OSMOSE

OPTIMAL SYSTEM-MIX OF FLEXIBILITY SOLUTIONS FOR EUROPEAN ELECTRICITY

FINAL WEBINAR SERIES

04 May 2022

Market design modeling and analysis for flexibility

OSMOSE WP2

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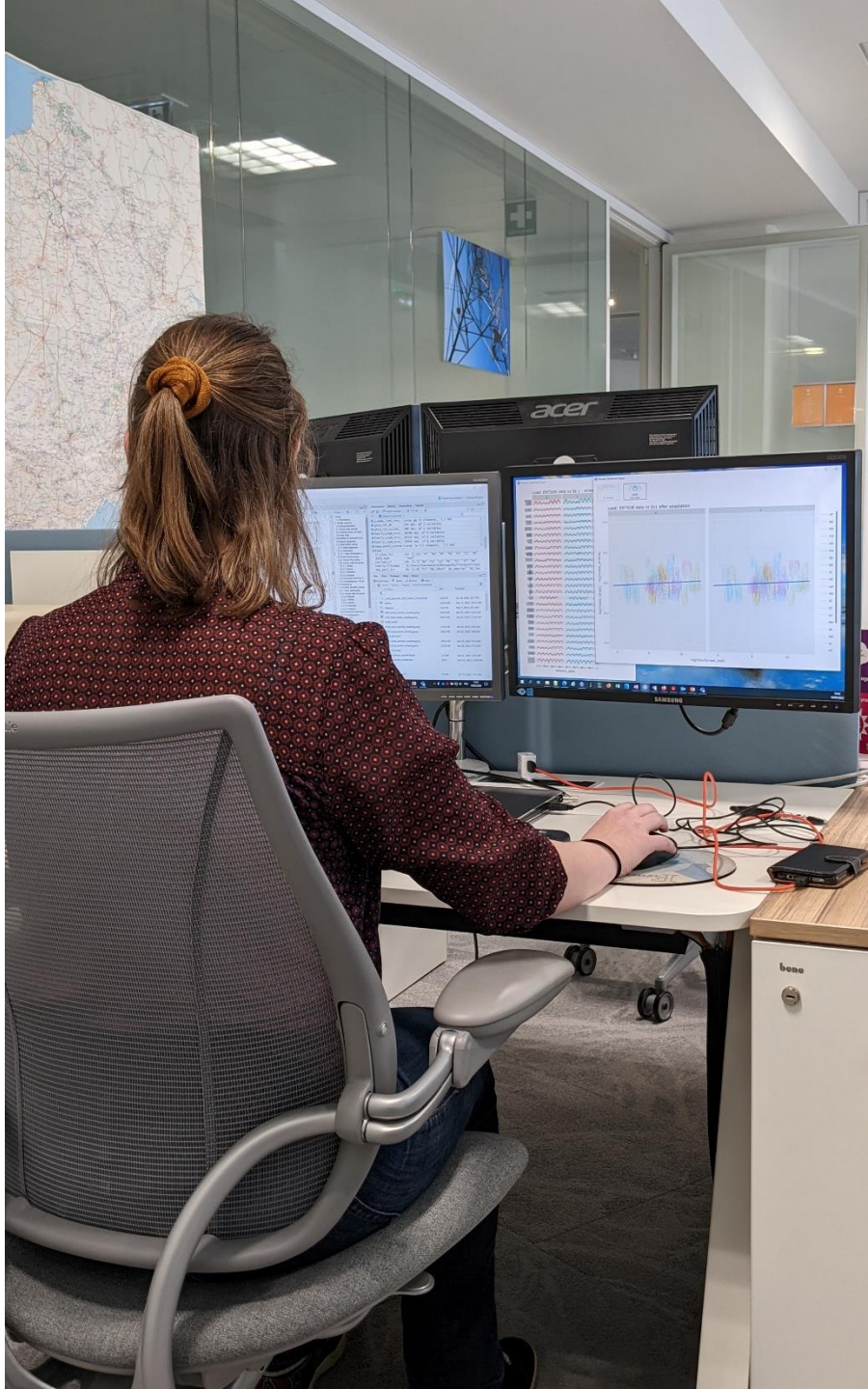
The project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 773406.

Agenda

1. Introduction (RTE)
2. Zonal study with forecast errors (UDE)
3. Agent-based market modelling for improved representation of uncertainties (RTE)
4. Modeling distributed flexibility (ENSIEL)
5. Nodal Market (UDE)
6. Key takeaways (RTE)



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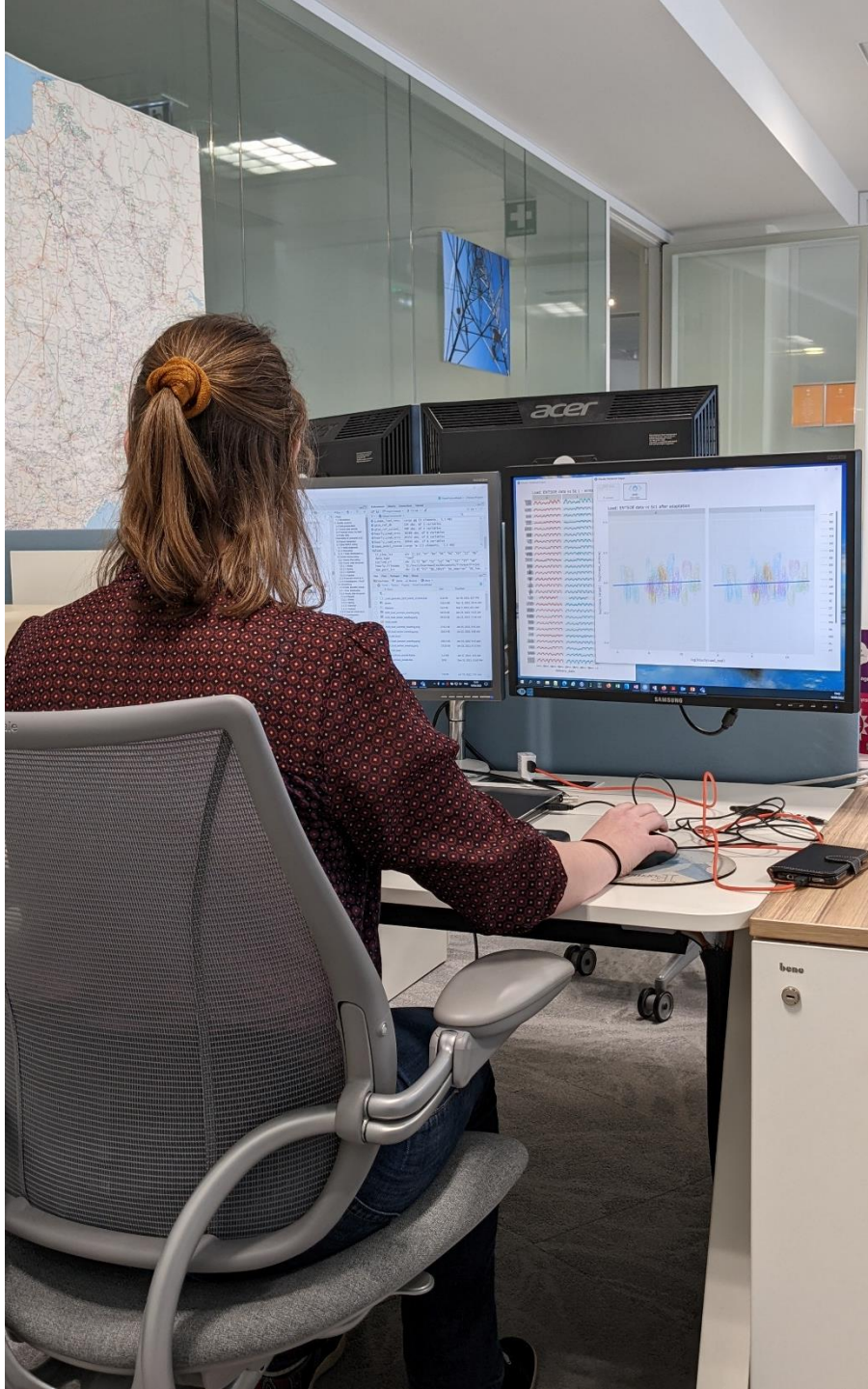

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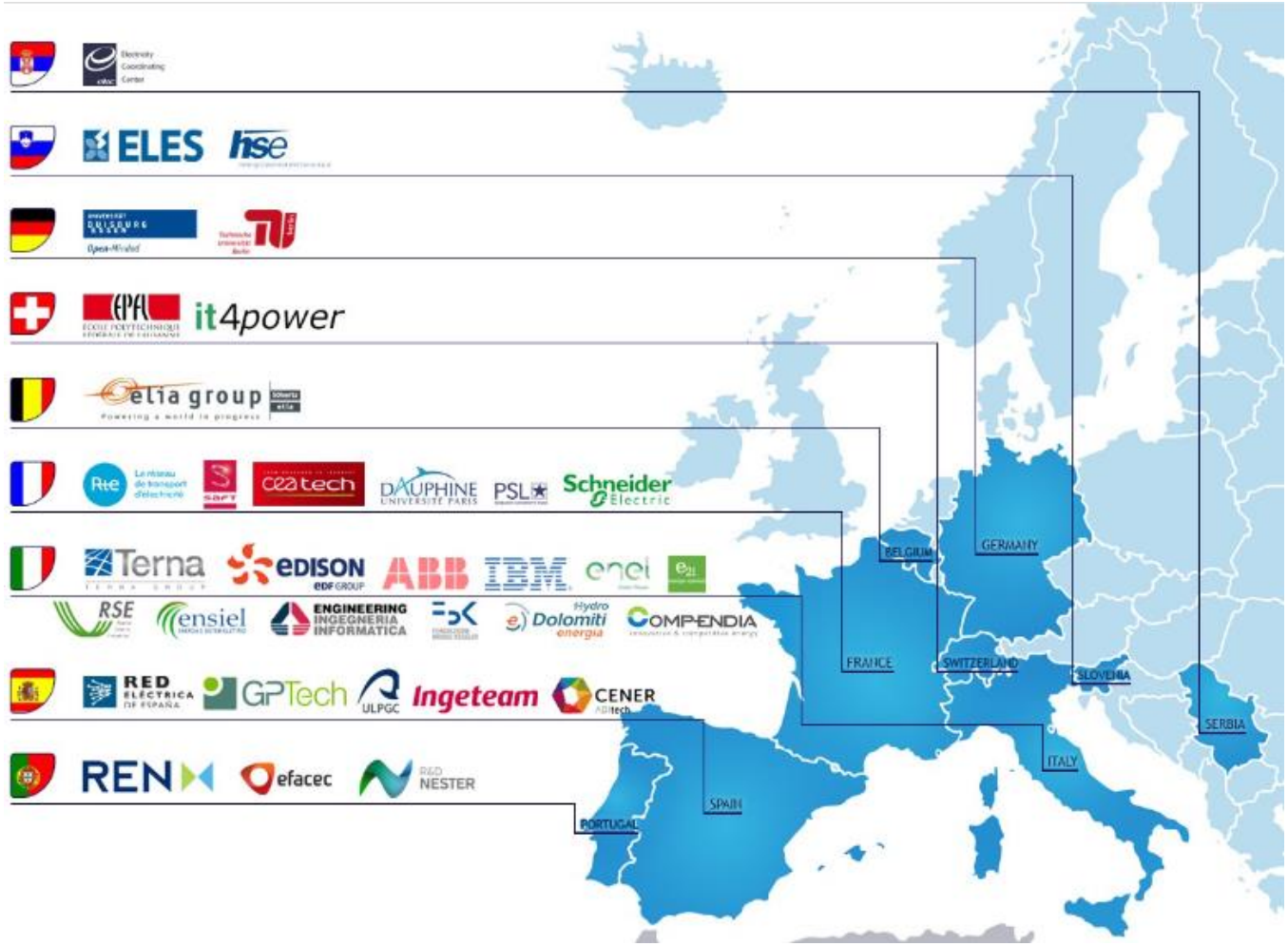
The OSMOSE project

- ✓ H2020 EU funded
- ✓ 28M€ budget
- ✓ 33 partners
- ✓ Leaders: **RTE**, REE, TERNA, ELES, CEA, TUB
- ✓ 01/2018 – 04/2022



OSMOSE objectives

- **Improve the understanding of future needs and sources of flexibility** required to achieve the decarbonization of Europe
  - ✓ Modelling and quantification of flexibility in European Long-term scenarios

- Foster the **implementation** of innovative flexible solutions
  - ✓ Large scale demonstrators led by Transmission System Operators (TSOs)
  - ✓ Advanced tools for Battery Energy Storage System operators and power System Operators

Work structure

Simulations of long-term scenarios

- ✓Identify future needs and sources of flexibility
- ✓Develop new tools and methods for flexibility assessment

WP1 Optimal mix of flexibilities

WP2 Market designs and regulations

WP7 Scaling-up and replication

4 Demonstrators

- ✓Foster the participation of new flexibility providers
- ✓Demonstrate new flexibility services and multi-services capabilities

WP3 Grid forming by multi-services hybrid storage

WP4 Multi-services by different storage and FACTS devices

WP5 Multi-services by coordinated grid devices, large demand-response and RES

WP6 Near real-time cross-border energy market

WP2 objective: refine WP1 assumptions

Simulations of long-term scenarios

- ✓Identify future needs and sources of flexibility
- ✓Develop new tools and methods for flexibility assessment

