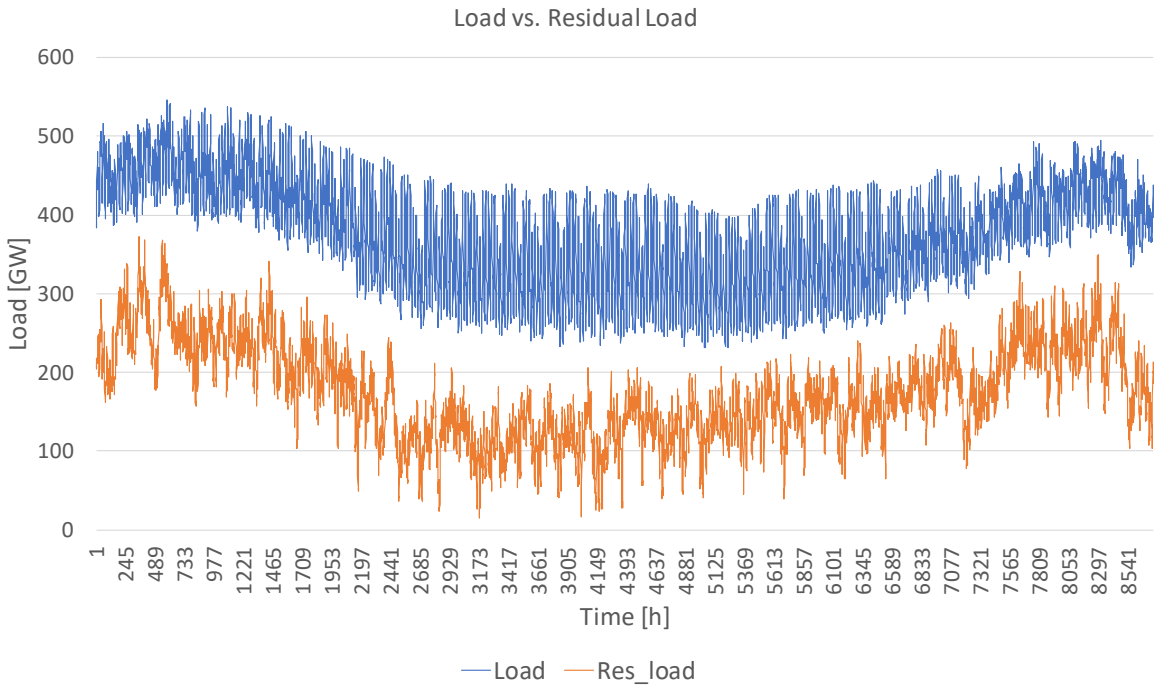


Zonal Market Design
Setup & Input Parameter

- Data input from WP1
- Scenario: “Current Goals”
- Scenario year: 2030
- Geoscope: 33 countries
- 2 case studies are part of this presentation:
  - Reference Case (LP, no uncertainties, NTC)
  - Uncertainties Case (LP, uncertainties for wind power generation, NTC)

Zonal Market Design
Input Parameter I

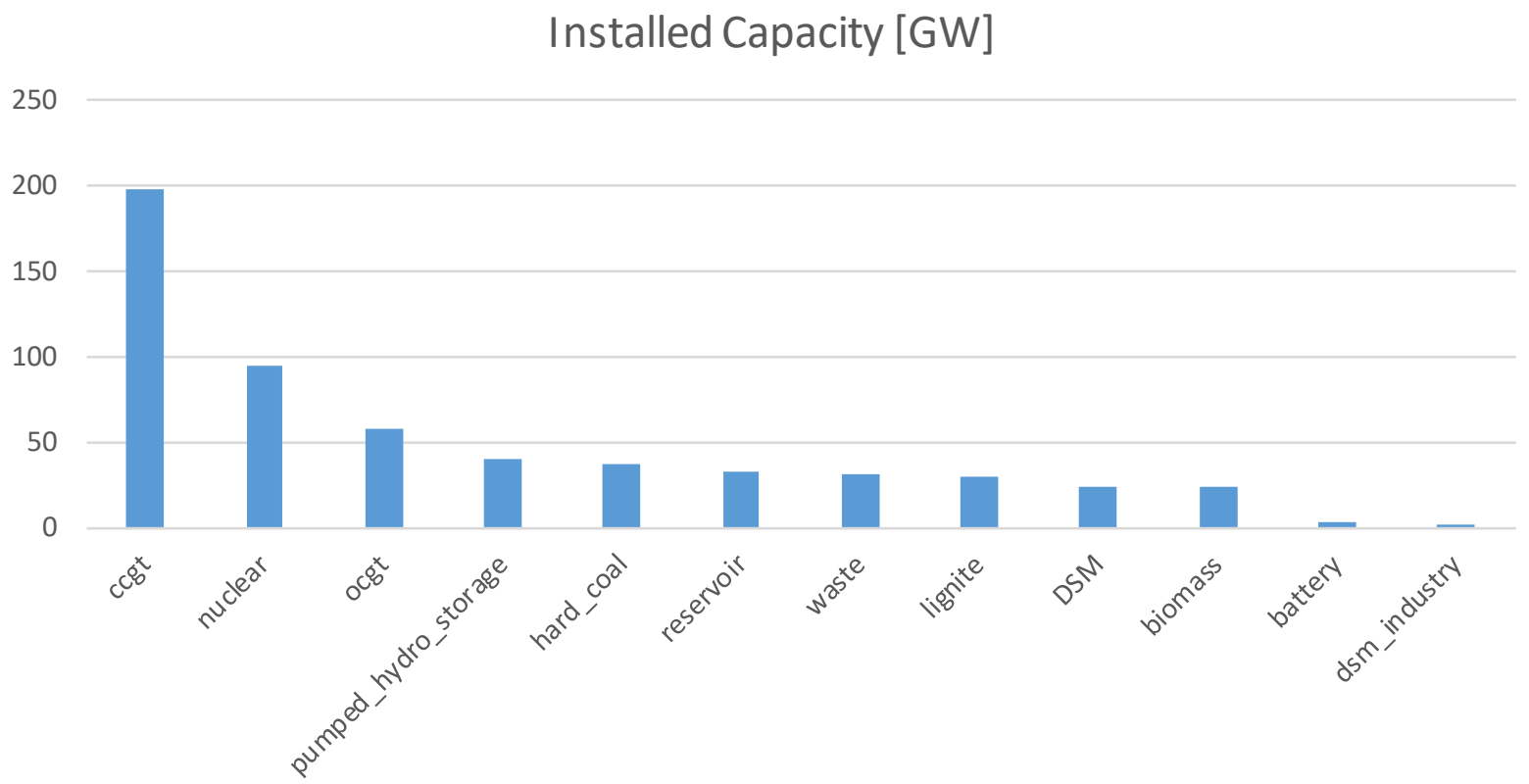




- Total Demand: 3.291 TWh
- Wind Power / PV / RoR / Total : 763 / 354 / 681 / 1798 TWh
- Max / Min Residual Load: 372 GW / 15 GW

