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FUTURE-PROOFING THE EUROPEAN POWER MARKET

REDISPATCH AND CONGESTION MANAGEMENT

EXECUTIVE SUMMARY

THOMASSEN, G.
FUHRMANEK, A.
CADENOVIC, R.
POZO CAMARA, D.
VITIELLO, S.

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Joint Research Centre

EUR 31924 EN

Contact information
Name: Georg Thomaßen
Address: Via Fermi 2749, 21027 Ispra, Italy
Email: georg.thomassen@ec.europa.eu

EU Science Hub
https://joint-research-centre.ec.europa.eu

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Executive summary

Policy context

In early 2024, the European Commission has proposed a climate target of 90% emissions reduction by 2040. The associated scenarios are relying heavily on the deployment of variable renewables, such as wind and solar PV. Deployment that focuses on resource-rich areas – where wind and solar potentials are strongest – increases the risk that transmission grid infrastructure could be insufficient to transport the energy to demand centres, which are often outside the main area of renewable deployment. This condition may lead to a state in which the wholesale market produces inefficient dispatch decisions that are not aligned with the physical reality in the grid.

The main instrument in the European legislation to address this issue is the Bidding Zone Review (BZR), which aims at redrawing bidding zone borders to take structural grid congestion into consideration at the border of each zone. The current BZR kicked off in 2019, with ACER proposing alternative bidding zone configurations in August 2022. Currently, European TSOs investigate the proposed configurations, with final results being expected in December 2024.

Key conclusions

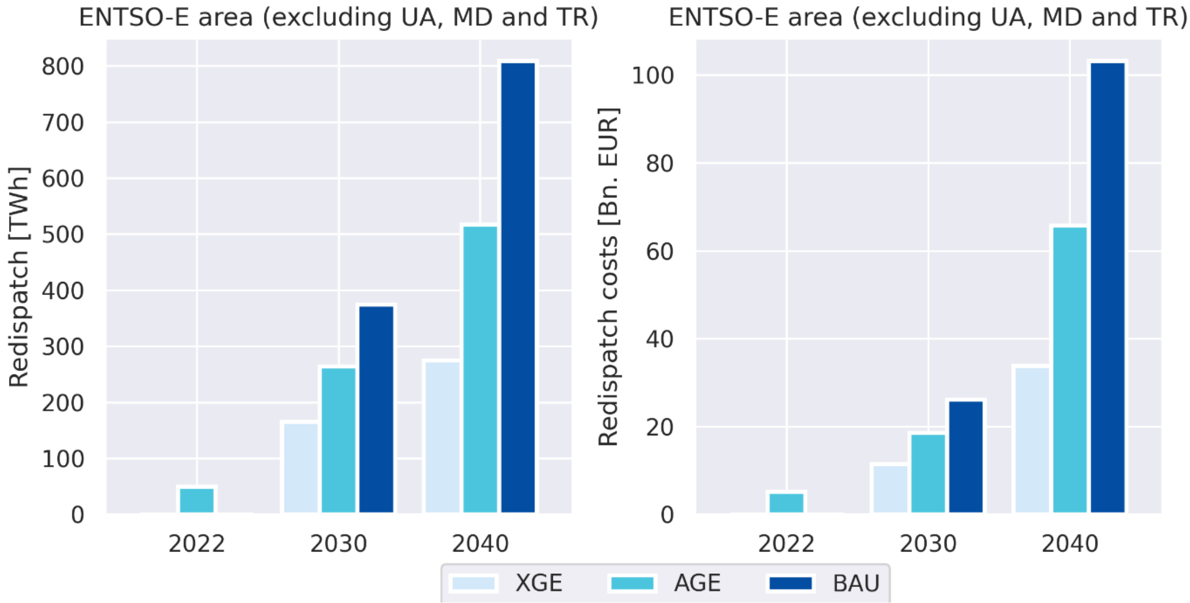
— **Redispatch volumes in *all* investigated grid-expansion scenarios increase massively in the time period until 2040. Even in the extreme grid expansion (XGE) scenario, which foresees expanding the total circuit length in Europe by more than a third, the total redispatch volume increases almost six fold.** While 2022 saw 50 TWh of redispatch in Europe, it could increase to 165 TWh in 2030 and 274 TWh in 2040 in the XGE scenario. In a business-as-usual (BAU) scenario – which foresees that grid expansion progresses only at historic rates – redispatch could even be as high as 374 TWh in 2030 and 809 TWh in 2040. The associated costs were calculated to be between 11 – 26 Bn. EUR in 2030 and 34 – 103 Bn. EUR in 2040, compared to 5 Bn. EUR that incurred for remedial actions in 2022.