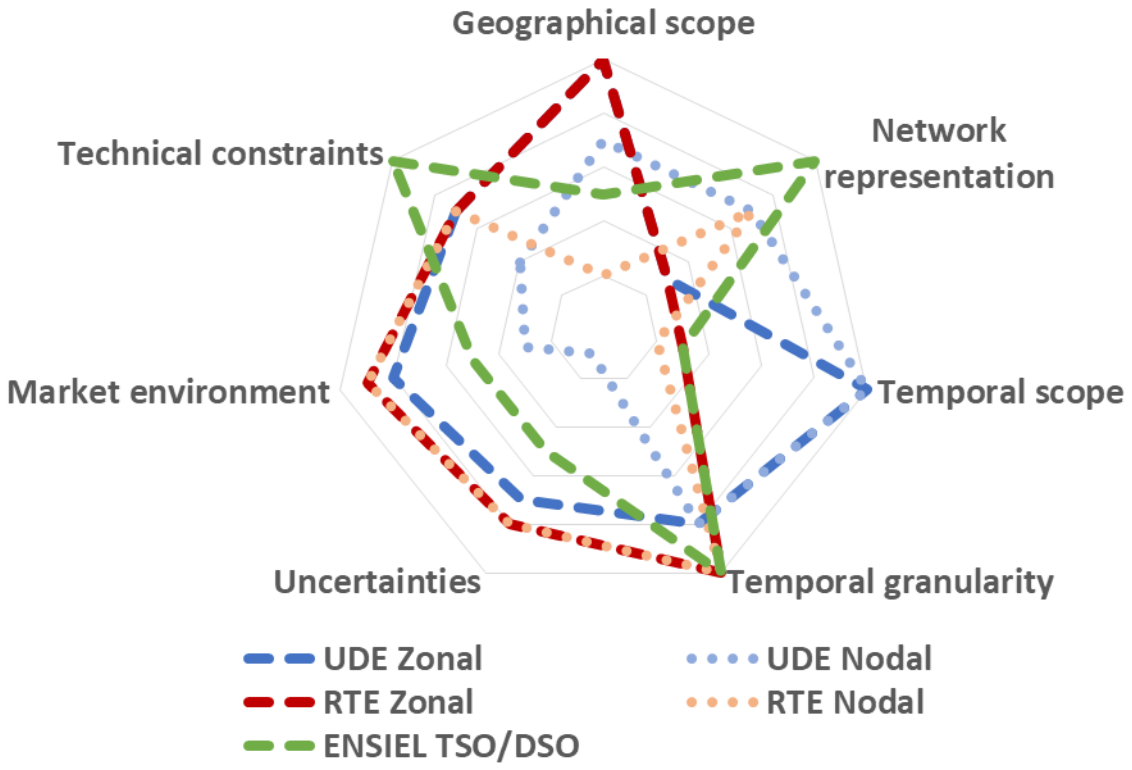
WP1 Optimal mix of flexibilities

WP2 Market designs and regulations

Proposal of investment pathways leading to optimal combinations of flexibility solutions

Benevolent monopoly	Perfect foresight	Low geographical granularity
Agent-based modelling	Gradual reveal of uncertainty	Study of TSO-DSO interface

Overview of performed 2030 studies: different trade-offs between model scope and precision



UDE

Simulation of day-ahead and intraday European power system operation over a full year under perfect competition / benevolent monopoly.

RTE

Detailed simulation of 24h of the European power system's short-term operation, considering successive agent decision-making in uncertain conditions.

ENSIEL

Simulation of power system behaviour at the TSO/DSO interface, to evaluate whether distributed flexibility can be activated while respecting local network constraints.

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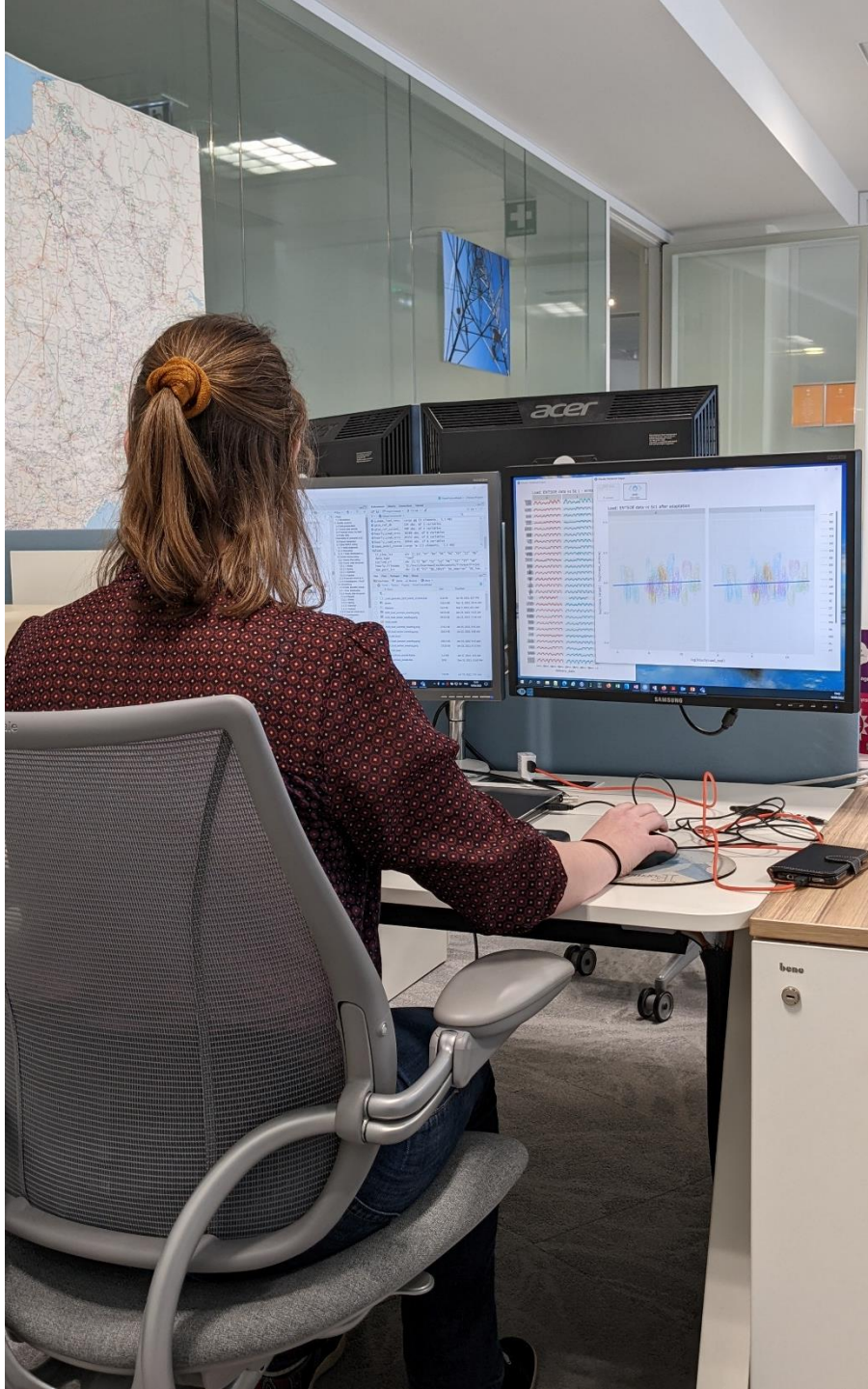

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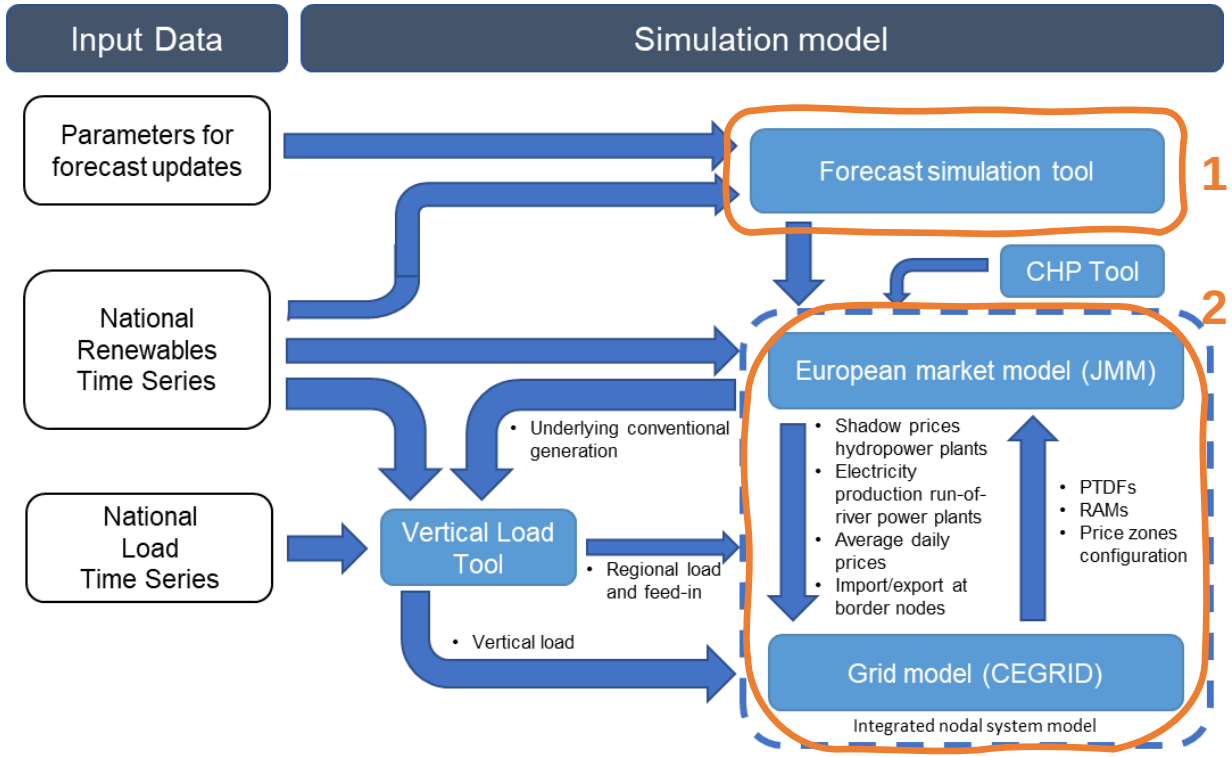
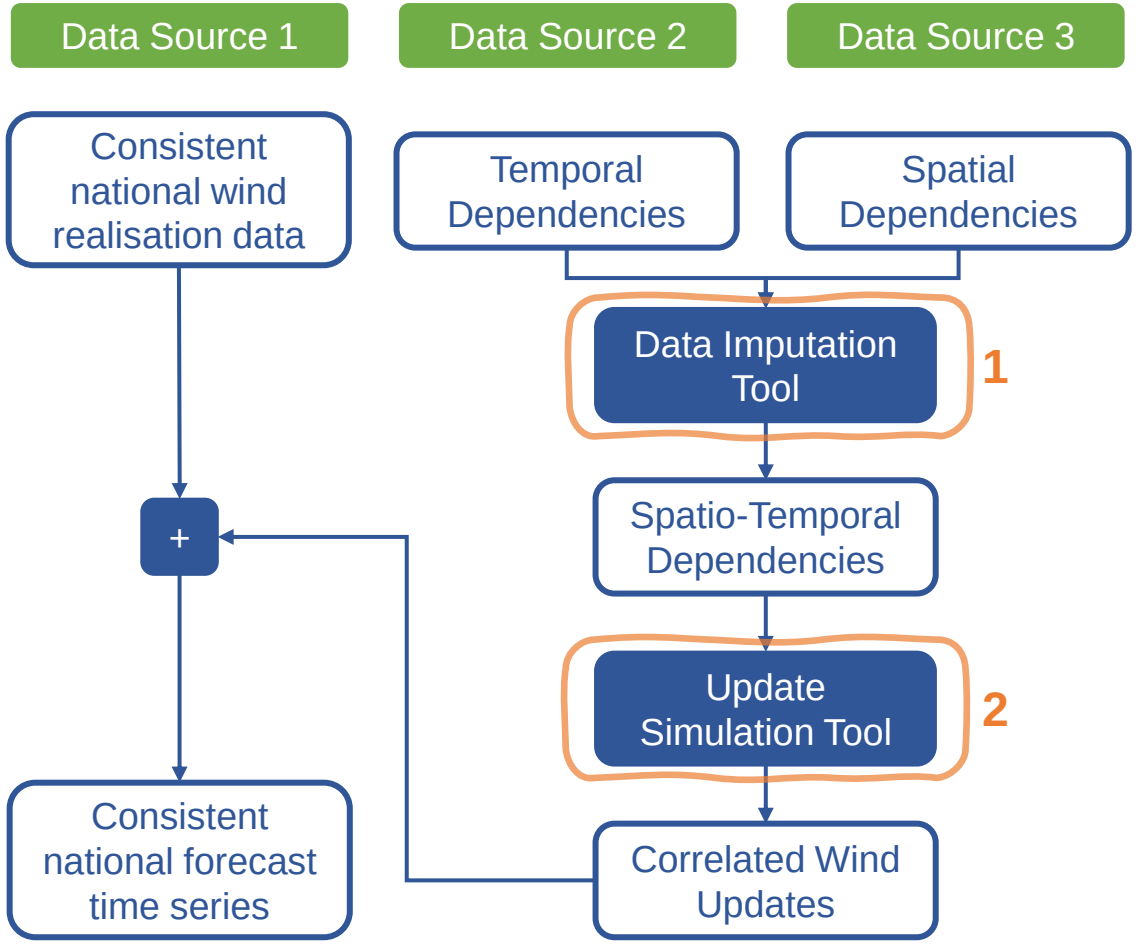
Zonal study with updated forecast time series:
Who provides flexibilty for wind uncertainty?

- Our study's aim is to assess how the energy system responds to uncertainty from RES production.
- UDE's European market model (2) takes advantage of a rolling planning approach and thus, allows to re-evaluate day ahead market results with updated information on repetitive and subsequent intraday market clearing cycles.
- Our forecast simulation tool (1) allows us to provide our market model with in space and time consistently updated forecasts.
- This allows us to study which technologies provide flexibilities, also cross-border.