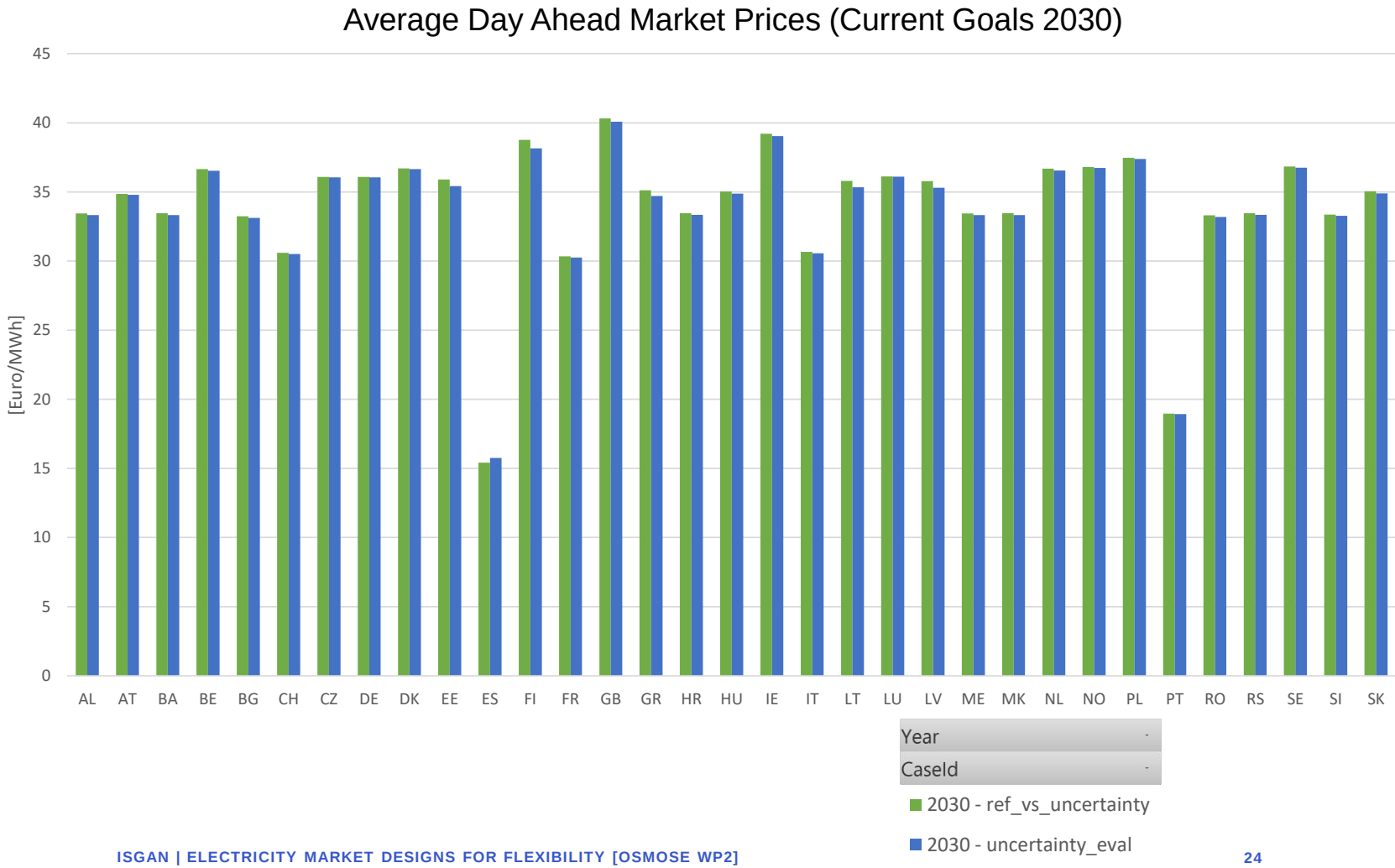
Zonal Market Design Input Parameter II

- Conventional capacities see graph
- Carbon Price: 18 €/t_{CO2}
- Fuel Prices (in €/MWh)
  - Nat Gas: 24.0
  - Hard Coal: 8.1
  - Oil: 49.4



Zonal Market Design Results I

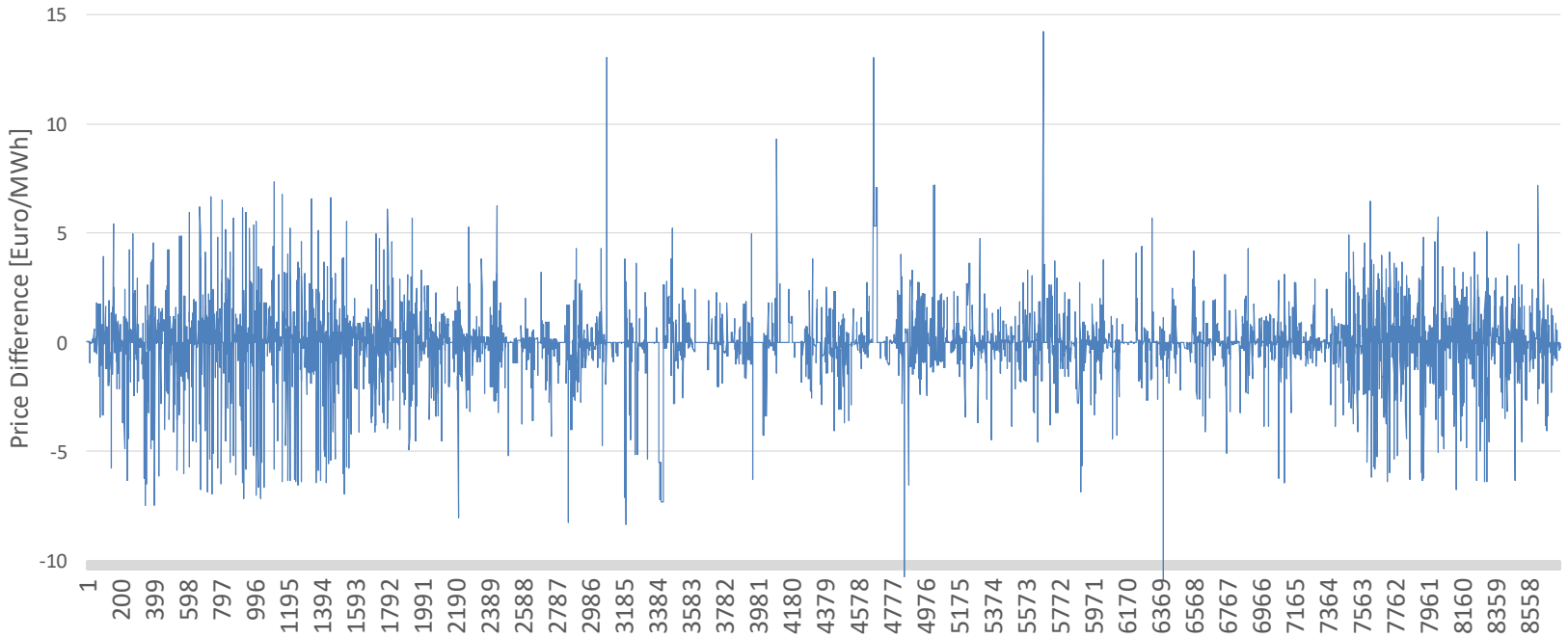
- Preliminary results in the chart
- Day Ahead price range between 30 to 40 €/MWh
- Considerably lower levels only in ES and PT
  - Insufficient transmission capacity
- Uncertainty does not affect DA prices (on average!)
  - Stochastic uncertainty time series
  - More volatile prices during the year



