



Market Boundaries and System Resilience

Optimization for
Power Grid Transformation

Thorsten Lenck

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About us

Who we are:

Agora Energiewende is a think tank, policy lab, and part of the **Agora Think Tanks**

What we do:

We develop scientifically sound and **politically feasible strategies** for a successful pathway to **climate neutrality** in the power and buildings sector – in Germany, Europe and internationally

How we work:

We are independent and non-partisan, with a diverse financing structure – **our only commitment is to climate action**

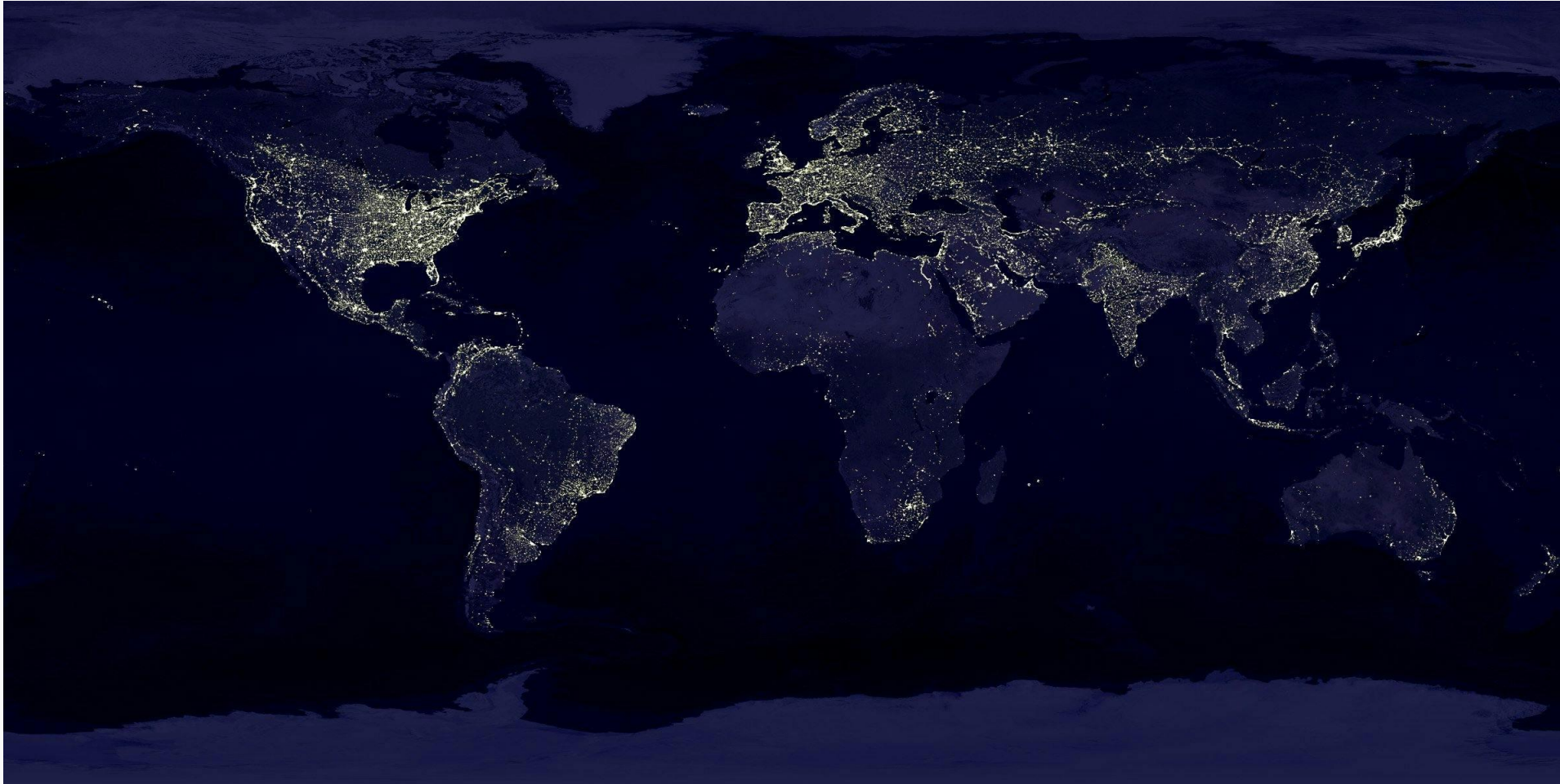
Where we take action:

Agora Energiewende has offices in Berlin, Brussels, Beijing and Bangkok, and cooperates internationally with more than 20 partner organisations

The image features a vertical gradient background transitioning from a light purple at the top to a deep magenta at the bottom. Scattered across this background are numerous liquid droplets of various sizes and colors, including shades of pink, orange, brown, and grey. Some droplets are isolated, while others are connected by thin, elongated stems, creating a sense of fluid motion and organic form. Two thin, white horizontal lines are positioned across the middle of the image, one above and one below the word 'Background'.