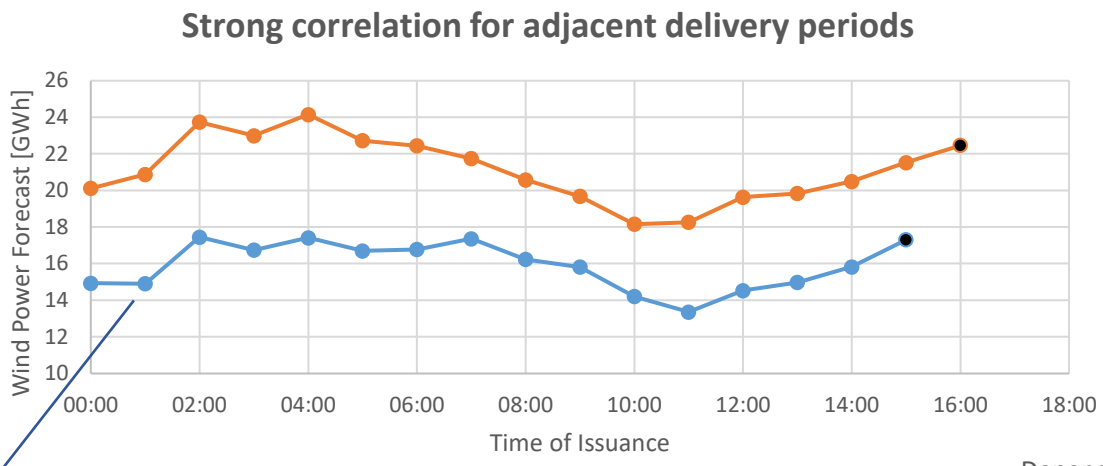


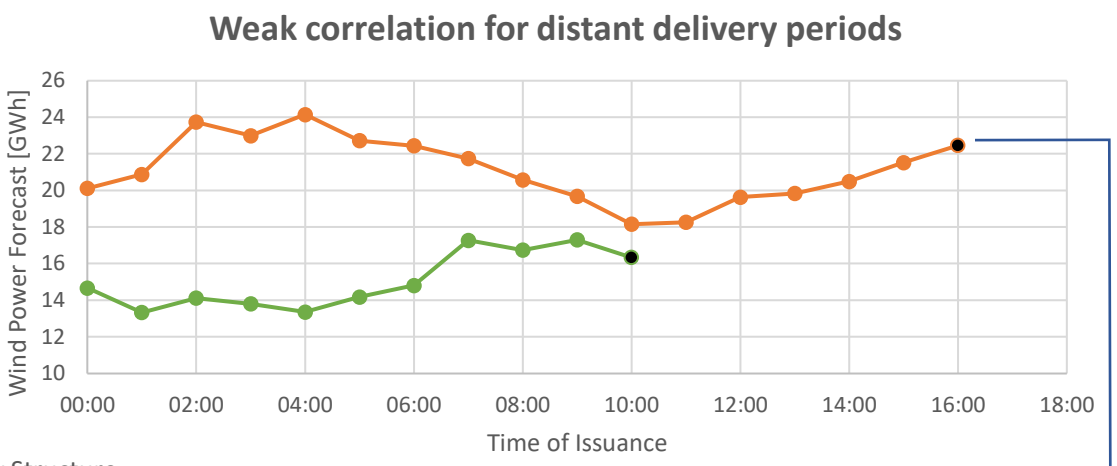
How to provide correlated forecast updates?

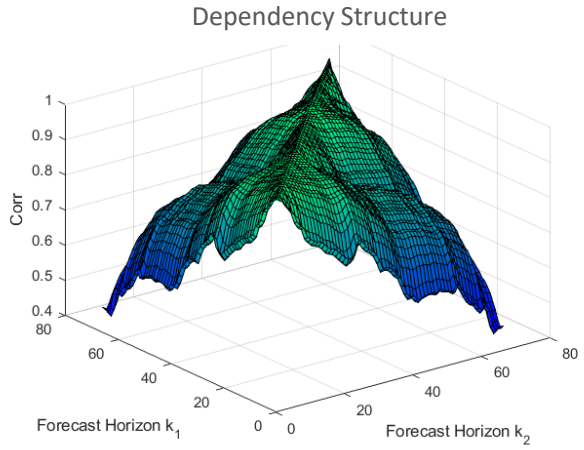
- A forecast first issued at the beginning of a day is updated consecutively till maturity. Thus, forecast updates are driven by new information that translates not equally but alike for subsequent hours and regions.
- With OSMOSE, we developed a tool (**2**) that can replicate forecast updates based on the spatio-temporal dependency structure.
- Consistent time series data with updated forecasts for entire Europe are publicly not available. Thus, we also developed a data imputation tool (**1**) to combine temporal dependencies from one dataset with spatial dep. from another.



Exemplary output of our update simulation tool



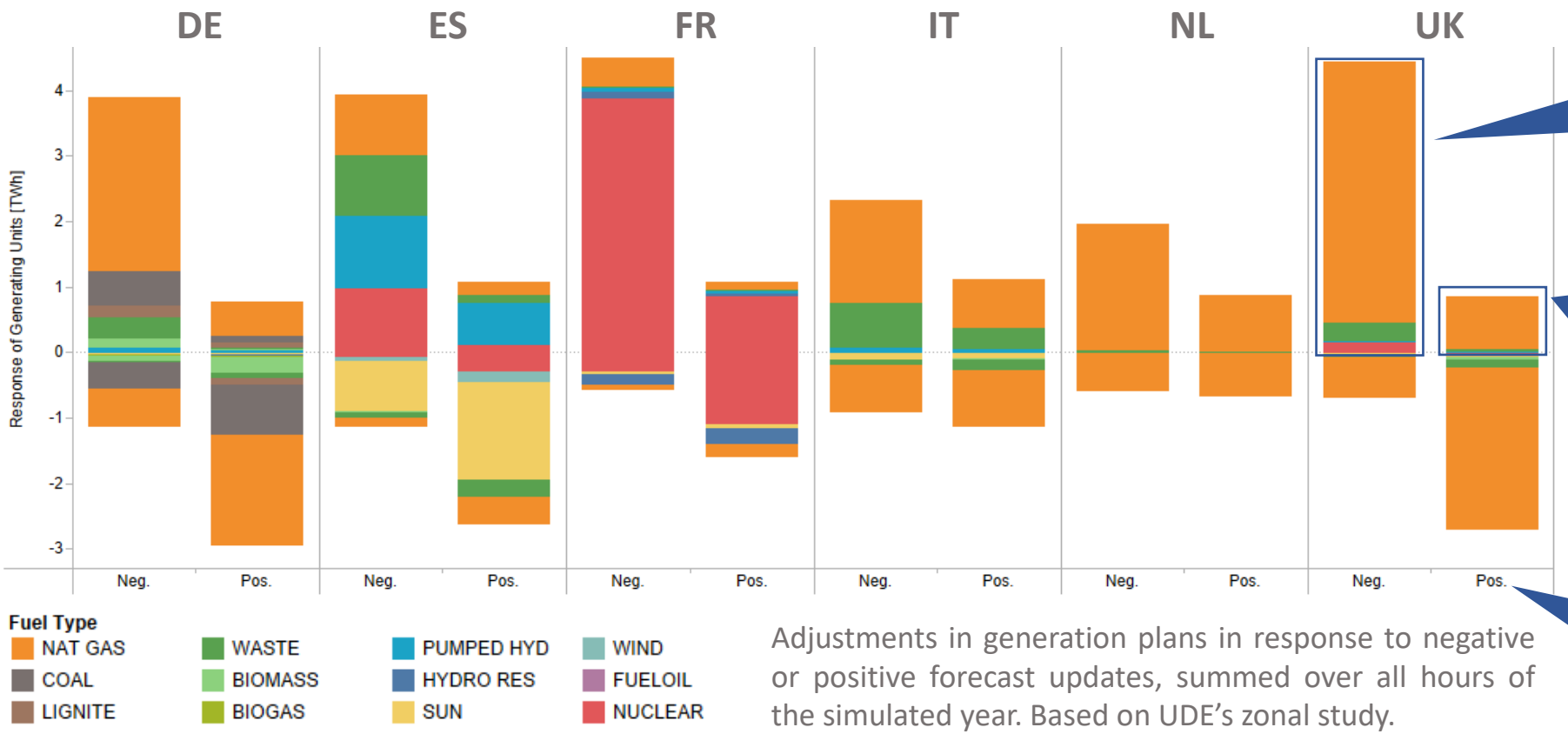




Information shocks affect forecast trajectories simultaneously, but not equally. Temporal distance between forecast trajectories affects the dependency structure

To ensure consistency with the realisation time series, forecasts aren't updated from their earliest issuance, but backwards in time from maturity.

Who responds to a surplus or shortfall of wind?



Adjustments in generation plans in response to negative or positive forecast updates, summed over all hours of the simulated year. Based on UDE's zonal study.

Shortage of wind is compensated with a surplus of conv. Prod.

! Surplus of wind **and** surplus of conv. production indicates **cross-border flexibility provision**

Sign of forecast updates

Who responds to a surplus or shortfall of wind?

- Technologies contribute with different shares to production and flexibility provision. E.g. gas-fired units dominate flexibility provision.
- Also, technology shares of up- and downward flexibility provision mis-match. Hydro reservoirs are preferably spared, whereas pumped hydro units only provide upward flexibility.

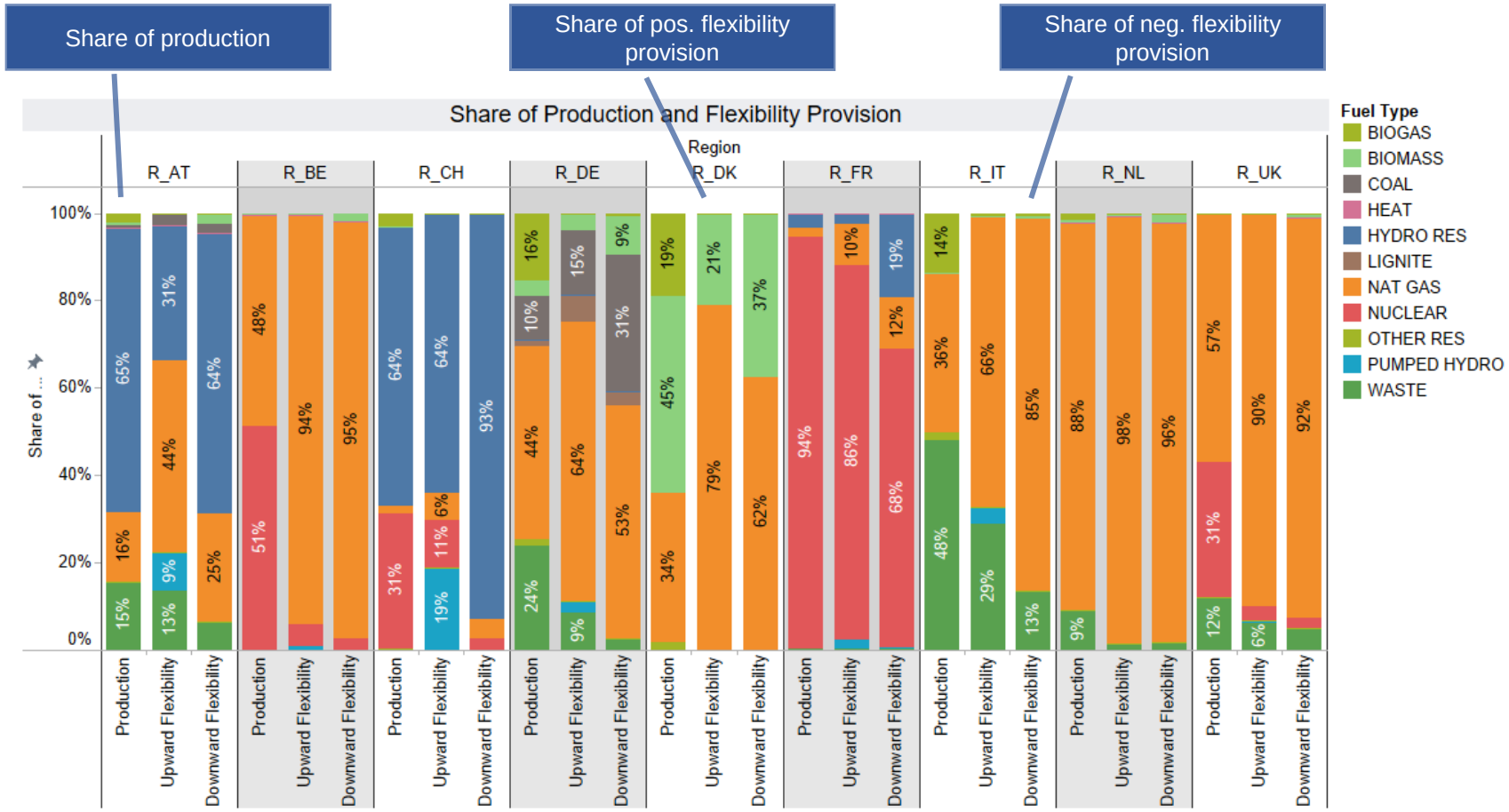


Figure compares share of production and up- and downward flexbility provision per technology and country. Wind and photovoltaic production are excluded.