Zonal Market Design Results II

- Volatile Day Ahead Prices when considering uncertainties
- Deviations more dense in Q1 & Q4 due to overall wind power generation
- Multiple hours in Q2 & Q3 with equal prices combined with strong (arbitrary) peaks in price difference

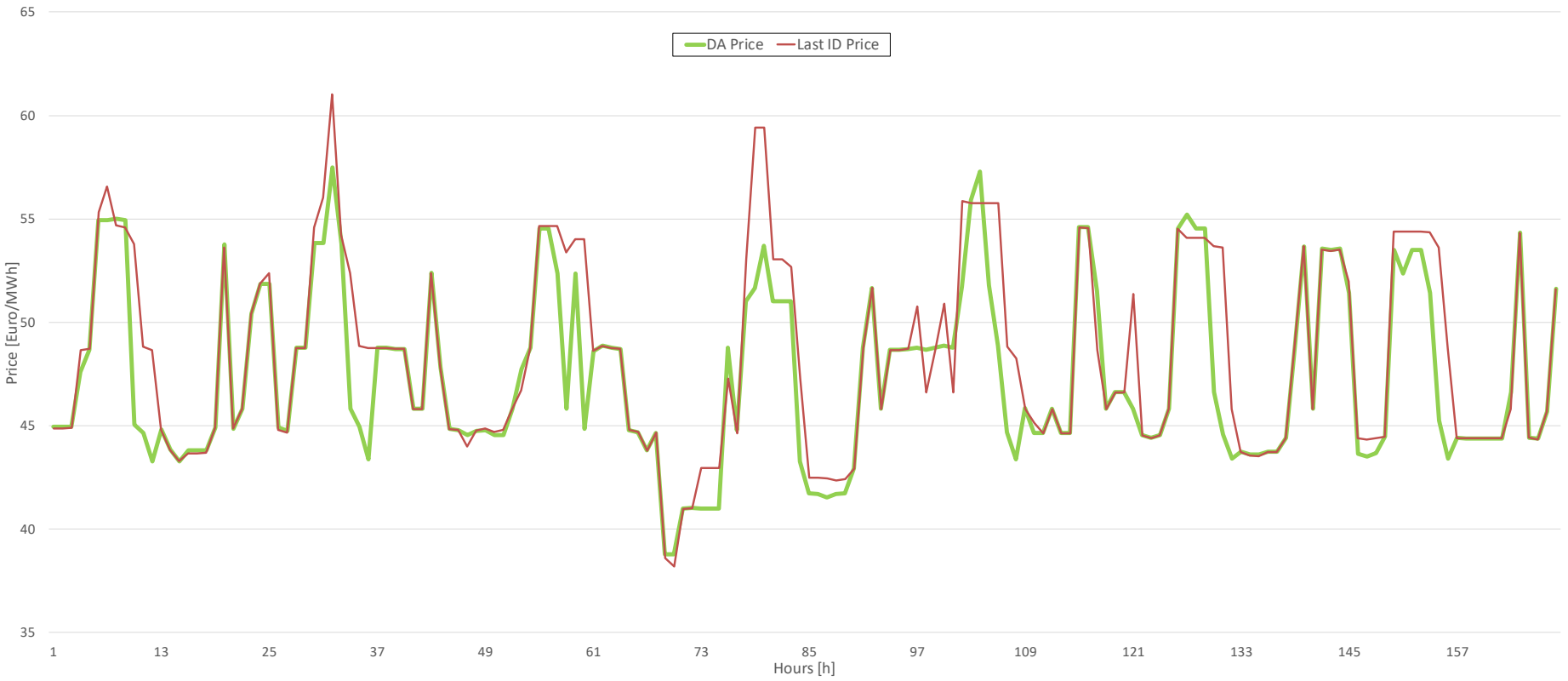
Day Ahead Price Comparison for Germany (reference - uncertainties) in 2030



Zonal Market Design Results III

- Initial update similar to wind expectation of DA UC
  - Temporal correlation of FC Errors
- Subsequent updates lead to price differences between DA and ID market prices, pending on the FC information

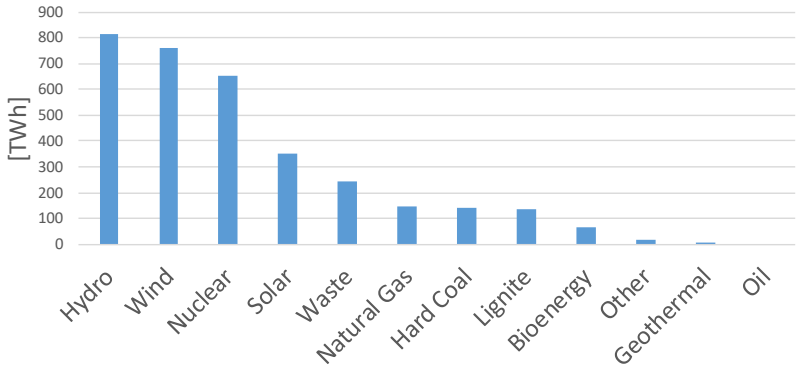
DA-price vs. ID last price update for first week in February 2030 (12:00h), Geoscope GER