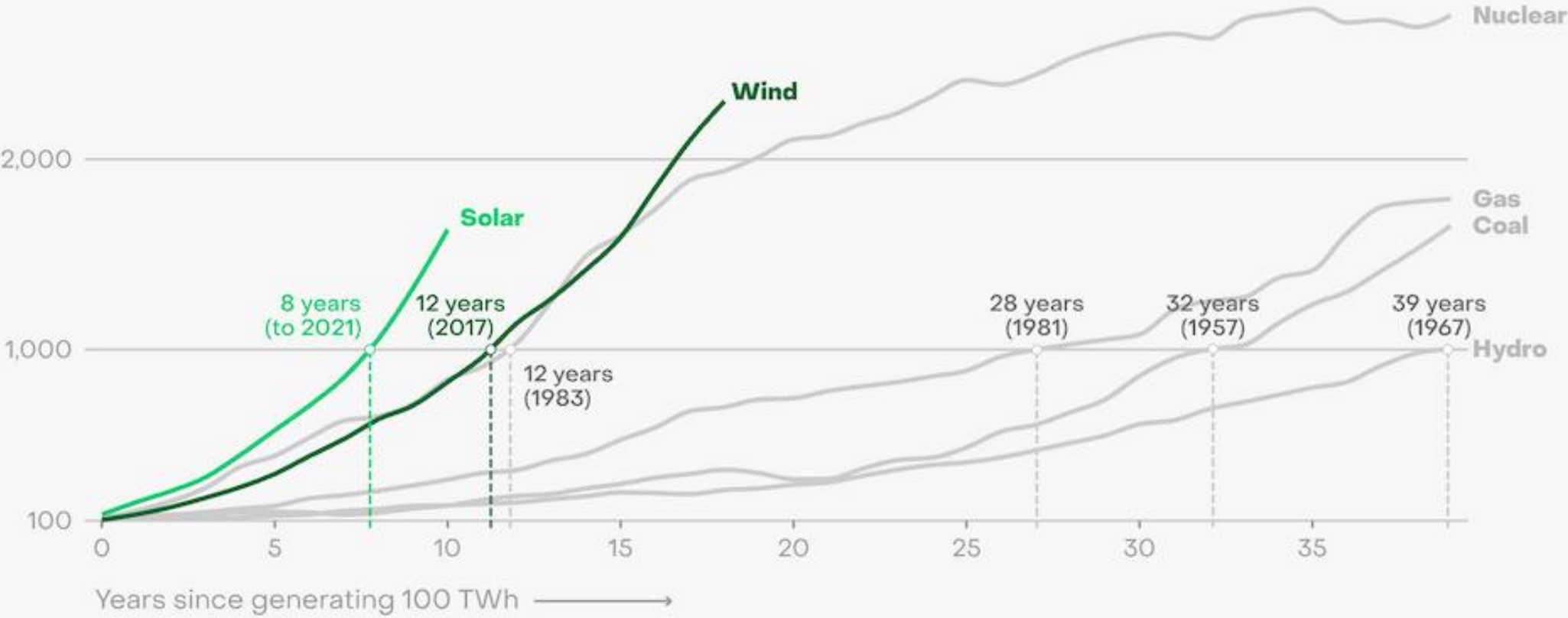
Background

**Three major trends will continue
to fundamentally reshape the power system – worldwide.**



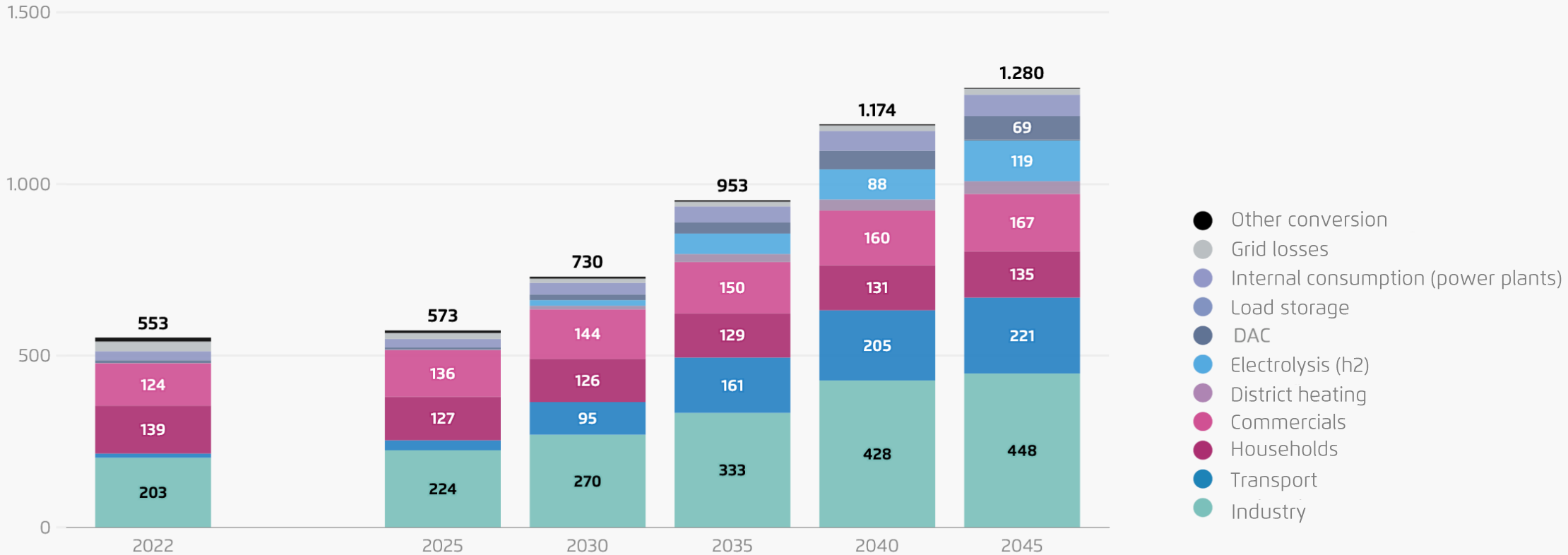
Trend #1: The strong and continuing growth of solar and wind.

Global electricity generation, by technology [TWh]



Trend #2: Increasing electrification as the cornerstone of decarbonization – across industry, transport and buildings.

Case study: Climate-neutral Germany
Gross electricity consumption [TWh]



Trend #3: Decentralized flexibility is emerging as a major and active player in the electricity system.

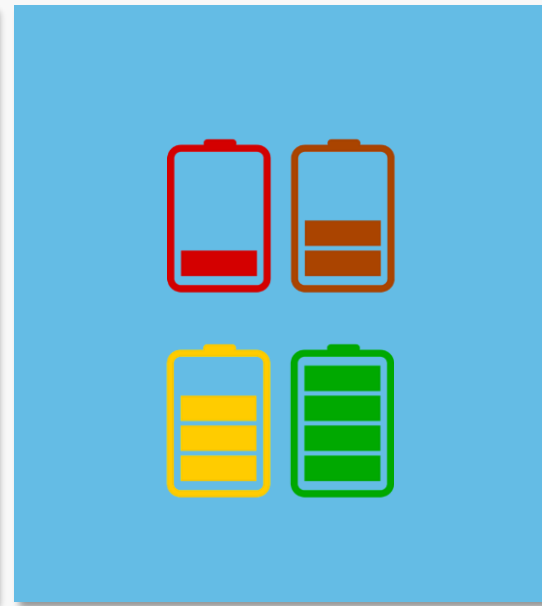
Examples for decentralized flexibility



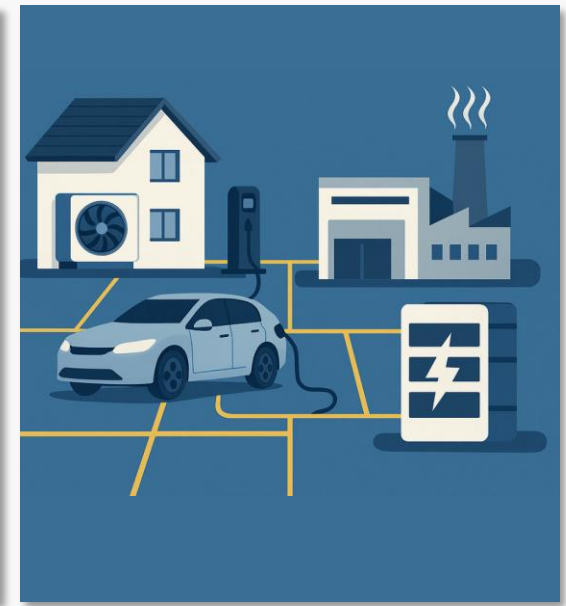
Heating/cooling
+ thermal storage



Electric vehicles
(bi-directional)



Battery storage



Demand response (in
new industry processes)

All three trends impact physically the temporal and spatial patterns of both, generation and consumption.



It is **physics** that **challenges market design**.

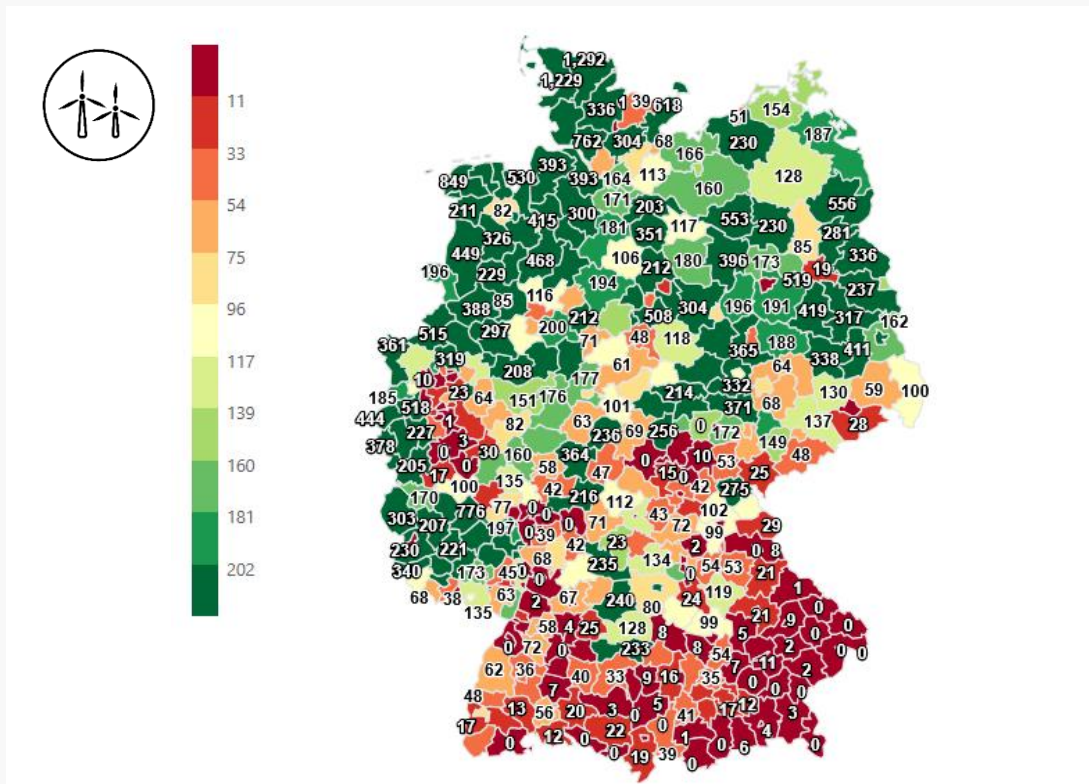


Challenges for the current electricity market design

Location discrepancy: While wind is predominantly located in the north, solar energy prevails in the south, ...