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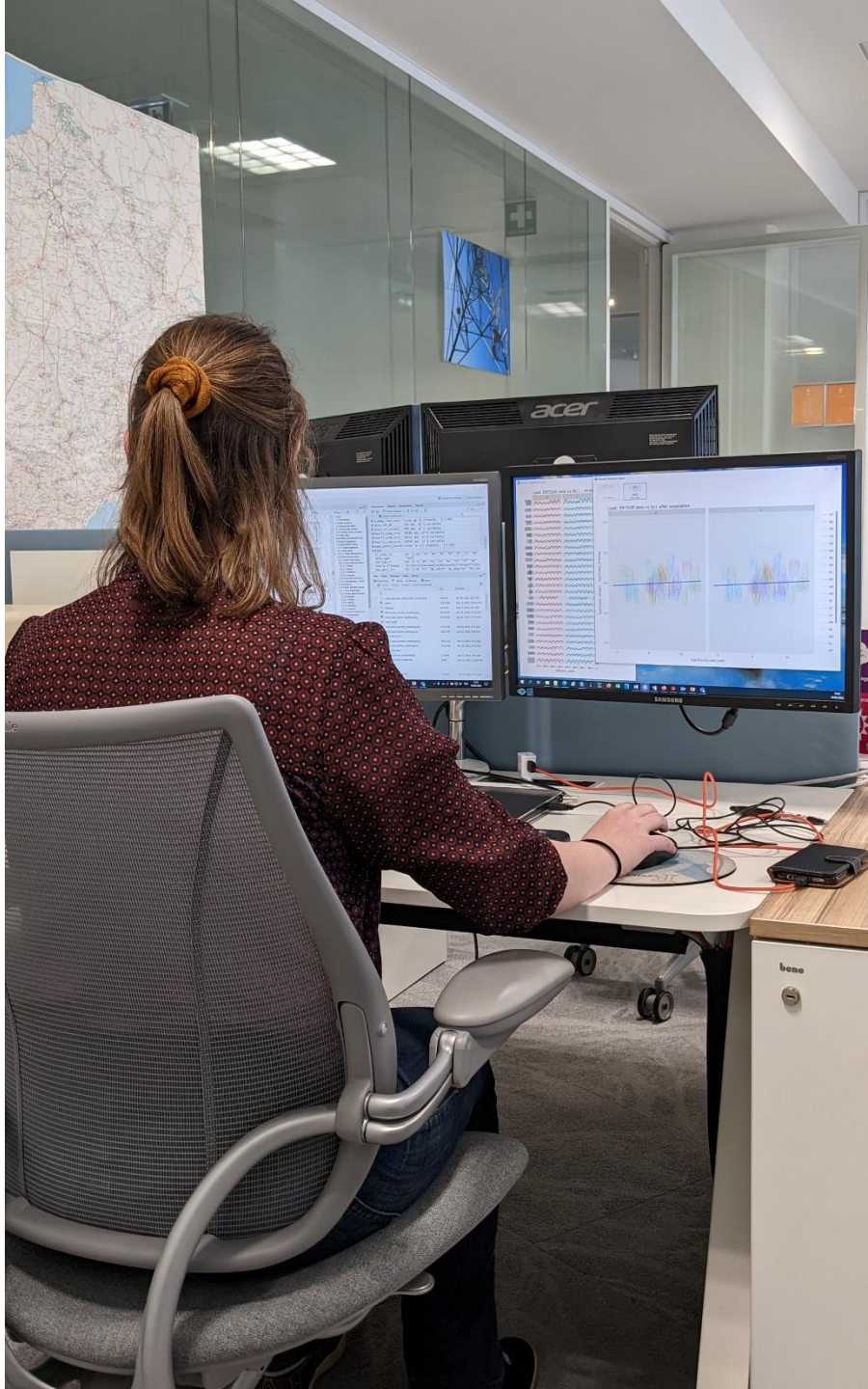

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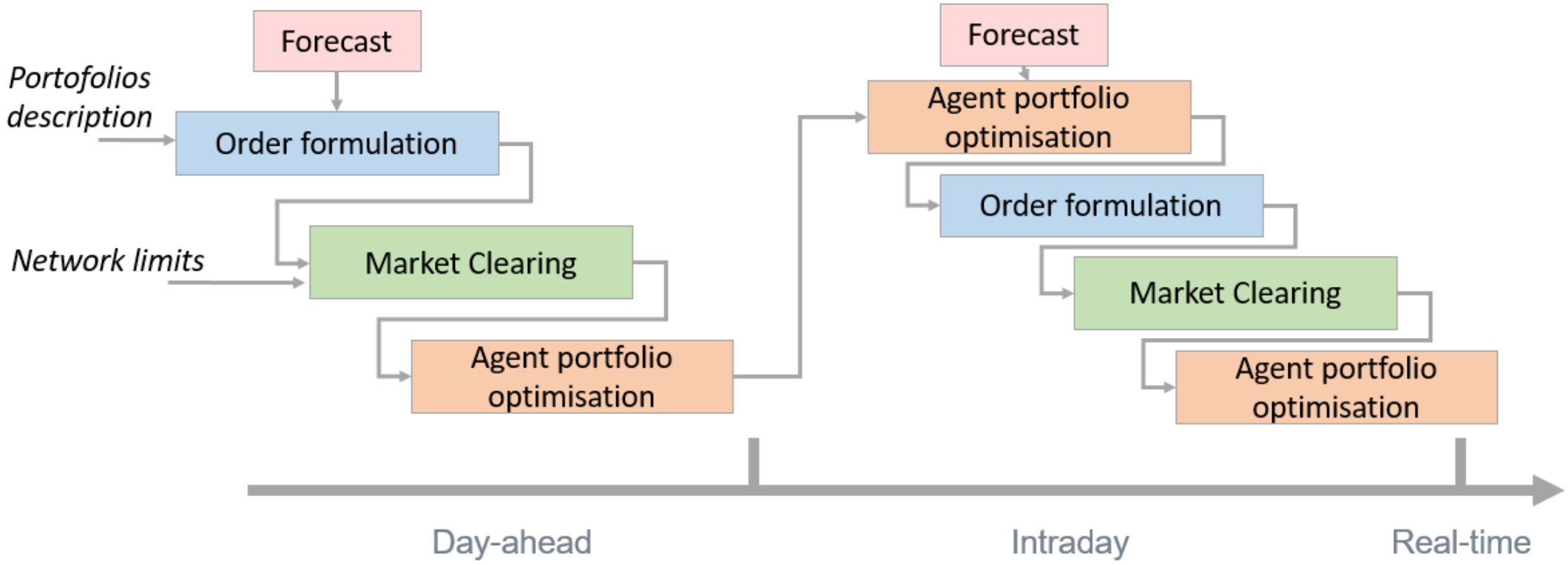
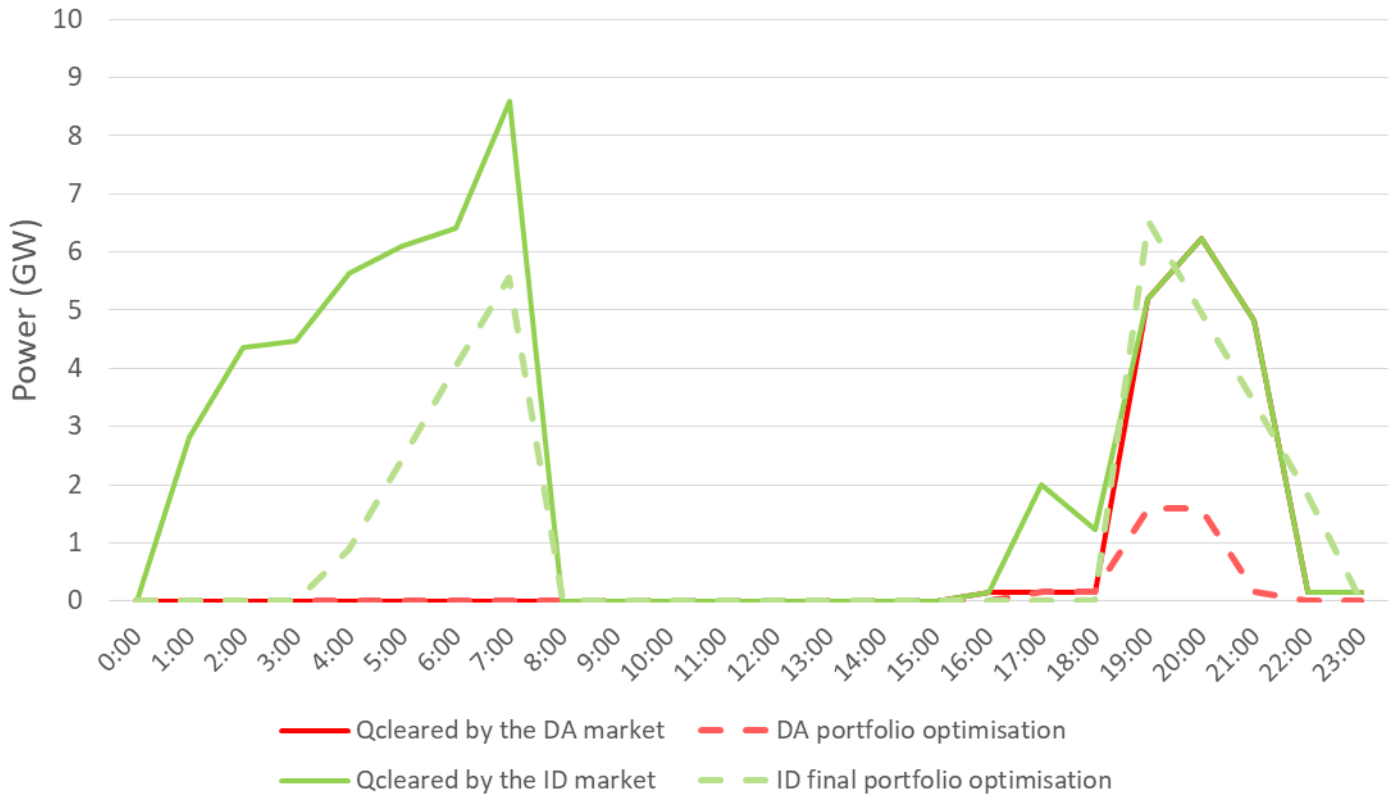
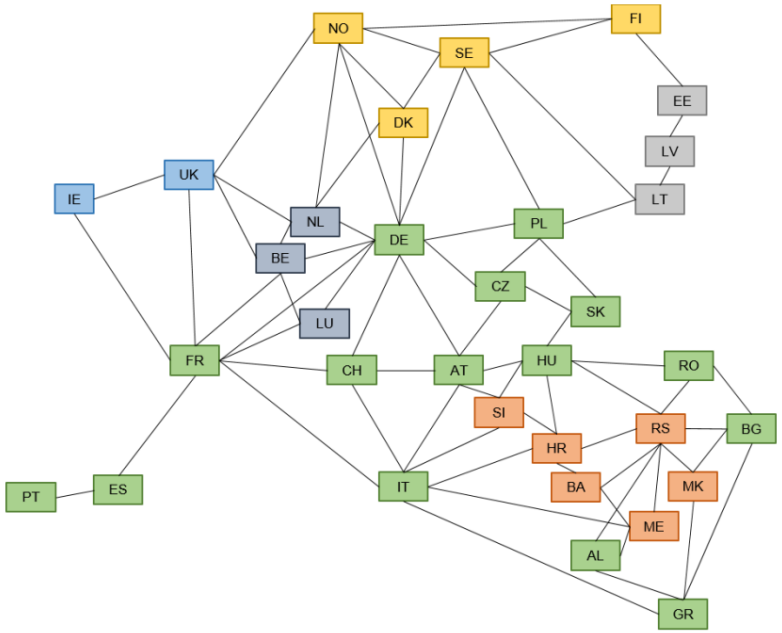
RTE's agent-based model ATLAS allows improved representation of uncertainty in power system operation



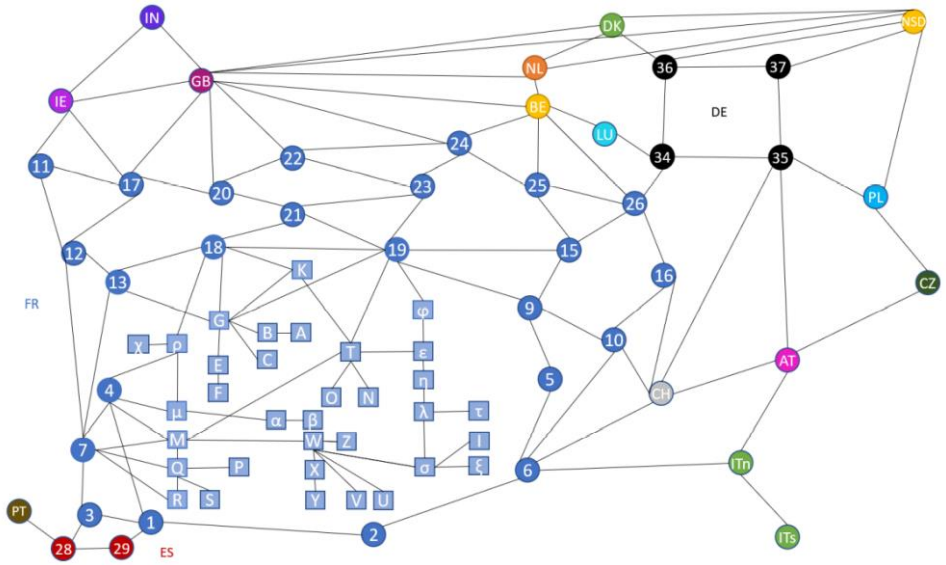
Example evolution of Spanish CCGT dispatch over 24 hours of ATLAS steps