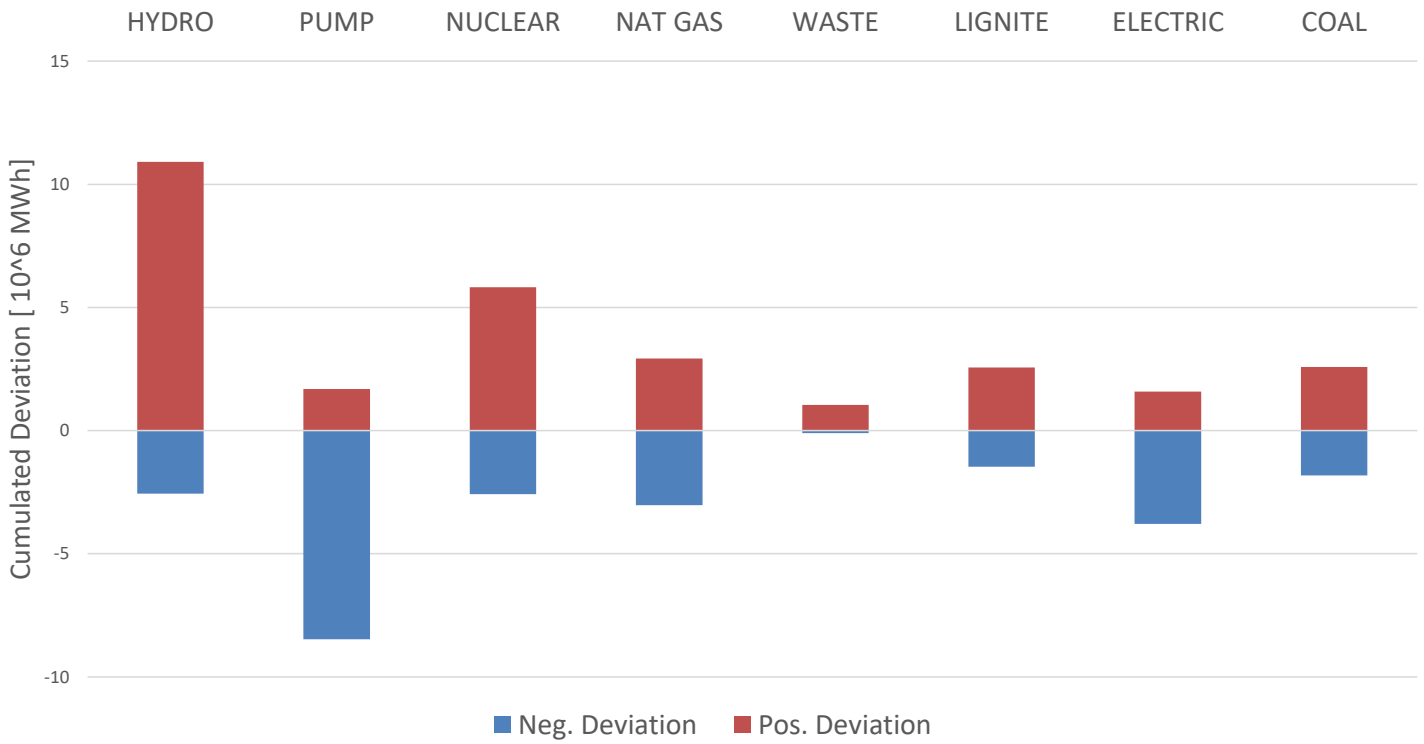
Zonal Market Design Results IV

- Positive deviation (dispatched quantity > planned quantity)
  - Depending on the lead time conv. power plants used for ramping needs
  - Most flexibility provided by Hydro Power
- Negative Deviation (dispatched quantity < planned quantity)
  - Energy is stored (Pump / Electric (DSM))
  - Downregulation of conv. Power plants

Generation per Technology



Cumulated Deviation per Technology (1 year)



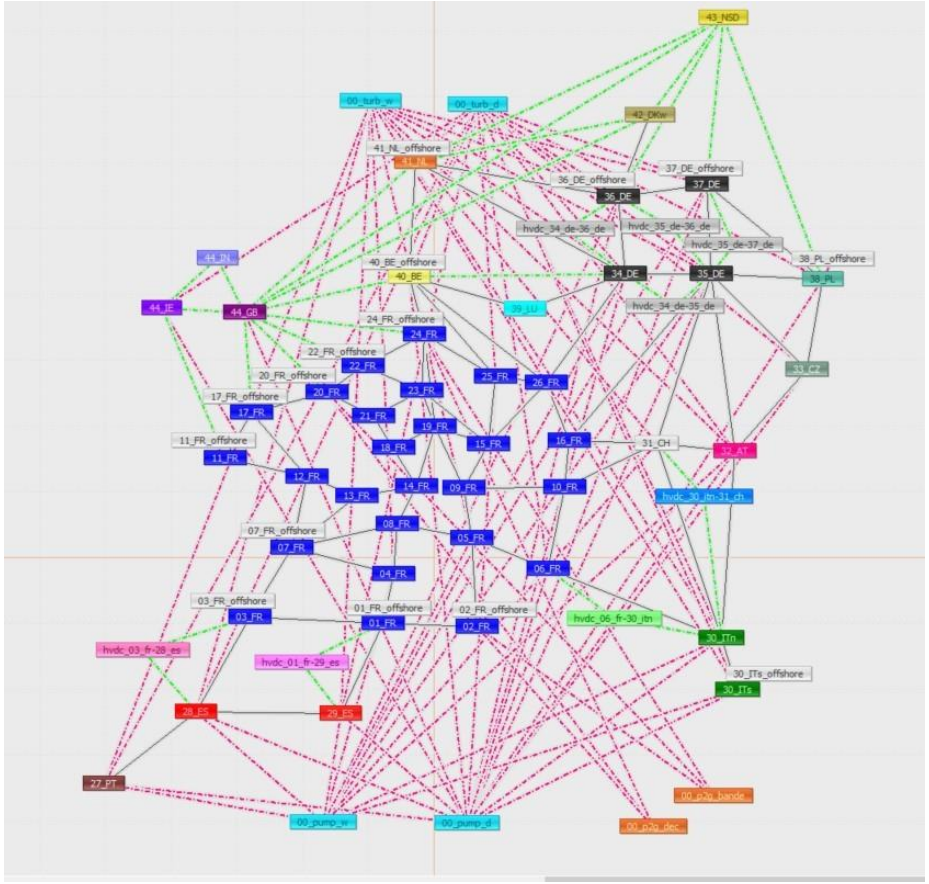
PART 2: NODAL market studies:

a) Study with RTE's PROMETHEUS-ATLAS model

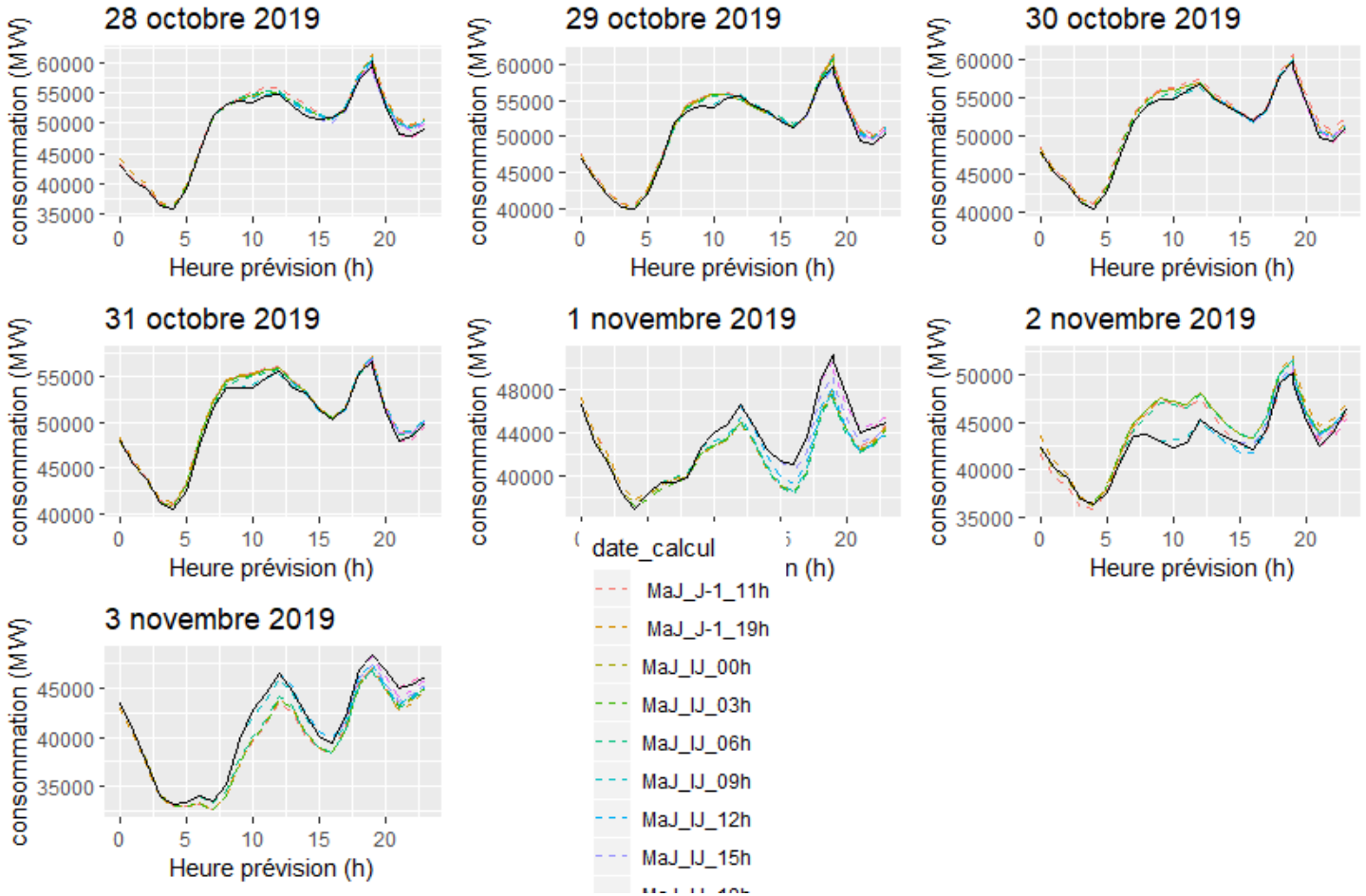
Sandrine Bortolotti, RTE

Study perimeter

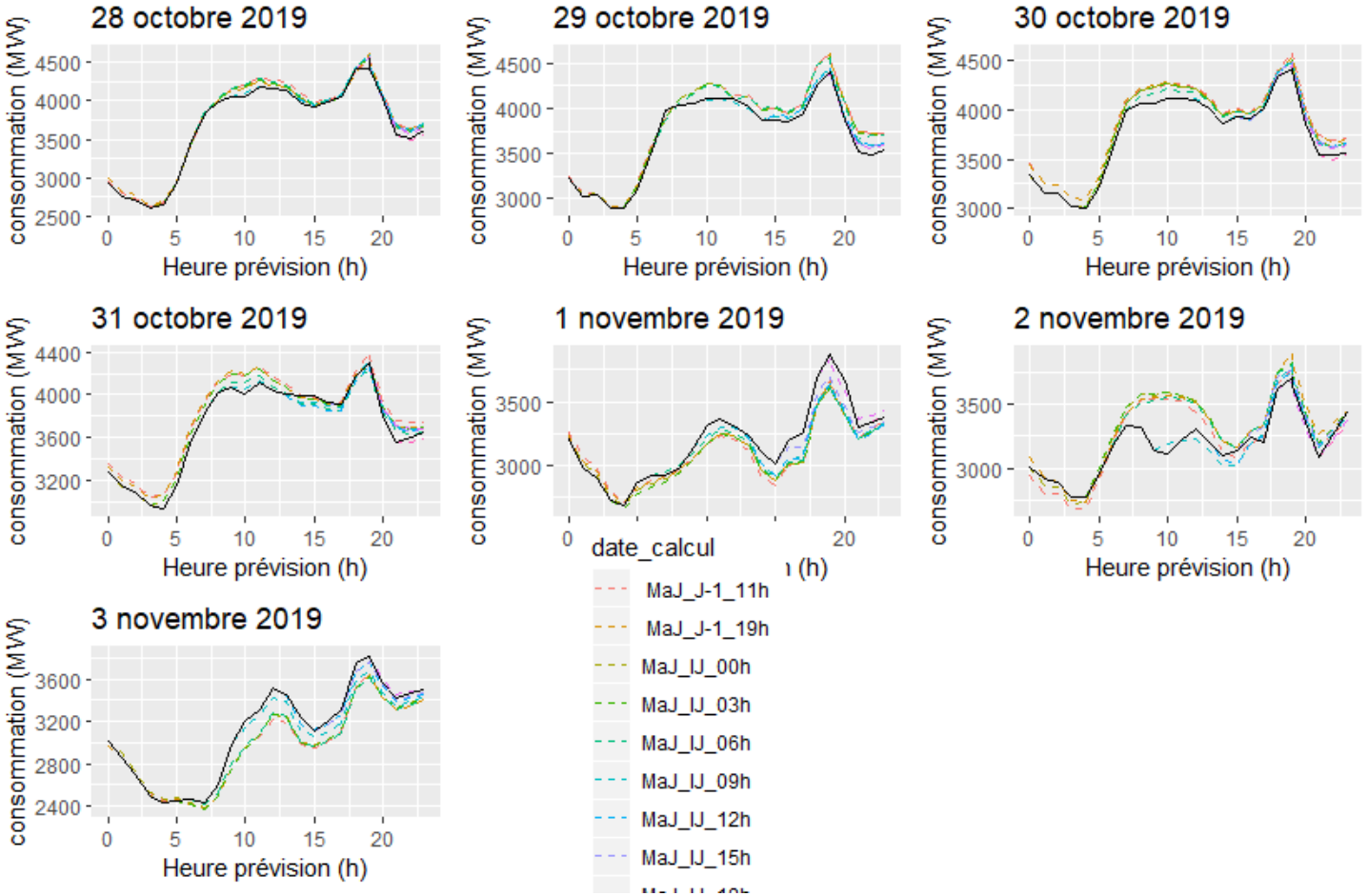
- Small region of central France simulated with a nodal market
- The rest of France is modeled with consistent electric regions
- The rest of Europe is modeled on a country scale
- RES forecast data come from historical measurements (which preserve spatial correlations between forecasts), and were scaled to match 2030 levels
- Selection of one interesting week to simulate at the beginning of November