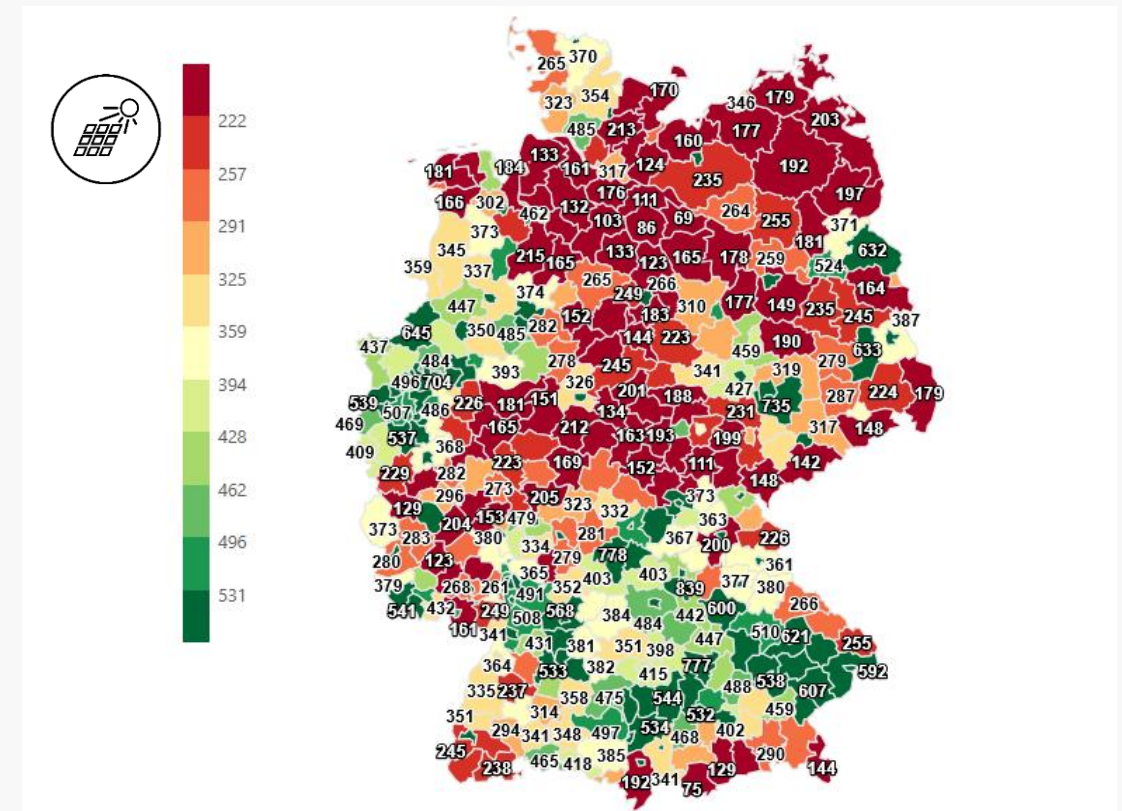
Installed wind power per area in Germany in 2025

Values in kW / km² – total: 66.681 MW



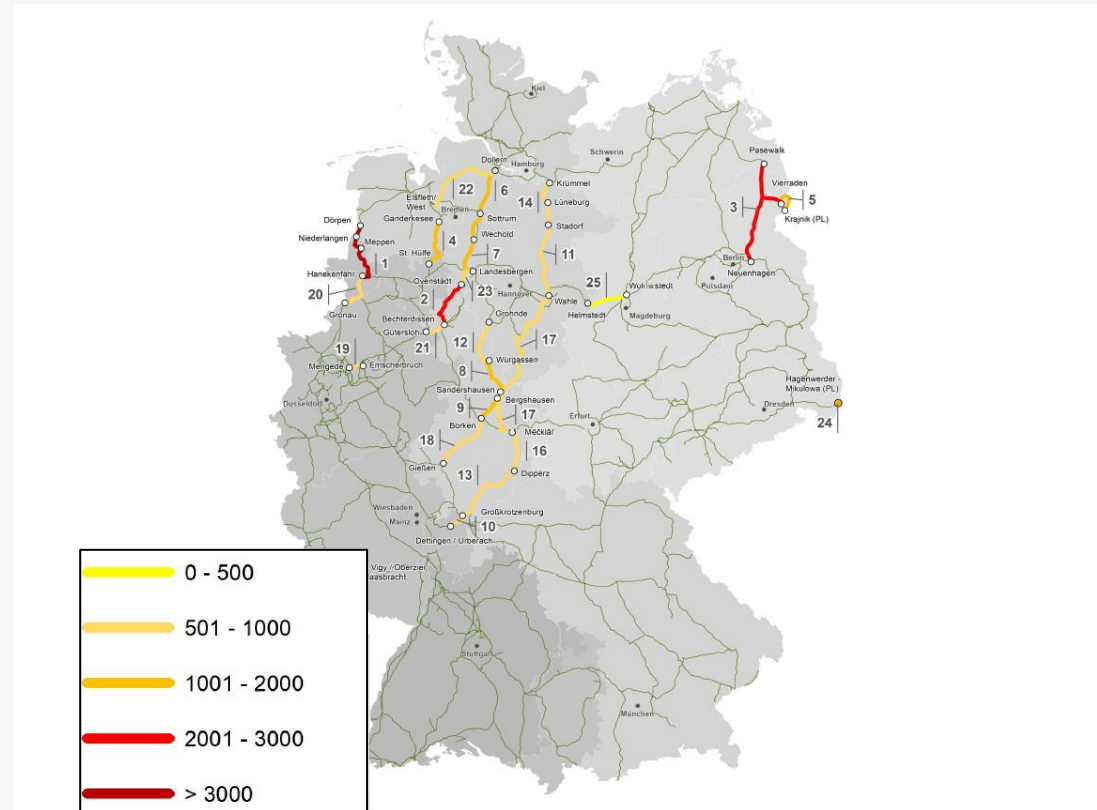
Installed solar power per area in Germany in 2025

Values in kWp / km² – total: 112.864 MWp

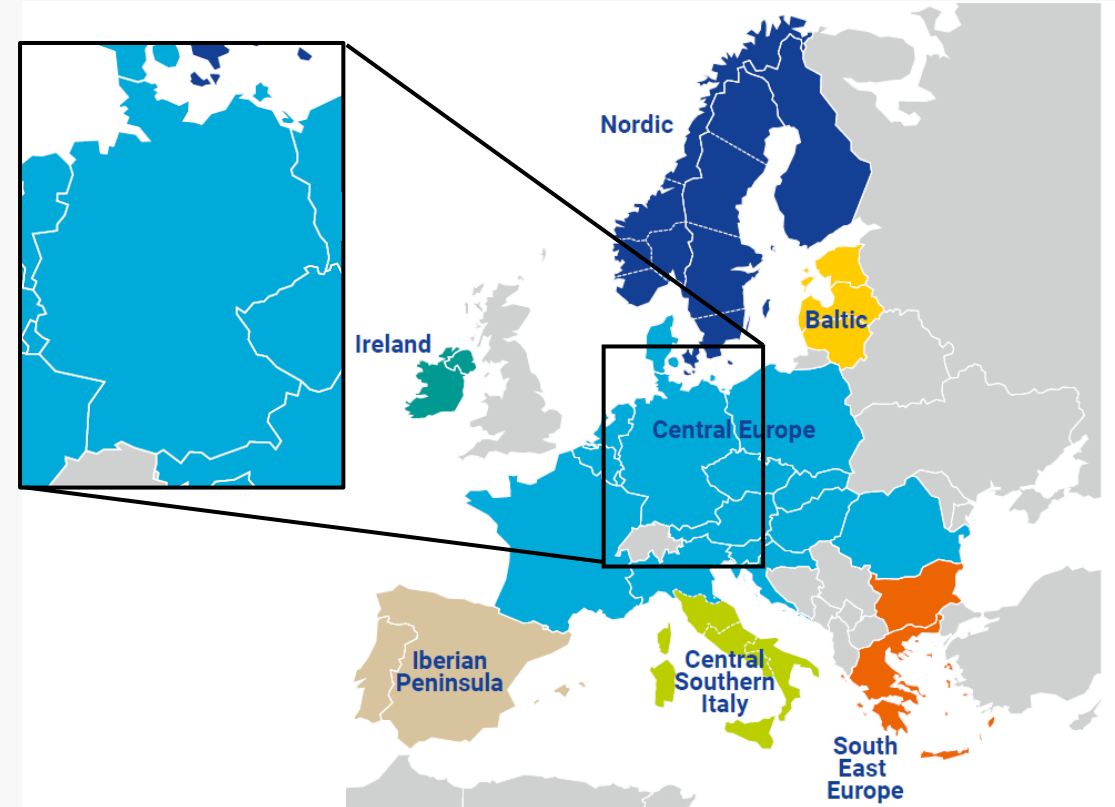


...Germany is facing a north-south grid bottleneck – despite grid expansion. However, there is only one big single bidding zone for Germany*.