Case study description: 2030 European power system

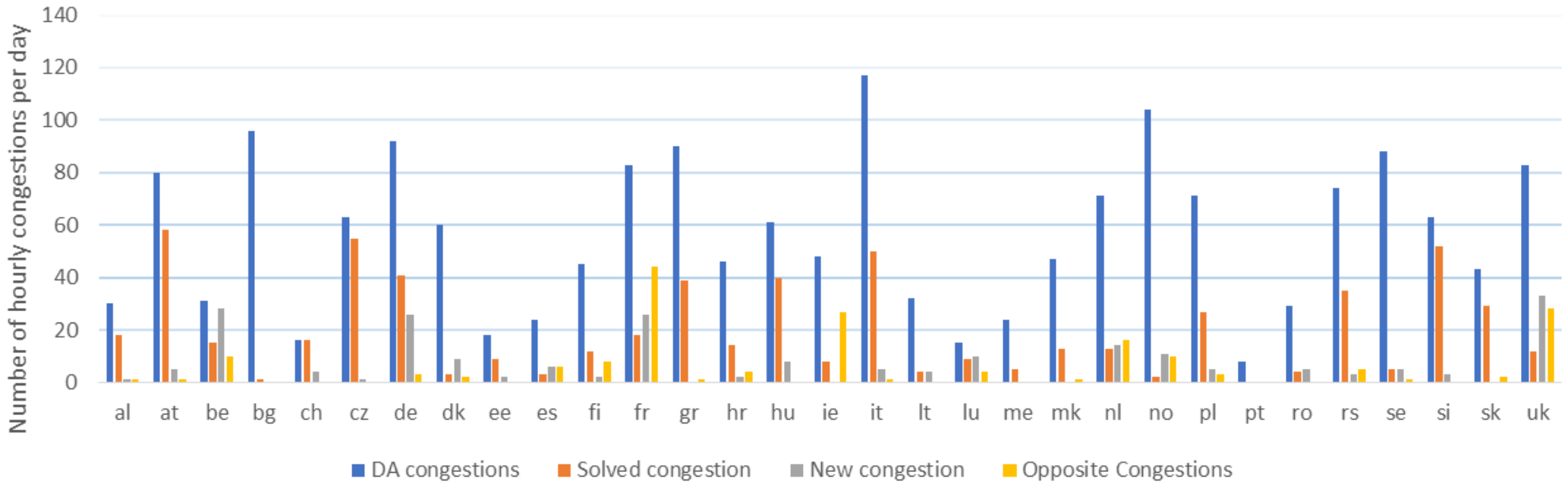


Zonal study



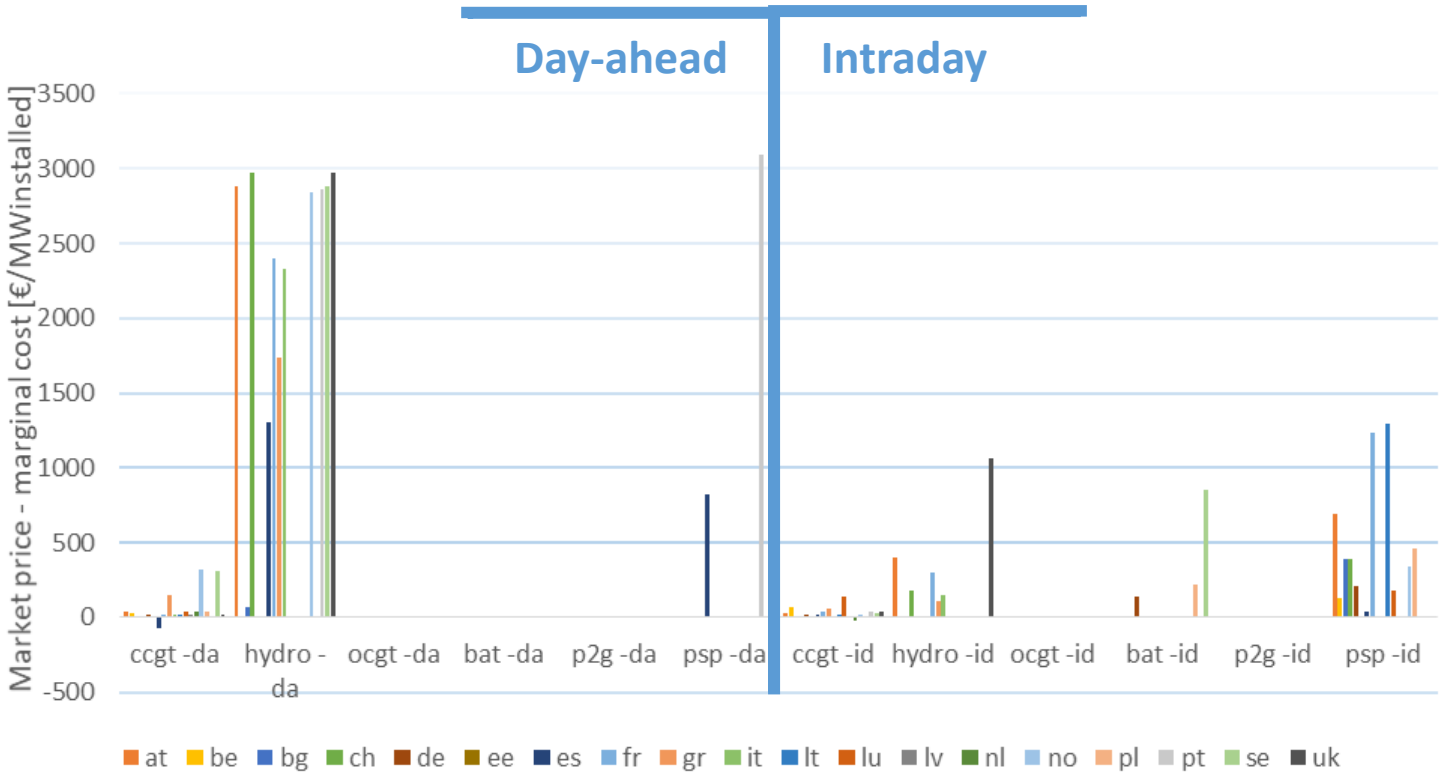
Nodal study

Grid congestions and flows will become harder to anticipate in day-ahead, because interconnections will contribute significantly to intraday flexibility



Evolution of cross-border congestions between the day-ahead and intraday markets, aggregated by country. Based on RTE's zonal study

Considering revenues from both day-ahead and intraday markets is necessary to evaluate asset profitability



Flexible asset market profits on the day-ahead (left) and intraday (right) markets, based on RTE's zonal study

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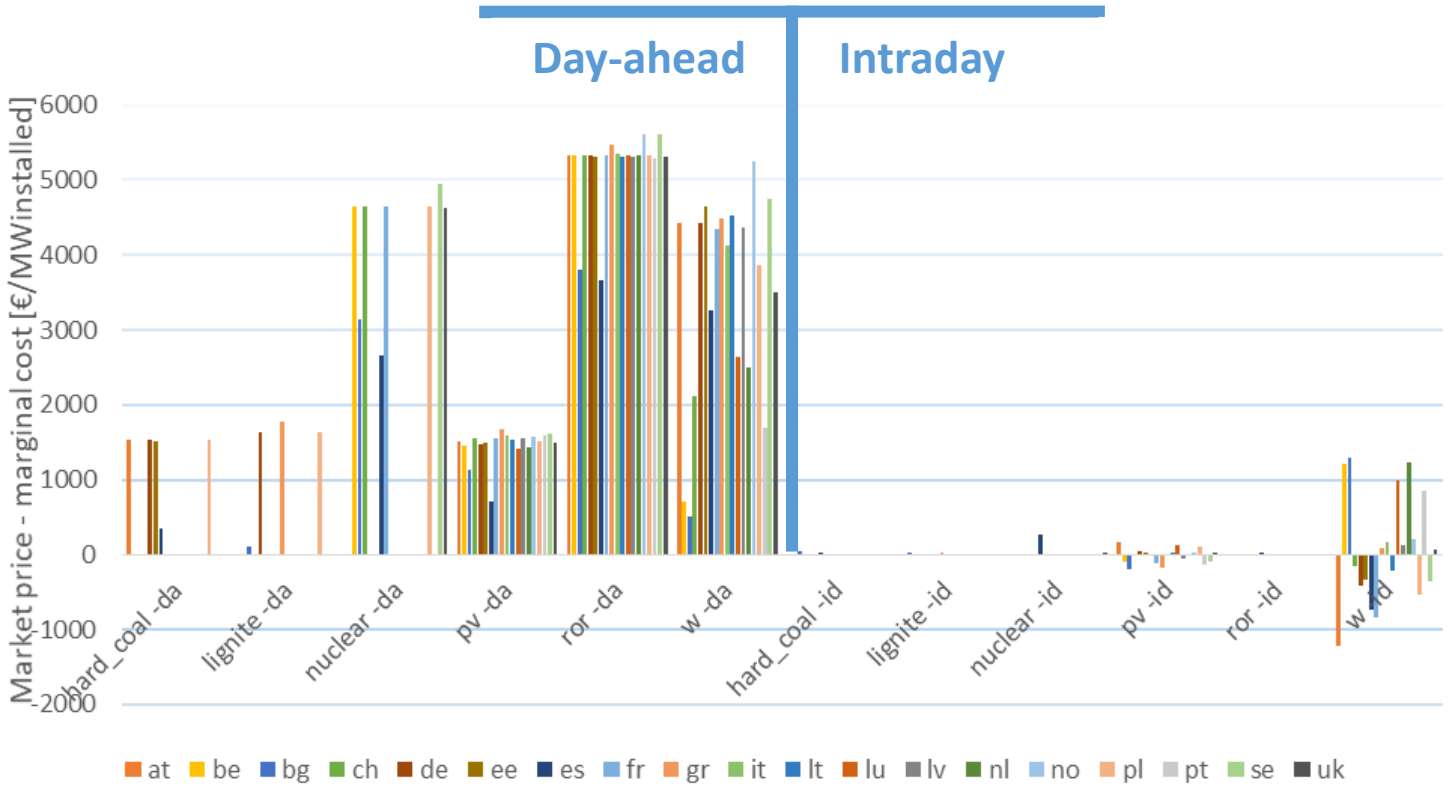

Less flexible asset market profits on the day-ahead (left) and intraday (right) markets, based on RTE's zonal study

These results suggest that a change in our planning methodologies may be required

- Optimal investment pathways based on perfect foresight may lead to sub-optimal or technically unfeasible solutions
- An assessment of a technology's value should consider all revenue streams, including the intraday market
- This also applies to the design of capacity mechanisms

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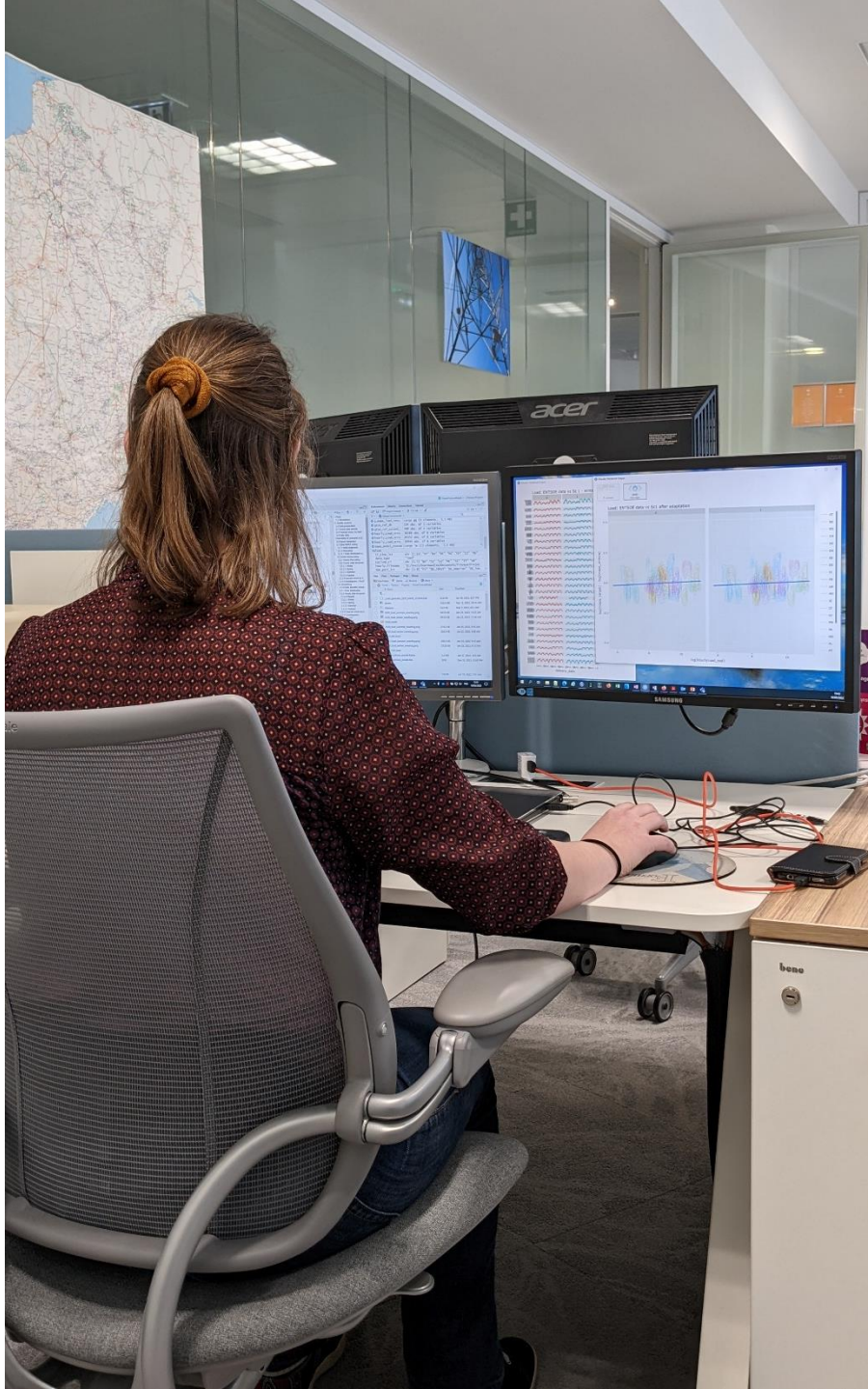

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Modeling distributed flexibilities by ensiel

- ***Flexibility*** is mainly found at the **distribution system level**, but it is needed by **both TSO and DSOs** to cope with grid operation challenges.
- **Open questions:**
  - Can the distributed energy resources connected to the distribution system provide flexibility to the system operators (DSO, TSO or both)?
  - To what extent can TSO exploit flexibility without causing issues at the distribution level?
  - Which are the main issues caused by flexibility?
  - Are there operational actions that enable flexibility at the distribution level?
  - Which are the expected costs to enable flexibility?
- Exploitation of distribution flexibility is a ***new practice*** that needs to be simulated via fair use cases or analysed in pilot projects.

Modeling distributed flexibilities

GOAL

- The methodology proposed by ensiel ENERGIA E SISTEMI ELETTRICI assesses **to what extent the use of flexibility by the TSO can impact the DSO activities** and what the costs are to be expected.
  - **Local distribution market models** where the Distribution Energy Resources (DERs) offer flexibility to the DSO have been hypothesized.
  - The final goal is quantifying the **residual flexibility that can be bid to the TSO** by the distribution networks.