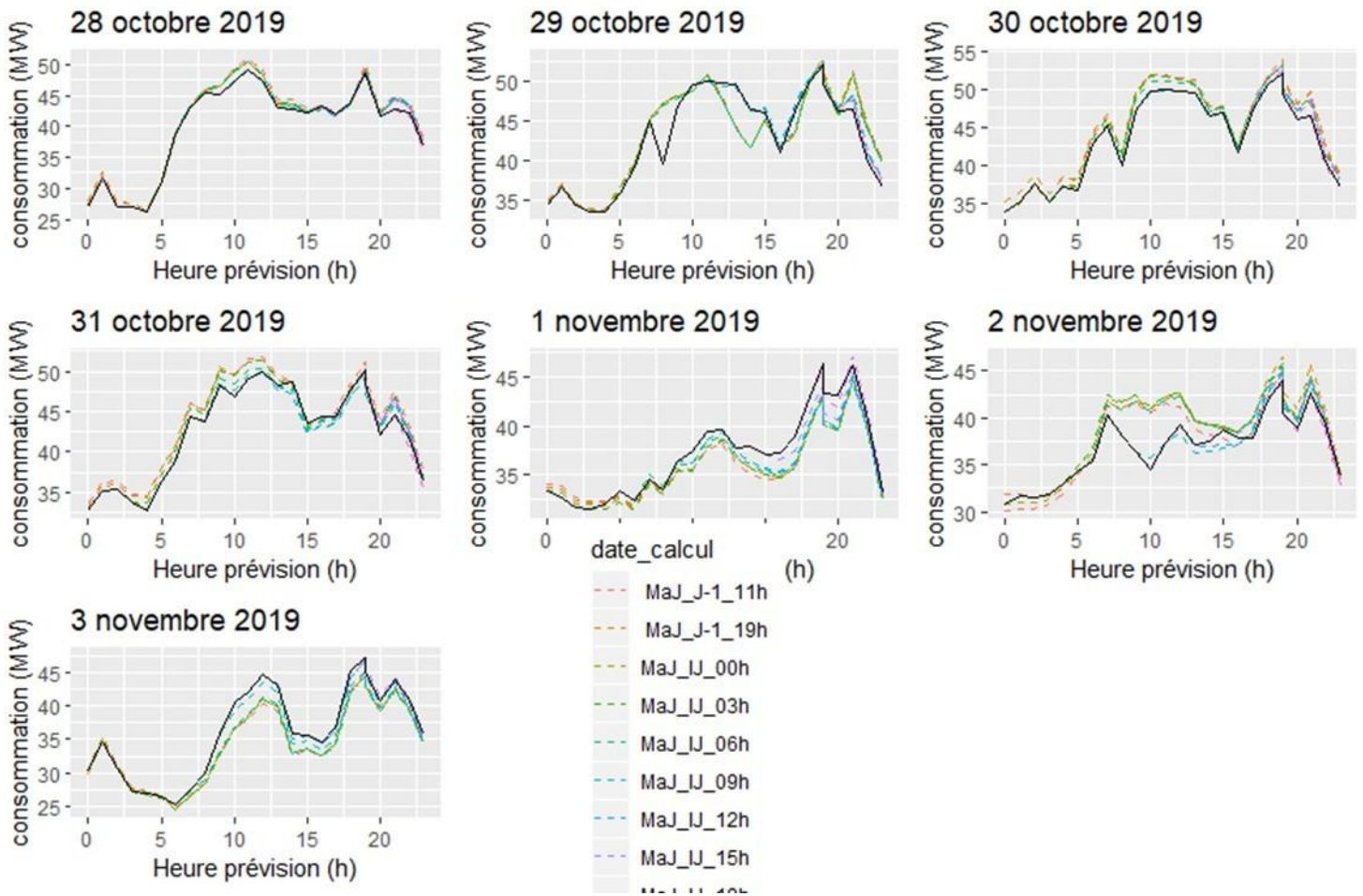
National load forecasts



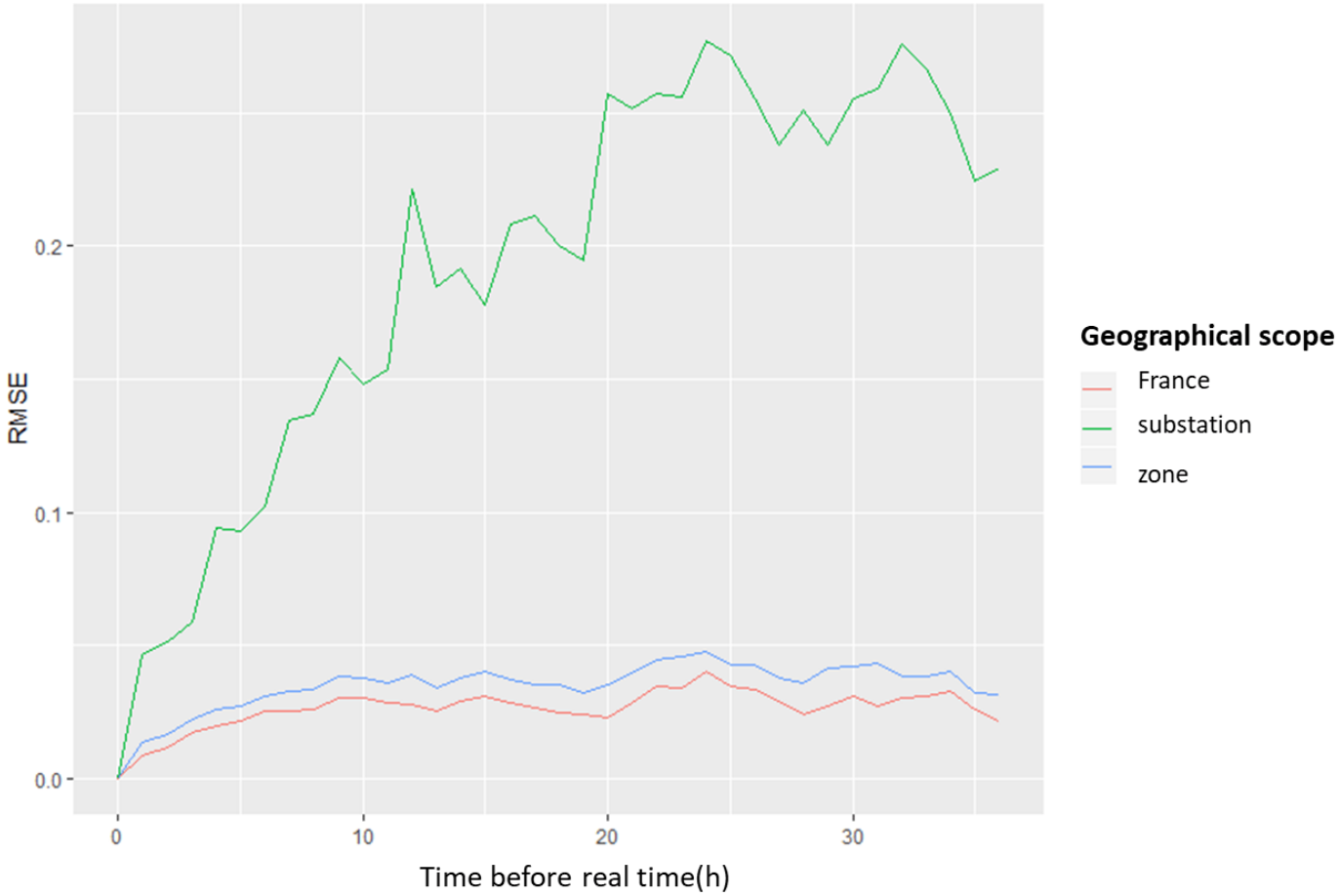
Regional load forecasts (05_fr)



Substation load forecasts (VICHYP3)



Primary results on historical data analysis: RMSE on load forecasts