Duration of overload
on the most affected network elements [hours]



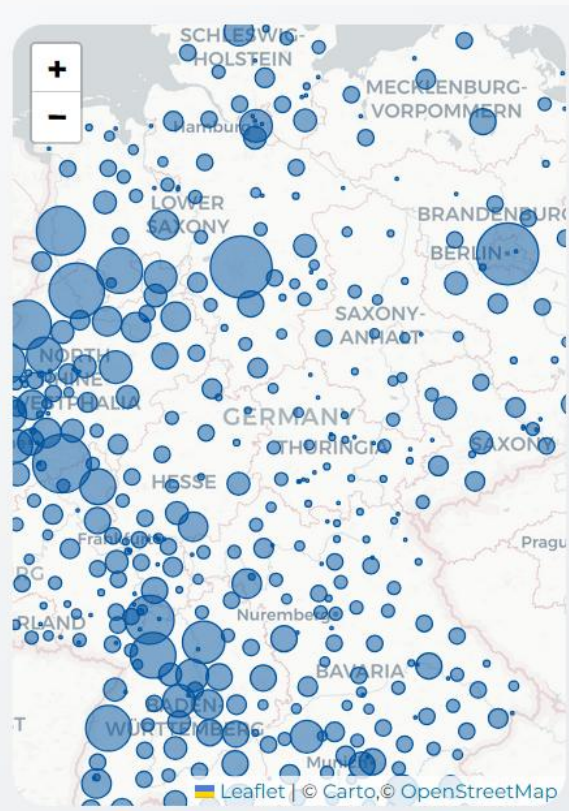
European bidding zones
in the electricity market



How will we determine the most appropriate times and locations for the use of batteries (and EV's, demand response, heat pumps, etc.)?

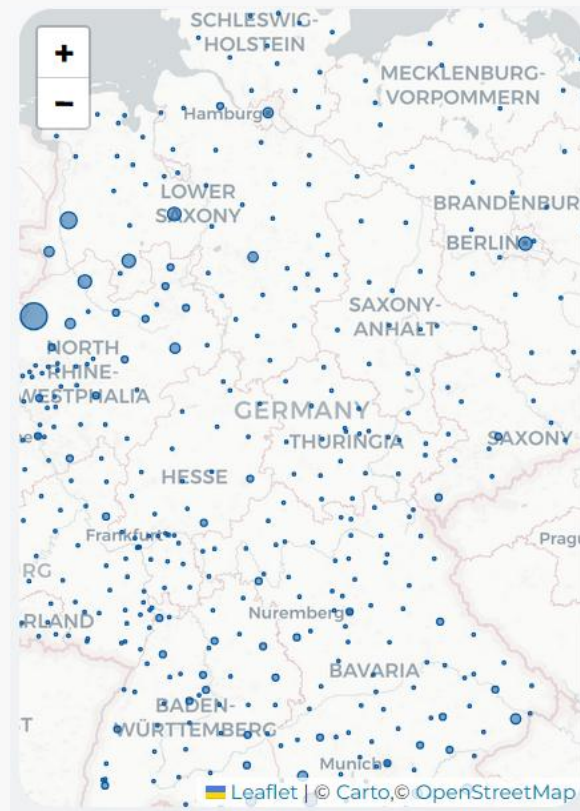
Home Storage

Regional Distribution by County



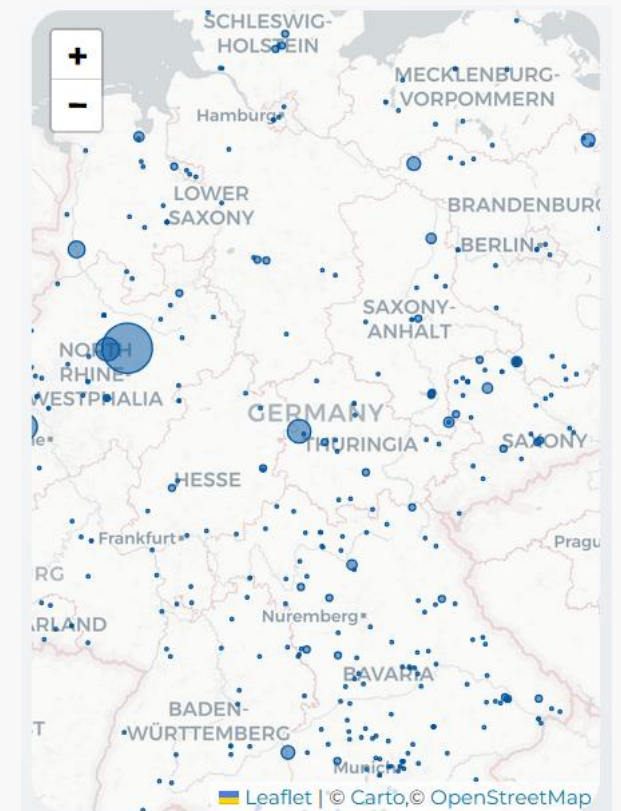
Industrial Storage

Regional Distribution by County



Large-Scale Battery Storage

Regional Distribution



total: 23.04 GWh, Oct. 2025

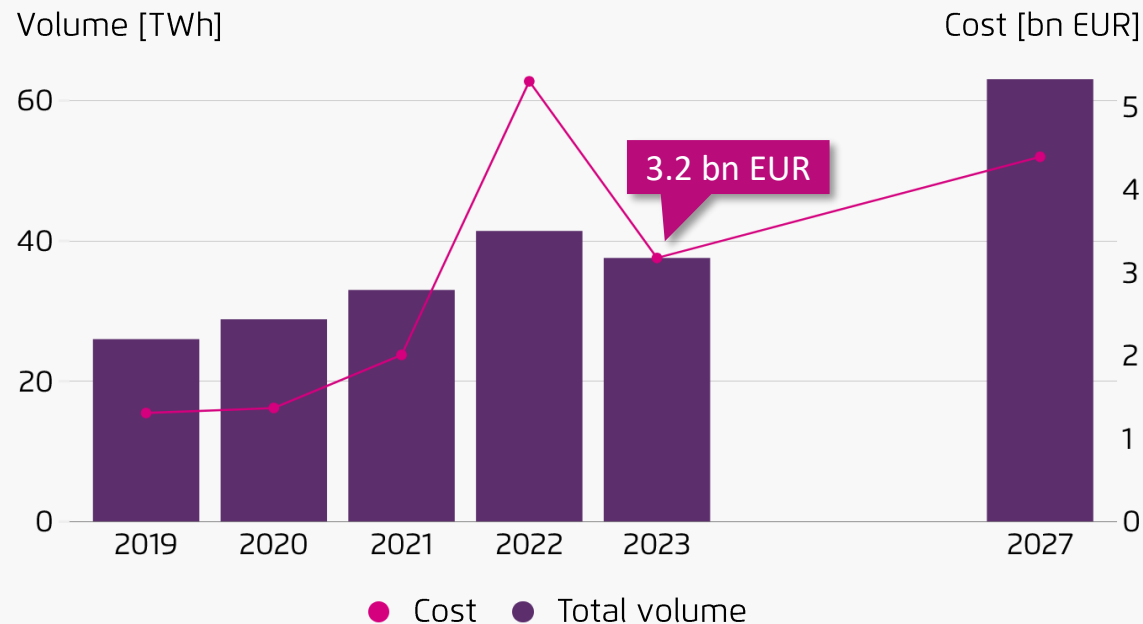


Bidding zones and locational prices: Impacts on the current system

Single bidding zone in Germany – the Debate

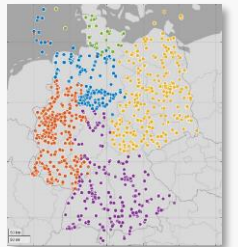
Why is it urgent?