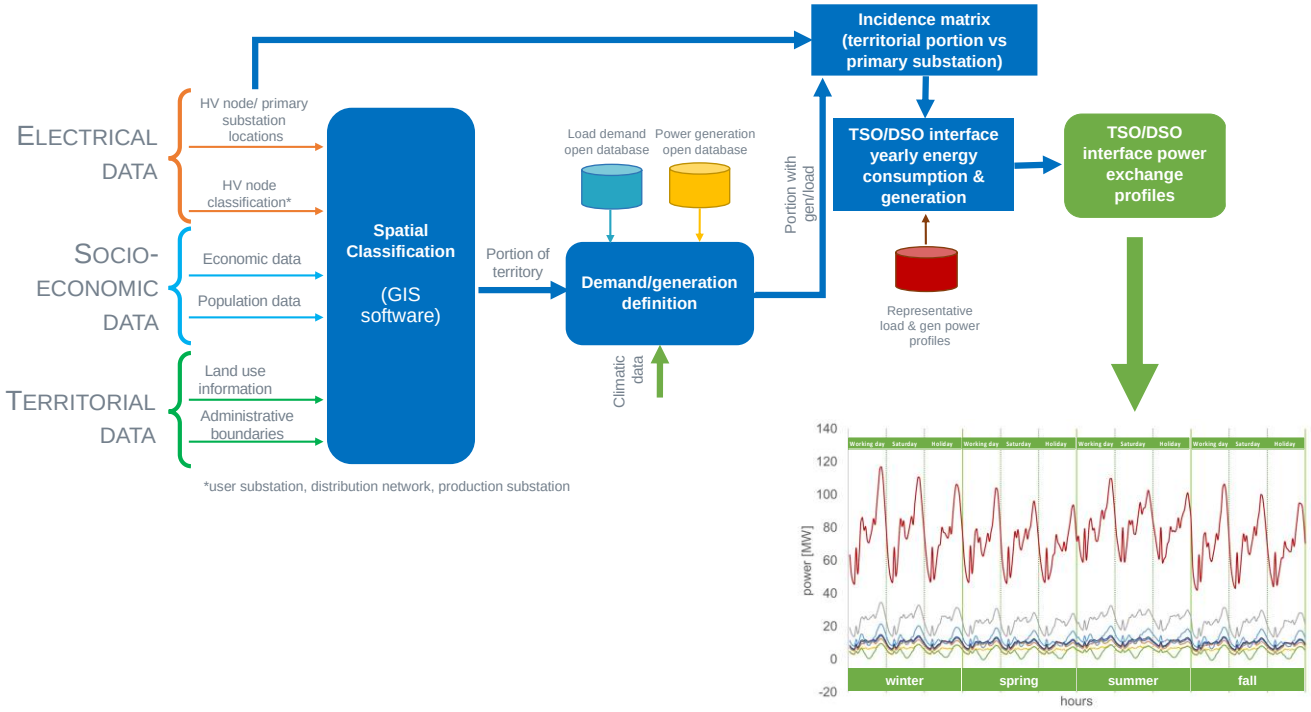
- The proposed methodology can be used by:
  - **TSO:** to estimate the expected level of flexibility products offered by distribution networks and the relevant prices
  - **DSOs:** can understand in advance the effects of the exploitation of flexibility for operational and planning analysis
  - **Players of the ancillary service market:** can assess at what extent the flexibility products from distribution system could compete with them
  - **DERs' aggregators:** can simulate reasonable operative conditions to better define prices and quantities of products that could be offered by their portfolio of customers

Modeling distributed flexibilities

- The proposed methodology consists in two main tasks:
  1. **Representing the distribution grid by building *synthetic networks***
     a. power profile estimation of at the TSO/DSO interface
     b. building of the topology of the underlying medium voltage network
  2. **Assessment of the distribution network market potential**

1. Representing the distribution grid

a. Estimation of load and generation profiles by using only available open data and by resorting GIS applications and tools



Modeling distributed flexibilities

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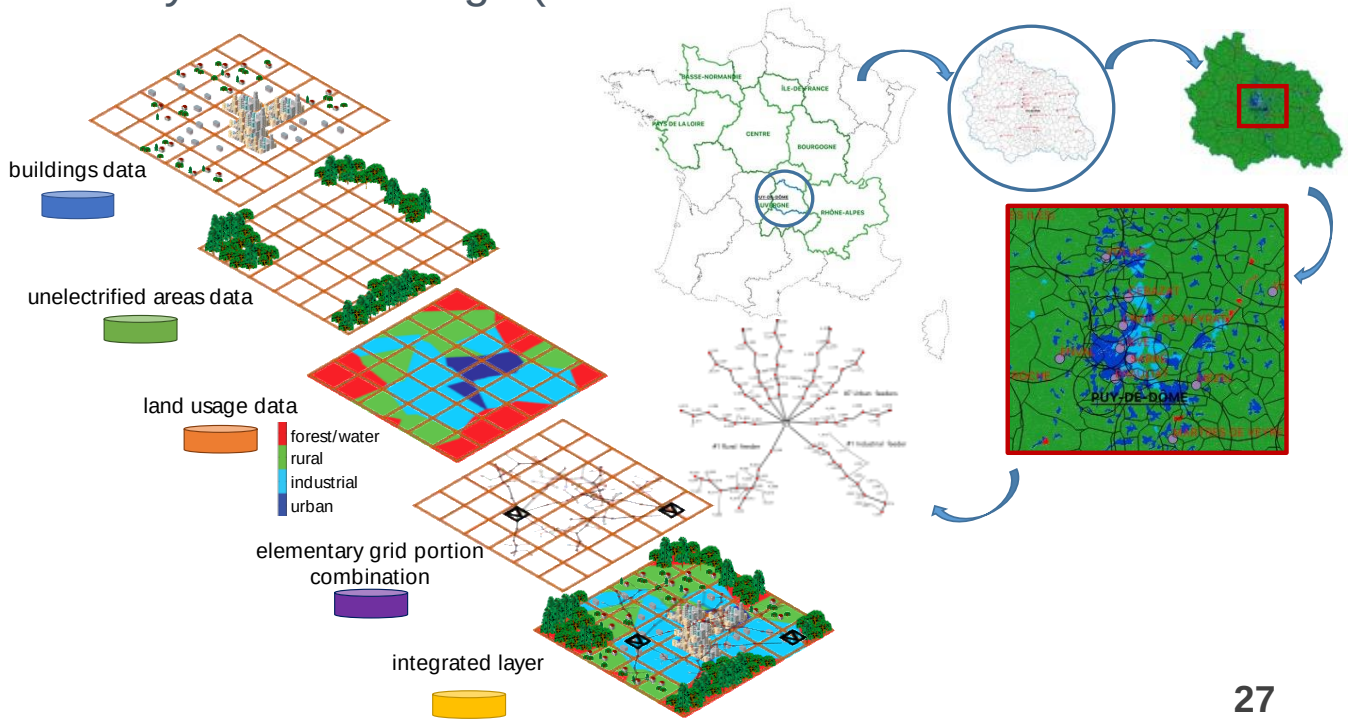
1. Representing the distribution grid

b. Synthetic networks, built by composing elementary portions of representative networks according to the territory segmentation derived by the land usage (GIS)



Modeling distributed flexibilities

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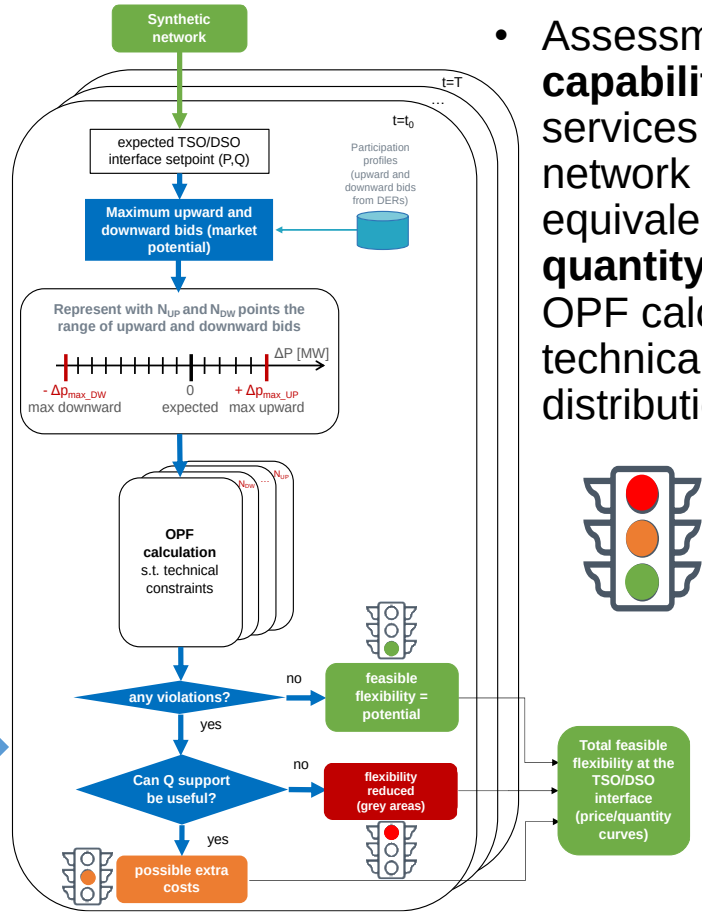
2. Assess the bids



- Assessment of **flexibility capabilities** and offers to ancillary services market for each distribution network model (four quadrants equivalent generator) in terms of **quantity/price** pairs, by running OPF calculations that consider the technical constraints of the distribution grids

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Q support needed
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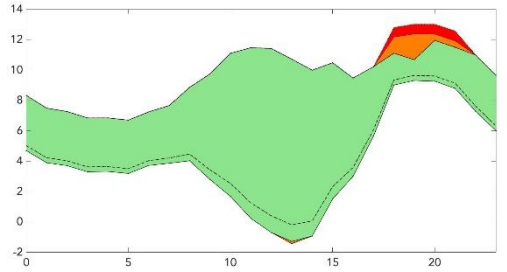


Modeling distributed flexibilities

Challenges of the studies

- **Lack of the distribution system observability**: difficulty to gather reliable data about the distribution system with the desired spatial and time granularity
- **Uncertainties typical of the distribution system studies,** e.g., variety of distribution network topologies, behaviours of the end users, RES-based production (especially from wind), from which derive typical portions of networks and typical profiles of demand and production
- **Forecasting prices of flexibility bids** (e.g., correlations with the energy market clearing price)

Strengths of the studies

- **Distribution network representation** (for any study about the distribution system)
- **Spatial downscaling**
- **Technical constraint compliance** of the potential flexibility bids from DERs
- **Prequalification of distributed resources** in a coordinated market environment
- **Possible extra cost estimation** to be sustained for exploiting flexibility

Modeling distributed flexibilities

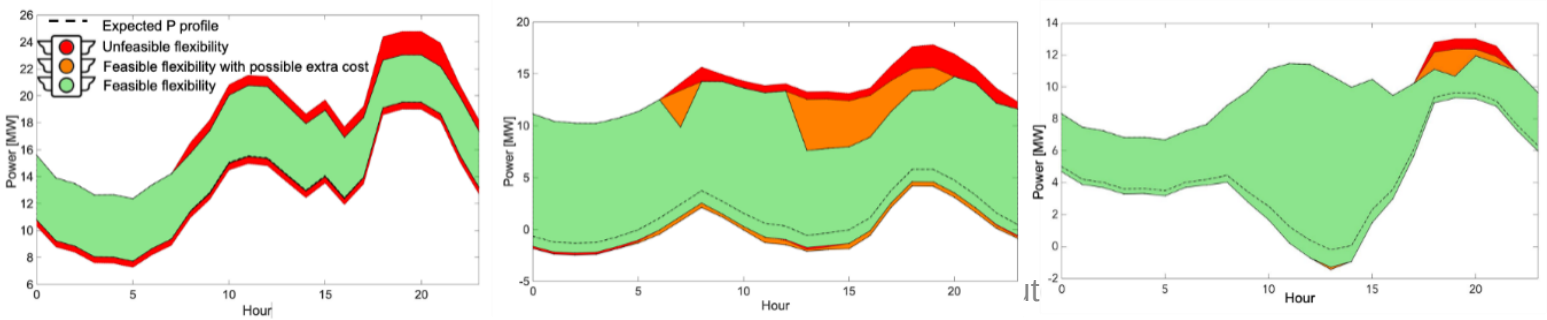
Results 1/2

Study perimeter: central France

#263 distribution networks #7 regions #14 departments

#2 scenarios: Fit & Forget and critical (only RES participation –UP and DW)

Entire region results	UPWARD bids	DOWNWARD bids
Theoretical market potential [GWh/year]	1229.448	12294.482
Reduction in the F&F scenario (Feasible market potential) [%]	-1.43%	-0.91%
Reduction in the critical scenario (Feasible market potential) [%]	-14.6%	-10.8%



Selected TSO/DSO interfaces

Modeling distributed flexibilities

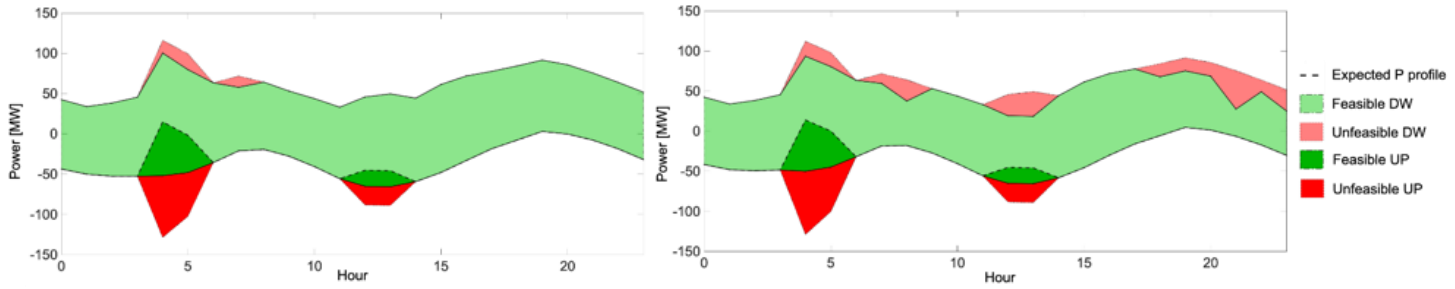
Results 2/2

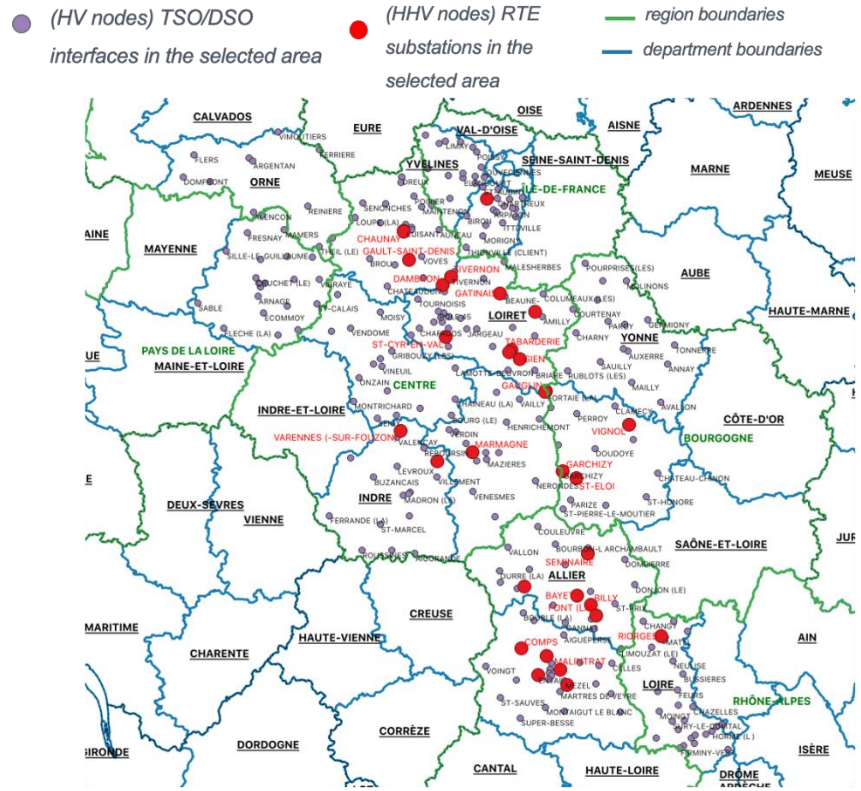
Study perimeter: central France

#19 HHV nodes of the transmission grid (225-400 kV) #112 distribution networks

#2 scenarios: Fit & Forget and critical (RES (DW) + EV (UP and DW) participation)

Single HHV node results	UPWARD bids	DOWNWARD bids
Theoretical market potential [MWh/day]	1031.84	1507.475
Reduction in the F&F scenario (Feasible market potential) [%]	-17.2%	-3.3%
Reduction in the critical scenario (Feasible market potential) [%]	-21.5%	-18.4%





HHV nodes in the selected area

Modeling distributed flexibilities

Key messages/remarks

- **The flexibility extent** that TSO can exploit without causing issues at the distribution level must be carefully assessed

It depends on

- the number of the DERs participating in the market (but enlarging potential **does not necessarily increase the feasible** flexibility), and
- the position of the resources in the network.