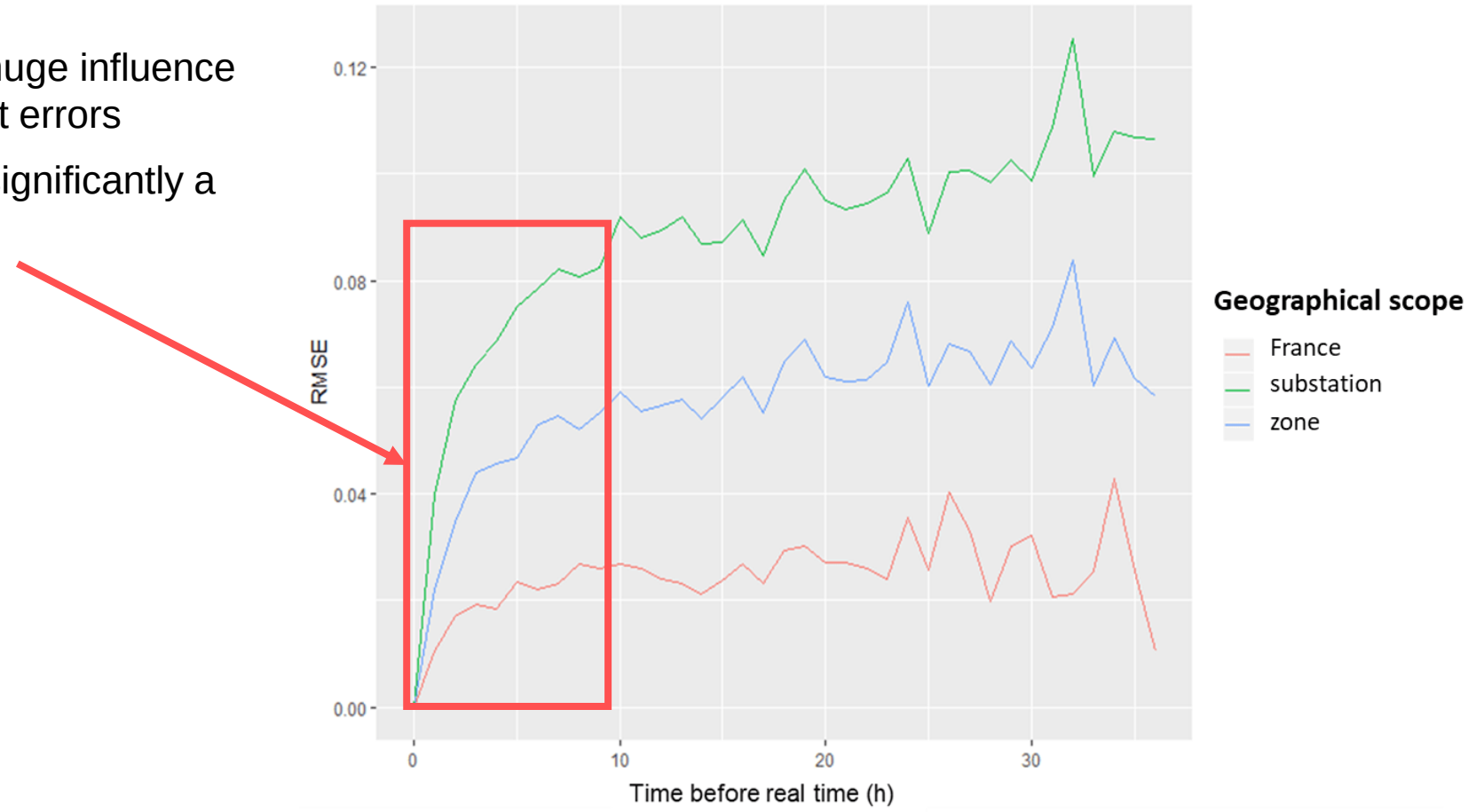
2 takeaways:

- The geographical scope has a huge influence on the magnitude of the forecast errors
- Regarding load forecast, aggregating some substations reduce drastically the magnitude of the errors.