Historical volumes and costs of grid congestion management 2017 to 2023 and forecast 2027



Why is it discussed now?

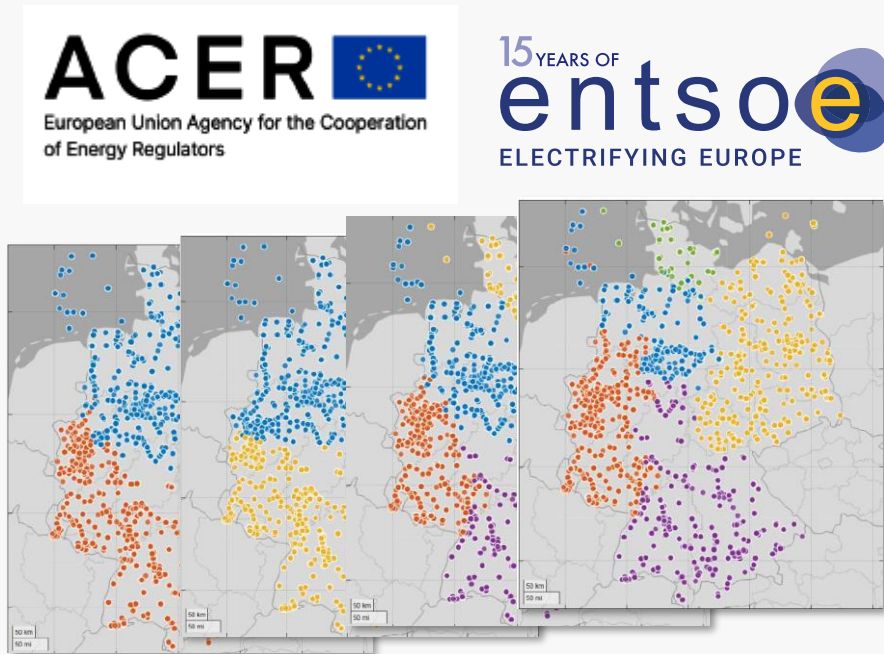
- Prominent economists published a plaidoyer for local pricing
- ENTSO-E's Bidding zone review cautiously proposed conditional split into 5 zones
- Coalition treaty positioned government against transforming the single bidding zone: *"We are sticking to a single electricity bidding zone."*



Review of the configuration of European bidding zones every 3 years; Agora study and tool provides new basis for analysis and discussion

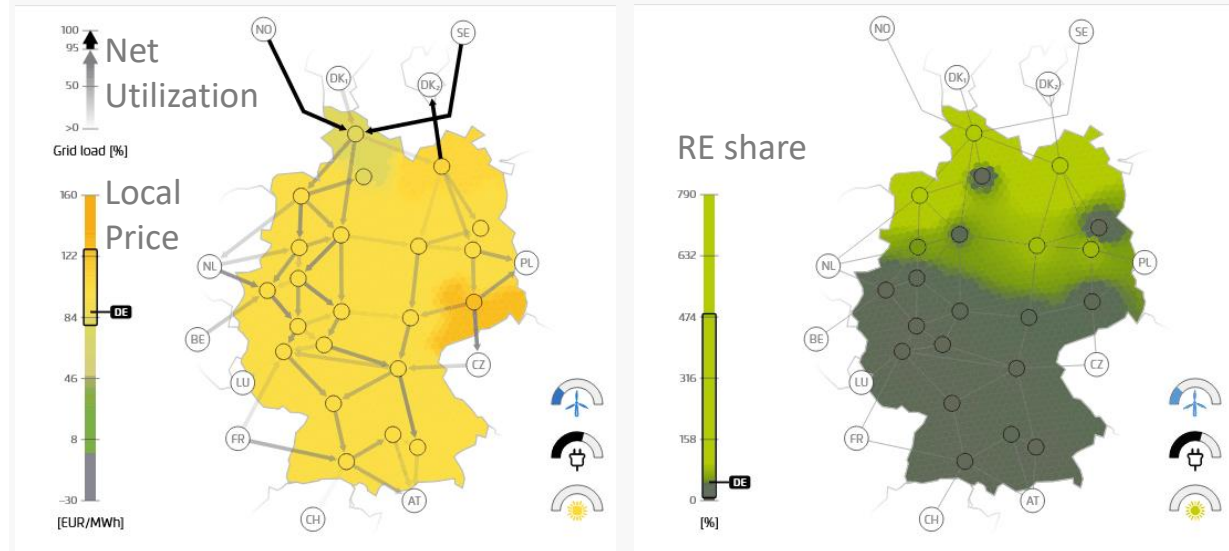
Bidding Zone Review

Goal: Review configuration 2025



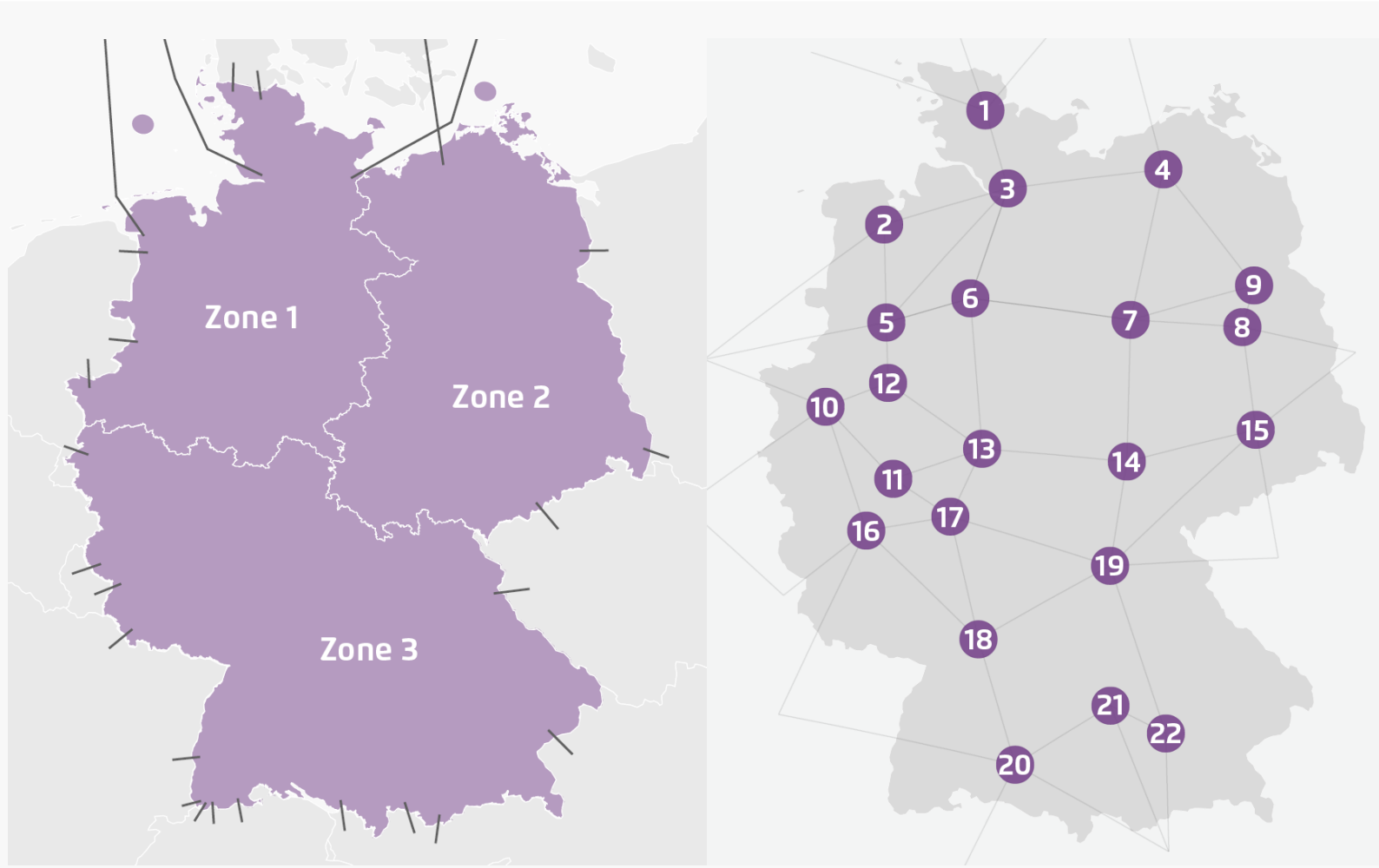
Local Agorameter tool + study

Basis for analysis and discussion: data for 22 hubs



Objective: Informed debate on the successful further development of the electricity market