- Grid limitations cannot be disregarded

The spatial downscaling reveals **local criticalities** (mainly voltage regulation problems)

- Mutual impacts on the flexibility provision by TSO and DSO
  - **TSO/DSO coordination needed**

The assessment of the possible violations of the network constraints may prevent blocks by the DSO and simplify the use of the flexibility for global services

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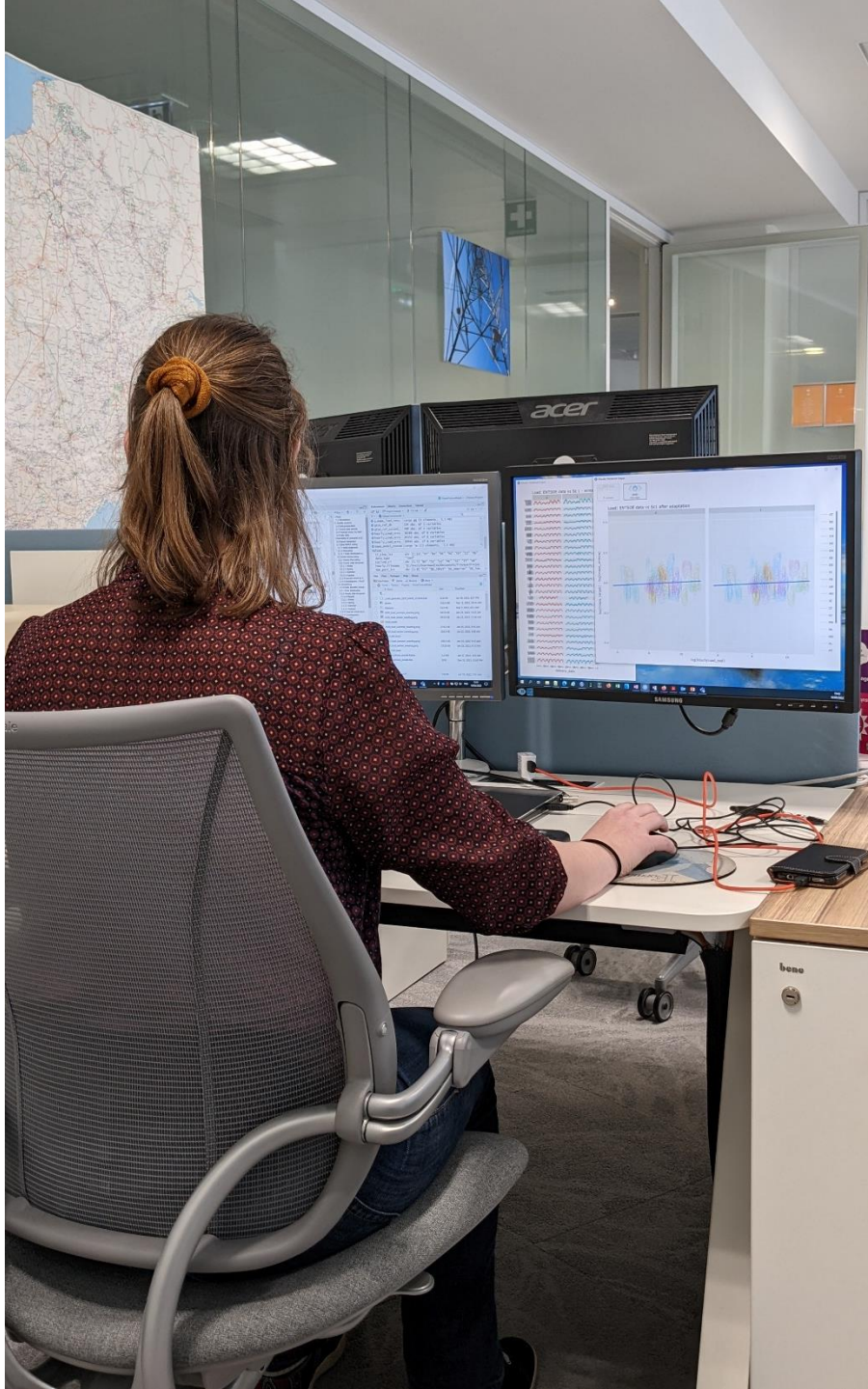

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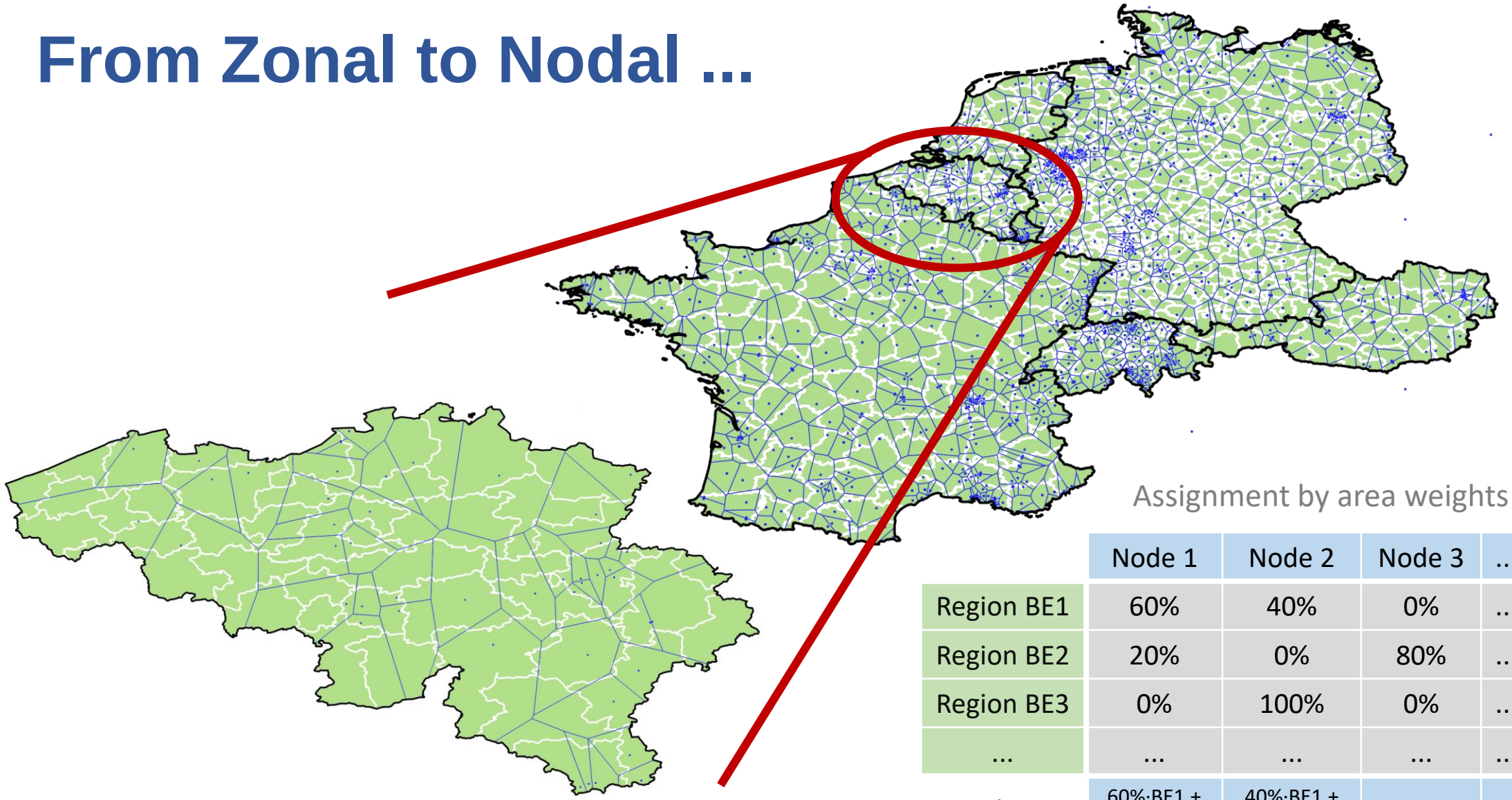
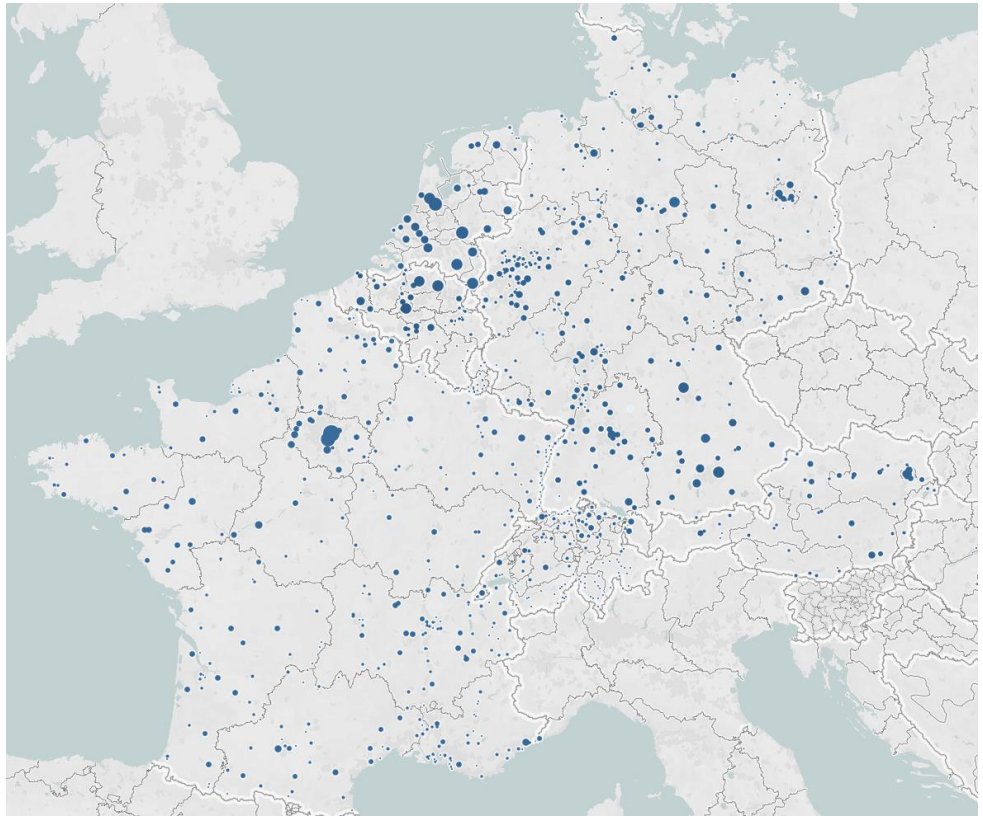
From Zonal to Nodal ...



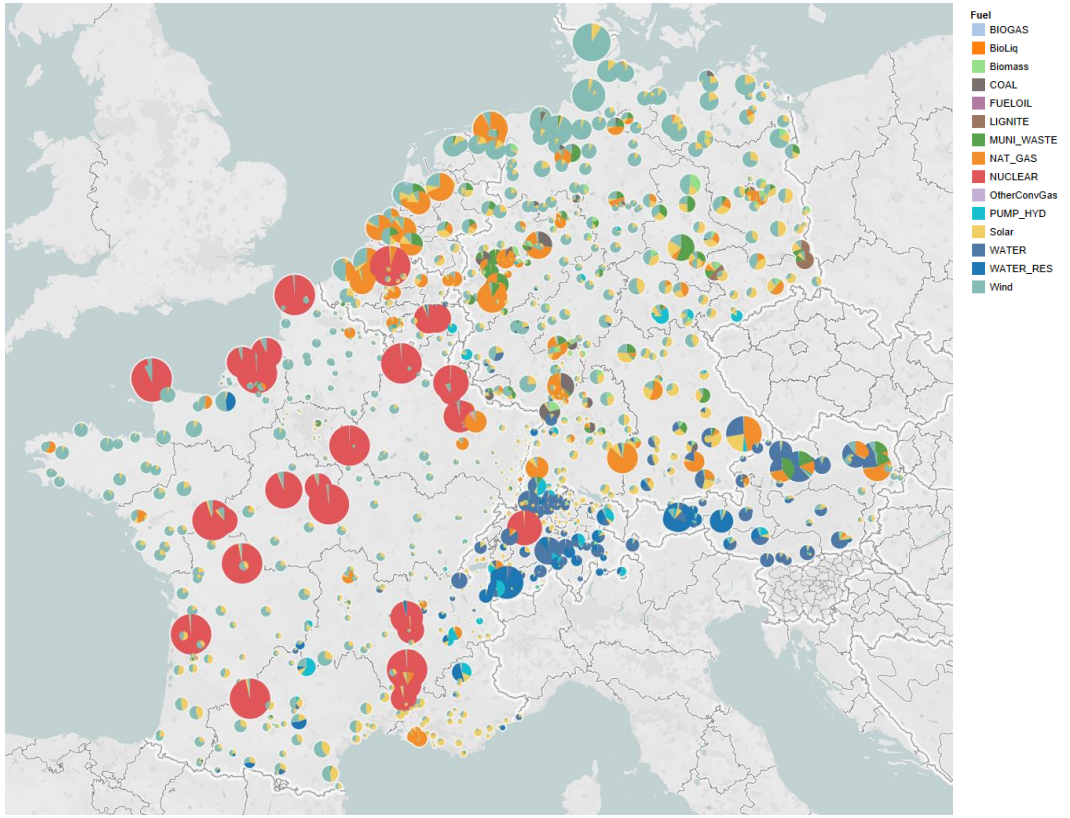
Assignment by area weights

	Node 1	Node 2	Node 3	...	Σ row
Region BE1	60%	40%	0%	...	100%
Region BE2	20%	0%	80%	...	100%
Region BE3	0%	100%	0%	...	100%
...	...	...	...	...	...
Σ column	60%·BE1 + 20%·BE2	40%·BE1 + 100%·BE3	80%·BE2	...	