Primary results on historical data analysis

2 takeaways:

- The geographical scope has a huge influence on the magnitude of the forecast errors
- The uncertainty only decrease significantly a few hours before real time



PART 2: NODAL market studies:

b) Study with the Join Market Model

Prof. Dr. Cristoph Weber, Florian Boehnke

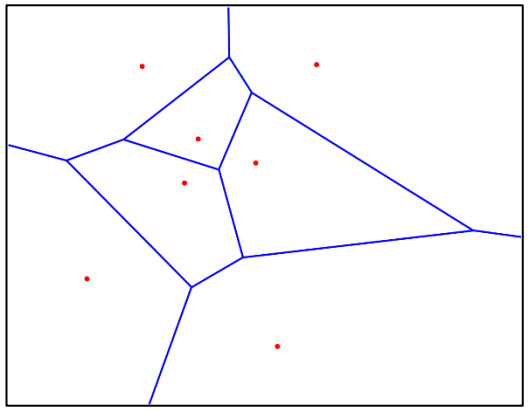
Nodal Market Design Methodology

- Nodal market design applies prices for electricity consumed or generated at a nodal level
- Market design to fully consider physical grid restrictions (congestion management)

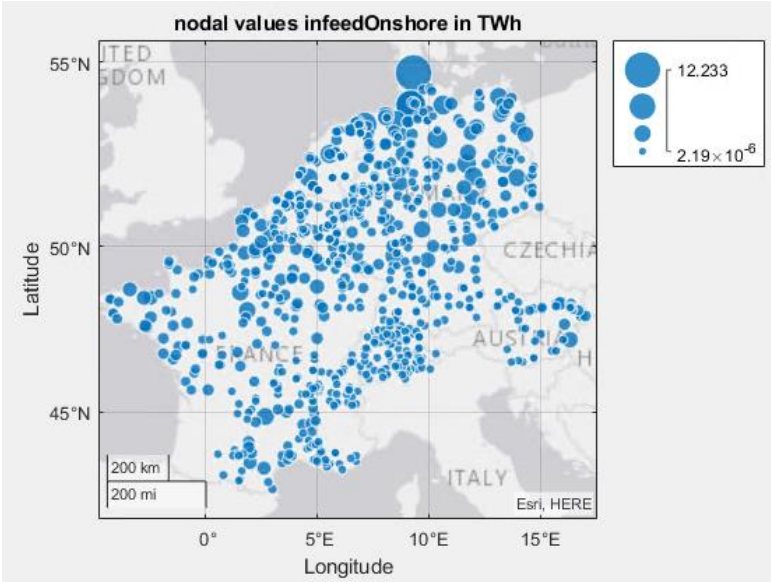
  (Zonal Markets NTC → Zonal Markets FBMC → Nodal Markets)
- Prices at adjacent nodes are equal in case of sufficient transfer capacities
- Implemented in many U.S. markets, e.g. California (CAISO), Texas (ERCOT)
- Main inputs
  - Grid ENTSOE TYNDP (without coordinates)
  - Zonal market design inputs (country level) → Nodalizing input parameters (nodal level)

Nodal Market Design
Nodalizing Wind Power

- Nodalizing Wind on NUTS3 level (county)
  - Estimating capacities from different data sources for current regional assets
  - Creation of infeed timeseries
    - Weather information from Cosmo-EU
    - Multiplied by turbines' power curves
    - Scaling to 2030 infeed timeseries
  - Wind turbines are assigned to nodes by Voronoi-areas

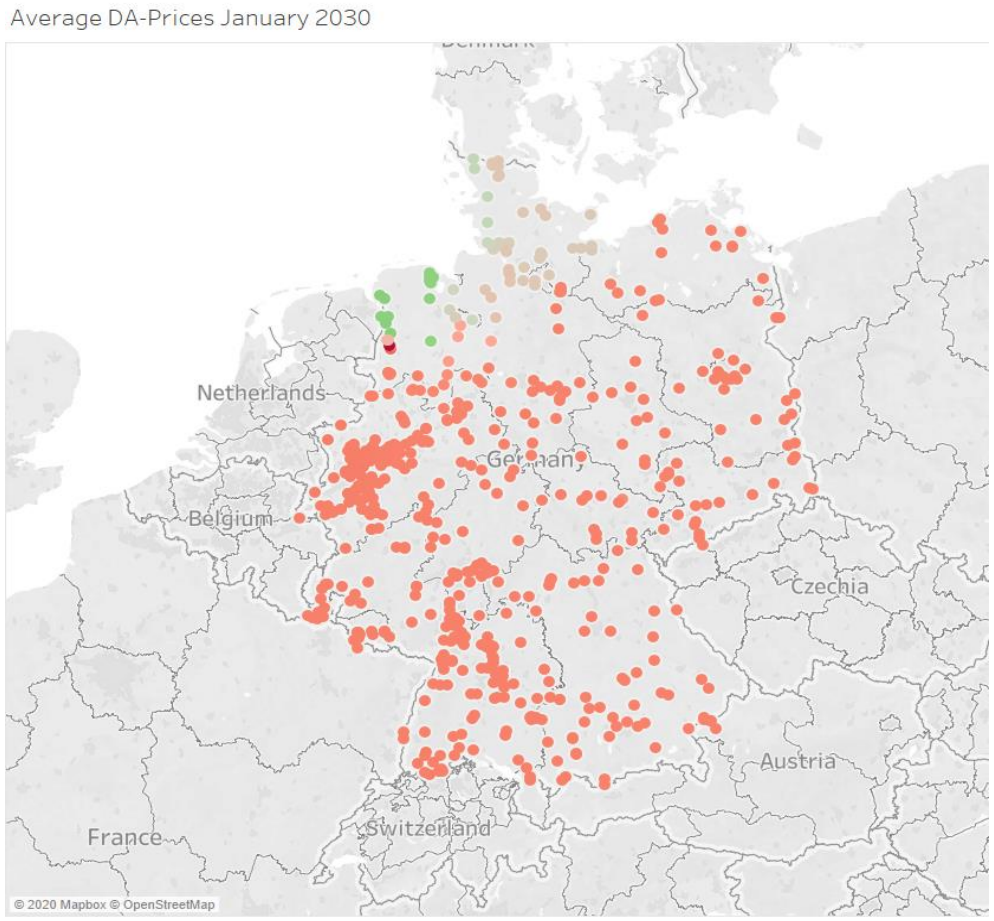


Voronoi Areas with Nodes



Nodal Market Design
Preliminary results

- Based on German case study
  - Not based on TYNDP Grid
- Average day-ahead market prices for January 2030
- Published in MS8



CONCLUSIONS

Maxime Laasri, RTE

Key messages

- The investigation of different market designs in a European context is necessary for ensuring the viability of any potential prospective energy mix

- Forecast uncertainties are a key element to be reflected in market design studies, as they impact how market opportunities are leveraged by market participants and how power system operators respond subsequently

- Nodal market designs are challenging to model and simulate in practice

Upcoming activities

- A second webinar on WP2 will be organised in Fall, with focus on modeling

- Three webinars jointly organised with the EU-SYSFLEX project on 15-16-17 June 14h00 CET:

  - ✓ *High RES scenarios : from adequacy to stability challenges and new solutions*
  - ✓ *IT challenges to activate and monitor flexibilities, Wednesday*
  - ✓ *Value and demonstrations of flexibility provision by distributed sources*

Thanks for your attention

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