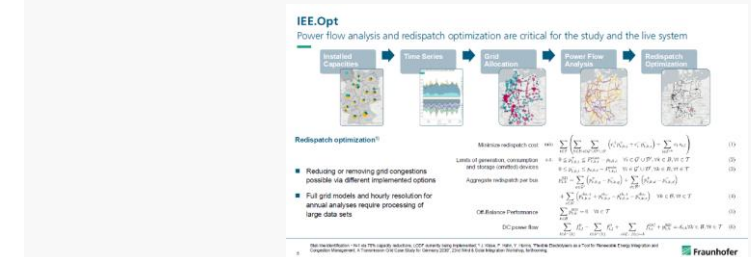
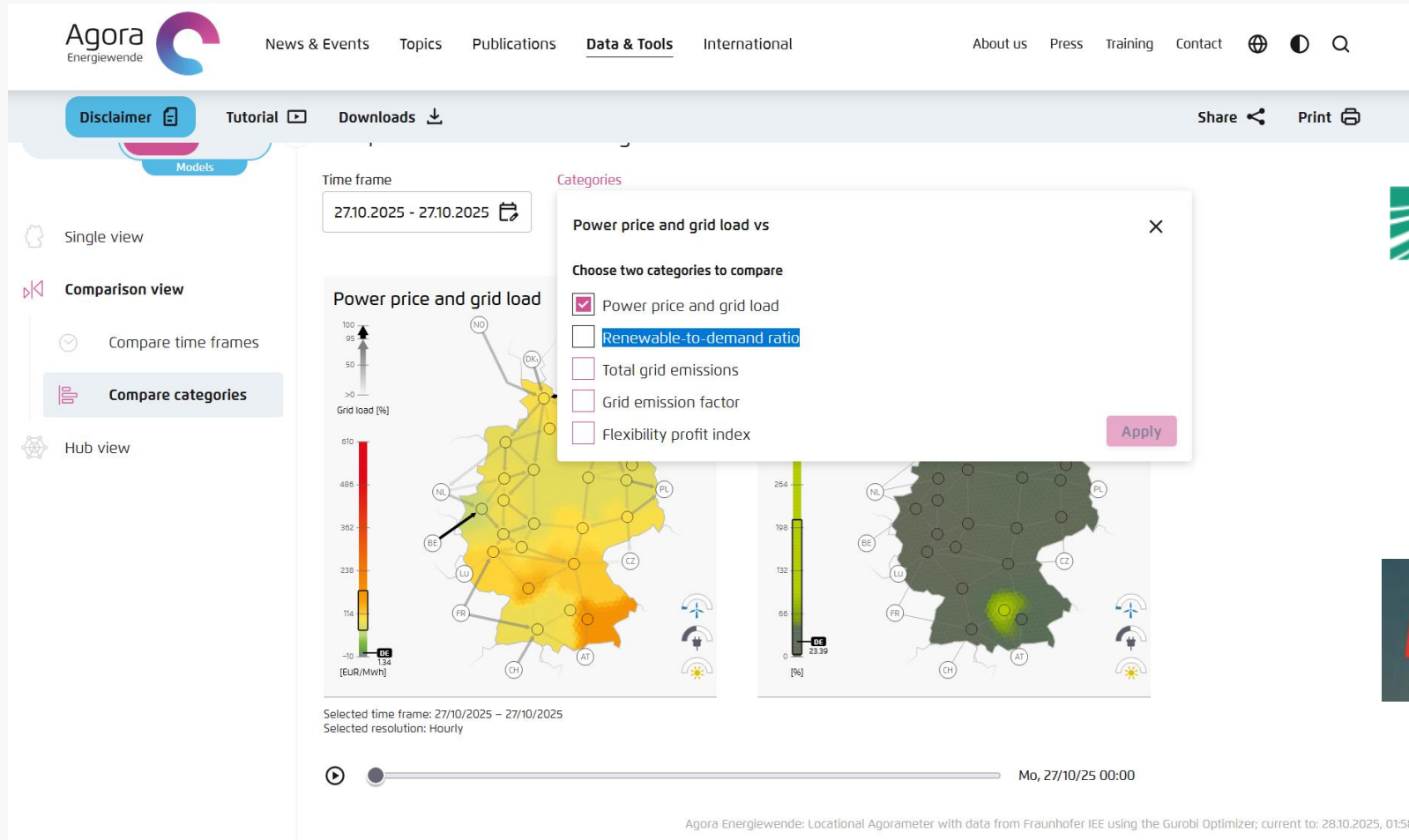
Agora study and live tool for a debate on a cost-efficient electricity market design. Variants examined.