Nodal distribution overview in CWE+

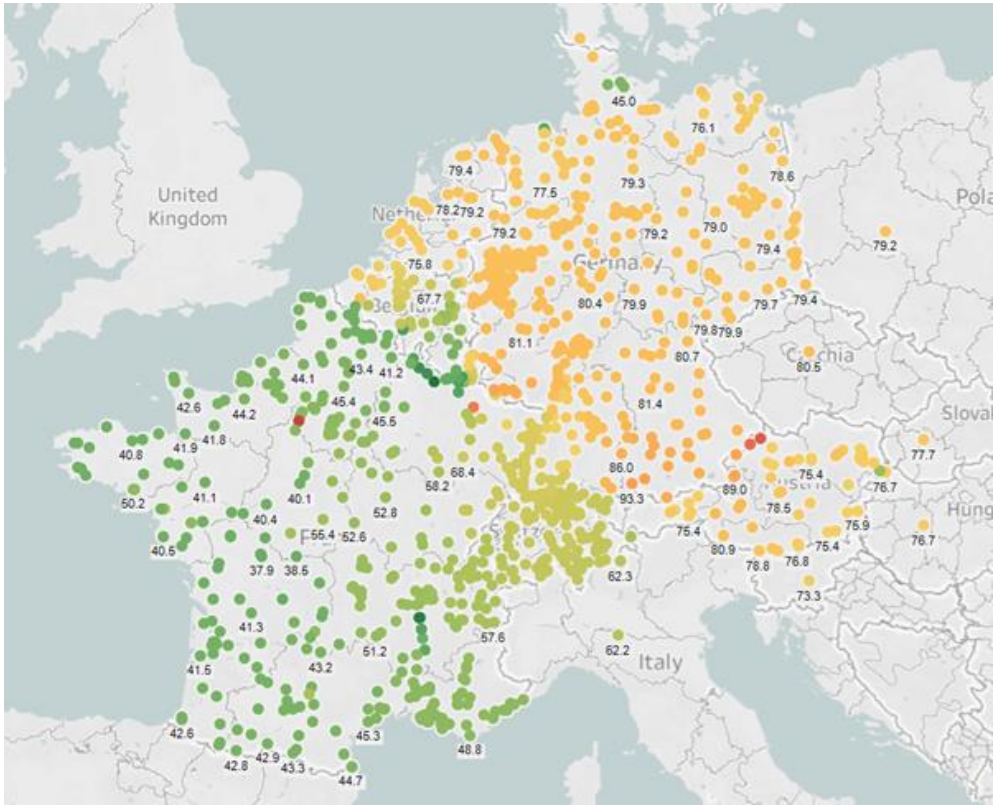


Load Distribution

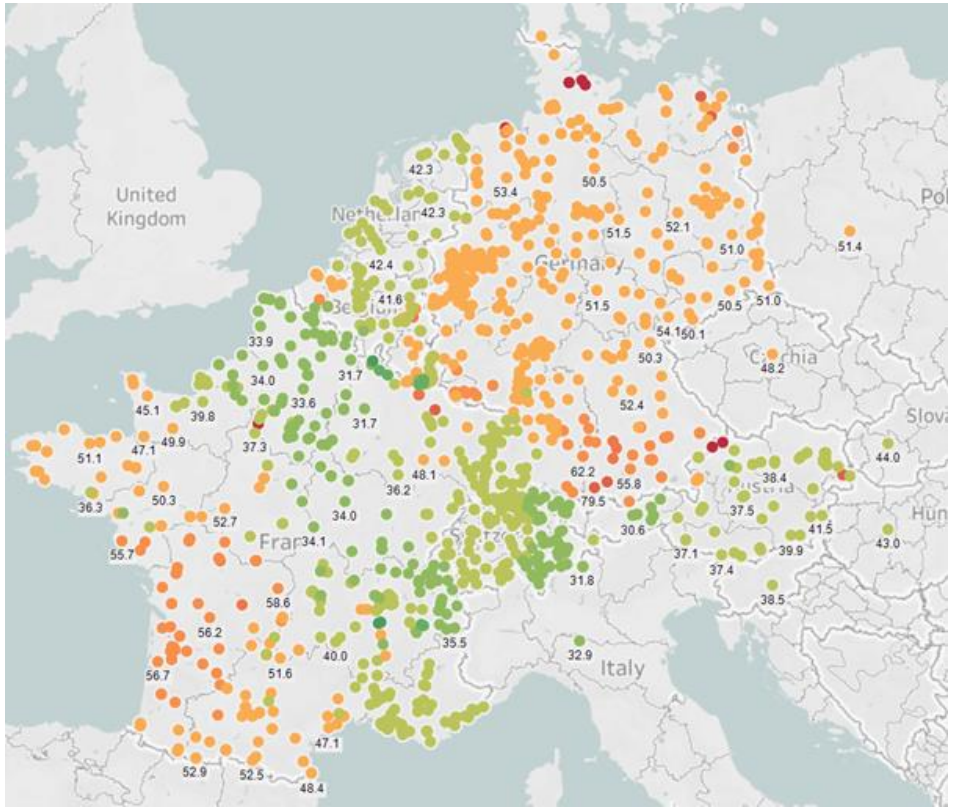


Nodal Infeed per Technology

Nodal market model results

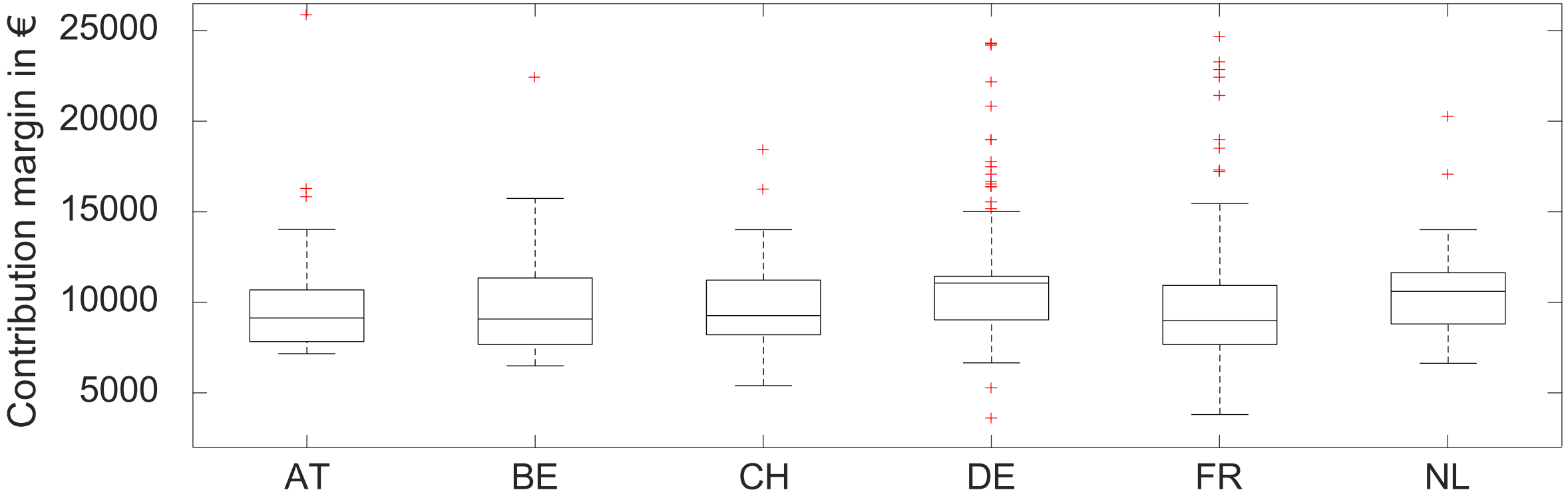


Average Day Ahead Price in 2030 in €/MWh



Average Daily Price Spread in 2030 in €/MWh

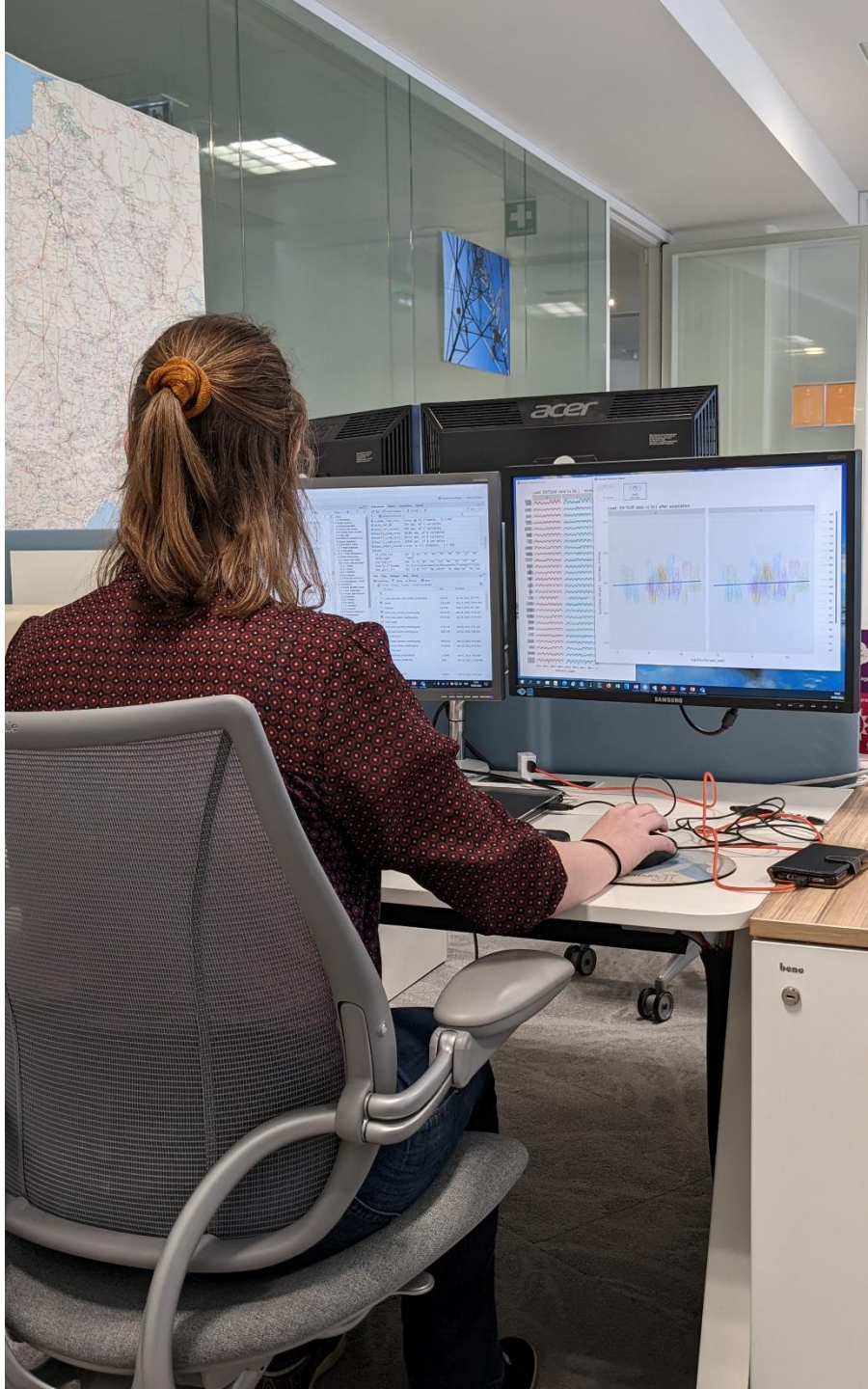
The added value of flexibilities will be location-dependent



Range of annual operational values for an additional unit of storage with 500 kWh/500 kW.
Based on UDE's nodal study and a small storage evaluation tool

Agenda

1. Introduction (RTE)
2. Zonal study with forecast errors (UDE)
3. Agent-based market modelling for improved representation of uncertainties (RTE)
4. Modeling distributed flexibility (ENSIEL)
5. Nodal Market (UDE)
6. **Key takeaways (RTE)**



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Key takeaways

- **Forecast errors** lead to significant dispatch differences between the day-ahead and intraday market outcomes, accounting for these differences is **likely to have an impact on optimal investment strategies.**
- There are still many modelling challenges to be tackled to perform European scale zonal and nodal market simulations, but these simulations are **crucial to providing quantified evidence** for market design recommendations.

Read More on WP2

Deliverables

- D2.1 Methodology for error forecasts
- D2.2 Candidate market mechanisms and regulatory frameworks
- D2.3 Models for market mechanisms simulation taking into account space-time downscaling and novel flexibility technologies
- D2.4 Quantitative analysis of selected market designs based on simulations
- D2.5 Recommendations for market designs and regulations

Publications

- Quantitative Assessment of Flexibility at the TSO/DSO Interface Subject to the Distribution Grid Limitations, 2022 Applied Sciences
- Risk-Oriented Planning for Flexibility-Based Distribution System Development, 2022 Sustainable Energy, Grids and Networks
- Optimal Transmission Topology for Facilitating the Growth of Renewable Power Generation, POWERTECH 2021
- Data Analytics for Profiling Low-Voltage Customers with Smart Meter Readings, 2021 Applied Sciences
- Market Participation of Distributed Energy Resources for offering Flexibility Services, 2020 European Energy Market Conference
- Synthetic models of distribution networks based on open data and georeferenced information, 2019 Energies

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Q&A SESSION