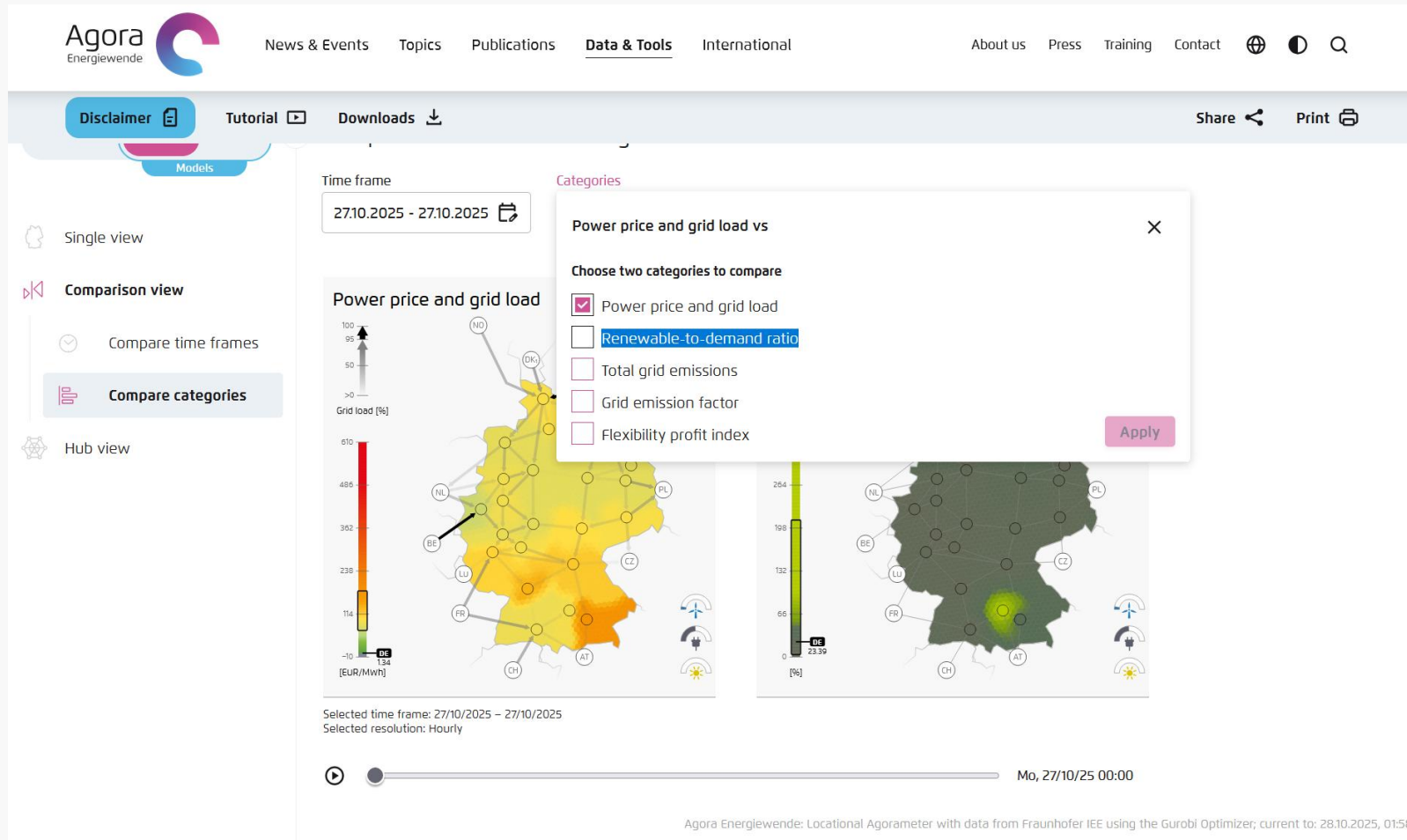
Study for 2019 to 2023

- No future scenario for a single electricity price zone, three zones and 22 hubs (local electricity market design)
- Tool for 2019 to live only for local electricity market design; forecasts for mapping the day-ahead market
- Market & grid simulation, modelling of redispatch volumes and cost
- Selection of 22 hubs with the goal of a congestion-free power grid 2019 - 2023

To inform the discussion we developed the “Locational Agorameter” with data from Fraunhofer IEE using the Gurobi Optimizer.

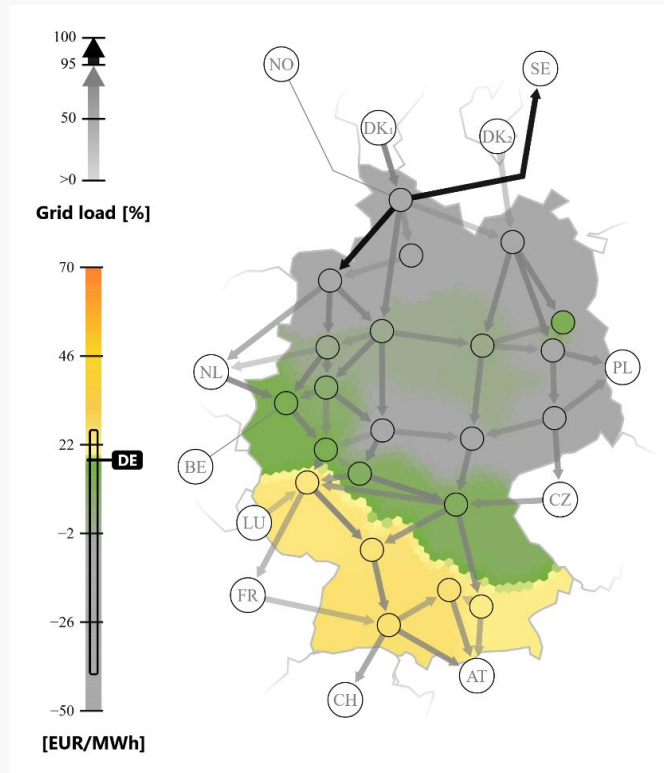


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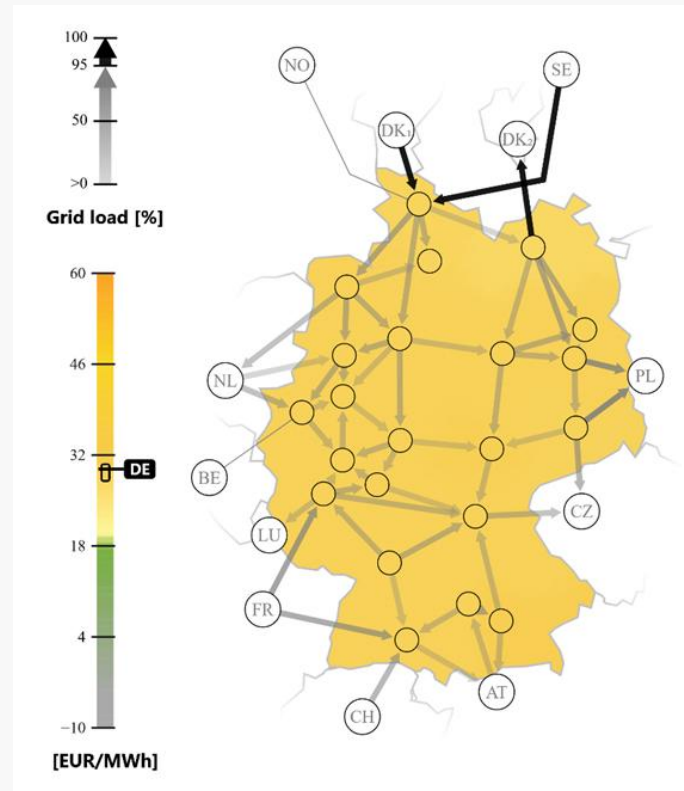


The Locational Agorameter live-tool provides hourly locational prices day by day. Visualization of exemplary situations

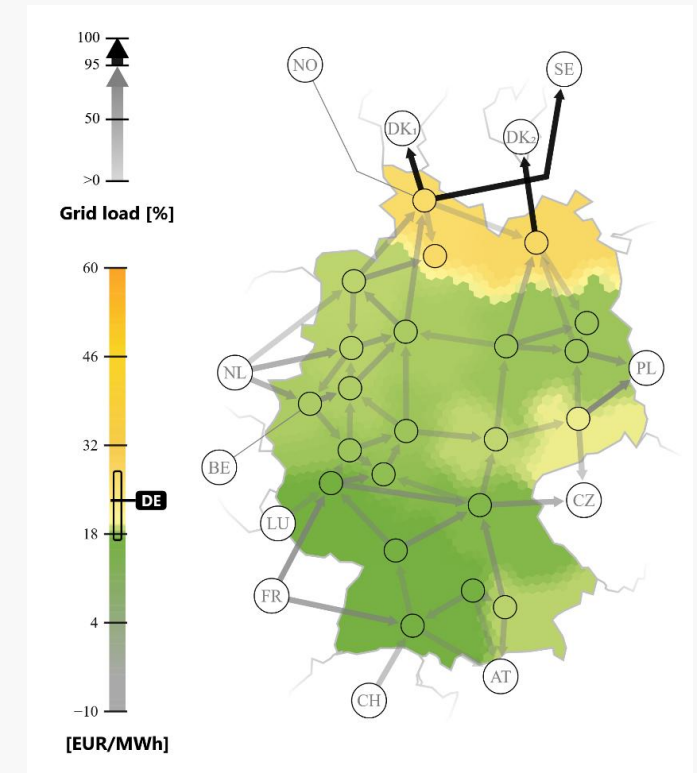
High wind feed-in



Uniform price



Lower prices in the south

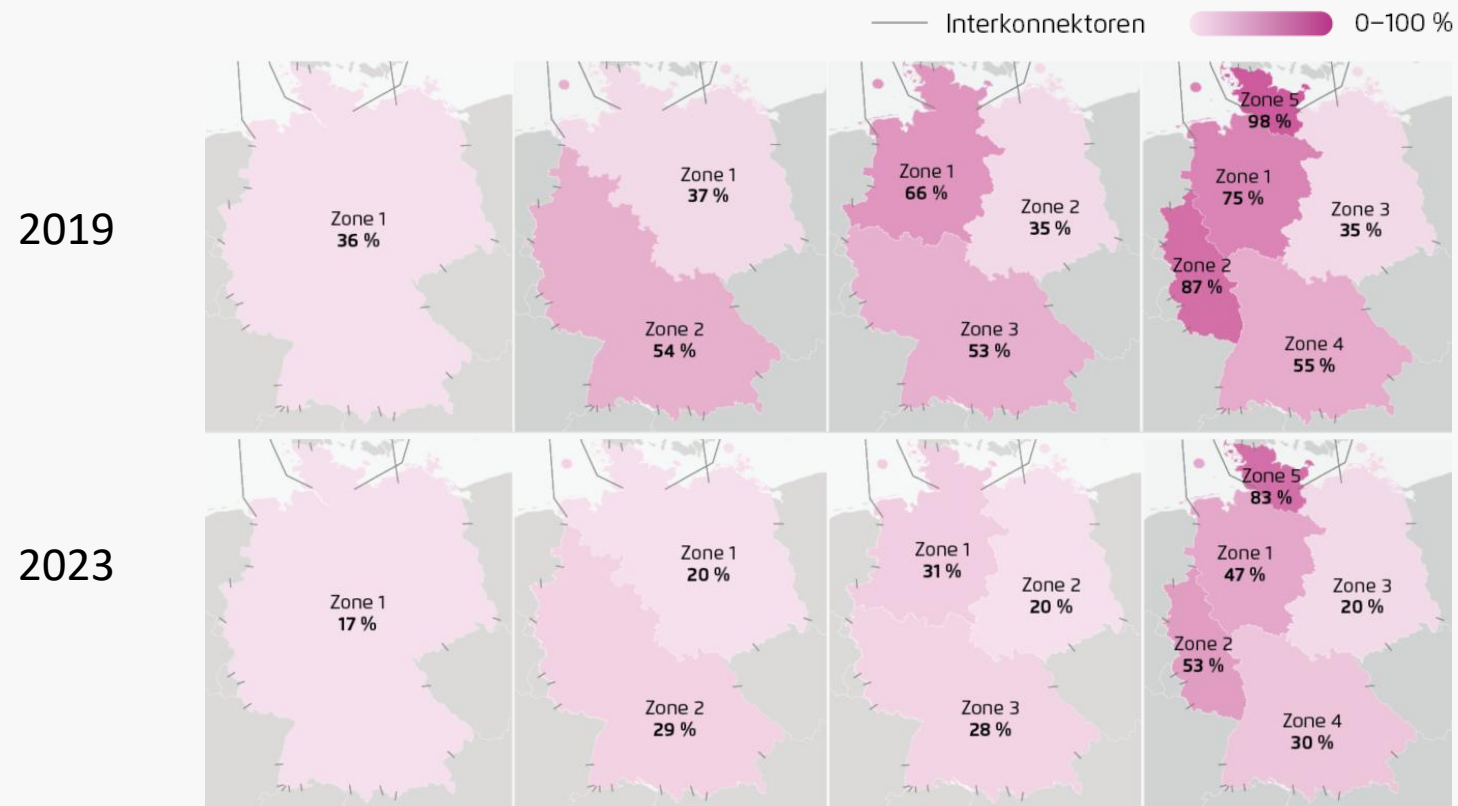




Core results

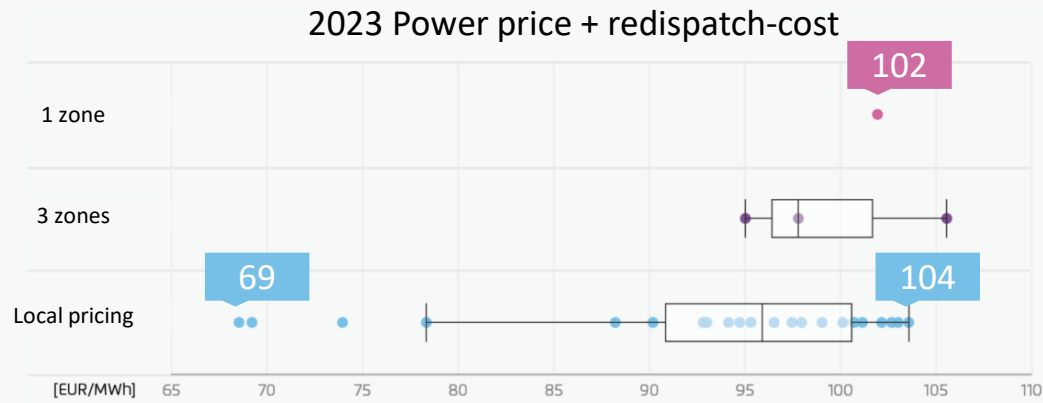
Result 1: The smaller the bidding zones, the more targeted the redispatch can be avoided: three zones are not sufficient in the long term

Electricity price convergence: Proportion of hours per year in which the prices of the modeled hubs within a zone match to within +/-1 EUR per MWh

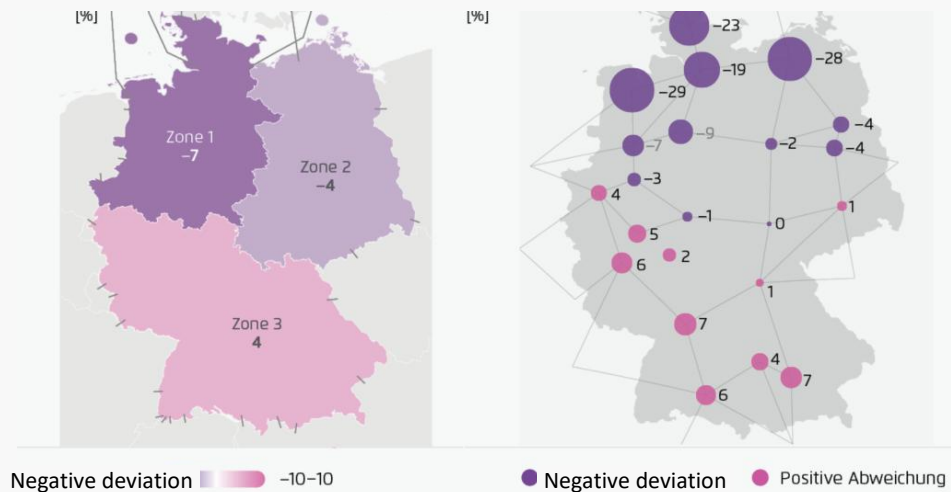


- The division into three zones would not have resulted in a substantially lower redispatch requirement between 2019 and 2023 and therefore does not reliably lead to a reduction in grid congestion in the current system either.*
- In alternative configurations of two to five price zones, the more local hub prices within the respective zone converge more strongly the smaller the zones become.

Result 2: System of local prices leads to falling electricity prices on average.



Power price: deviation from uniform power price



- At local prices, electricity costs fall in 18 of the 22 hubs and in the consumption-weighted average
- Electricity costs: Electricity price plus the redispatch costs rolled into the grid fee (2023, one zone: 5.3 EUR/MWh)
- **Distribution effects:** While electricity costs are falling on average and especially in the north, the **price of electricity for industry** in the south is rising and **RE plant operators** in the north have substantially lower electricity market revenues
- **Solution:** Compensation for RE in the north via the EEG and for industry in the south via new domestic bottleneck rents



Conclusion and recommendations

A comparison of the system costs from 2019 to 2023 showed that **Cost-based redispatch is still a cost-effective option. But:**

- Cost-based intervention in the power plant schedules by the grid operators is an economically sensible option **only until consumers start to react to the electricity price on a large scale.**
- However, flexible consumers and storage are a necessary element of the climate-neutral electricity system
- Locational electricity prices would...
 1. systemically lower consumer electricity prices on average,
 2. increase system stability through better market & grid coordination, and
 3. thus, enhancing system resilience

Conclusion and recommendations

- 1 The uniform electricity price in Germany is blind to the utilisation of the transmission grid and is therefore sending increasingly problematic false signals to consumers, storage systems and producers.
- 2 Local electricity prices can avoid most interventions by grid operators.
- 3 The introduction of local prices would reduce electricity prices for the majority of consumers; disadvantaged industries could be compensated without additional funding.
- 4 A locally organised electricity market increases the cost efficiency of a climate-neutral electricity system.
The German government should develop a roadmap coordinated at European level in the new legislative period to set out the prospects for introducing local prices. A first step could be to supplement the price zone with local investment signals. Before changing the pricing system, liquid futures trading for local electricity markets should also be established and the economic viability of investments in renewable energies secured across the country.

Thank you for your attention!

Do you have any questions or comments?

Thorsten Lenck

Thorsten.Lenck@agora-energiewende.de

www.agora-energiewende.de