— **Curtailment of renewable energy due to grid congestion in 2040 could be as high as 310 TWh in the BAU scenario. Hydrogen production was further identified as a redispatch driver across all investigated scenarios and target years.** For 2040, a conservative estimation yielded a redispatch increase of 78 TWh in the BAU scenario.

— **Several policy options exist to tackle these challenges by improving investment incentives as well as incentives for a better operation of the system.** Policy instruments that aim to mobilize investment – such as renewable auctions and capacity markets – can be improved by adding a locational component that reflects the state of the grid. Bidding zone splits that prove to improve the market outcome should be implemented, as they set better incentives for an efficient operation. We furthermore recommend to perform an analysis of the costs and benefits of locational marginal pricing at a high granularity in a climate-neutral power system.

— **It is vital that this issue is addressed as soon as possible to achieve a better balance of demand and supply inside the market zones of the European power system.** The period until 2040 is essential to manage where renewables and hydrogen generation are located. To achieve an efficient system, it appears necessary to improve incentives for investment *and* operational decisions.

Figure 1: Evolution of redispatch volumes and costs in the European power system



Source: JRC analysis. 2022 values based on (ACER, 2023).

This study

For this work, we have developed a European model that mirrors closely the interactions between power markets and grids. The base model features a resolution of 1024 nodes in the electricity network and is based on the open model *PyPSA-Eur*. We expanded on this system model, incorporating custom routines for grid expansion, flow-based market coupling and redispatch. These routines are essential to capture market dynamics and how these affect the physical system. The performance of these routines was assessed through a backtesting exercise that aimed to replicate the redispatch volumes of 2020, and which delivered good results.

The model further takes into consideration the future evolution of the system in line with the proposed 2040 climate target. This includes deployed renewable capacity, the projected evolution of demand, the penetration of flexible consumers such as heat pumps and electric vehicles and the amount of installed electrolysis capacity in the European system.

Main findings

In this study, we investigate three grid expansion scenarios for the target years 2030 and 2040, which differ in how much countries reinforce their national grids. They describe a business-as-usual (BAU) case, which extrapolates current grid expansion trends, an ambitious-grid-expansion (AGE) scenario, which assumes that the rate of reinforcement doubles, as well as an extreme-grid-expansion (XGE) scenario, where current grids are expanded by more than a third of their currently existing circuit length until 2040.

We find that the uncoordinated deployment of distributed renewable generation in line with the EU's climate targets will exacerbate existing congestion in the European electricity grid and create new bottlenecks. All scenarios result in a massive increase in redispatch needs. Redispatch describes the adjustments made to the dispatch *after* the market cleared, which become necessary to achieve a physically feasible dispatch. In 2040, two of the three scenarios foresee that European redispatch needs increase to the order of magnitude of the annual electricity consumption of countries like France and Germany. Where redispatch is organized through bilateral contracts, this amount could require massive efforts to bring forward the necessary remedial actions.

In systems that rely on a market-based approach, redispatch volumes could be even larger than assessed here, as redispatch markets offer opportunities for inc-dec gaming[1].

In this way, large amounts of renewable generation could end up being curtailed, due to grid congestion. Our assessment suggests that between 50 and 120 TWh of renewable generation is at risk of being curtailed in 2030 due to insufficient grid capacity, with 100 to 310 TWh being at risk in 2040.

We further observe that the operational incentives for hydrogen production are misaligned with system needs. In the BAU scenario, electrolysers exacerbate grid congestion, increasing redispatch by at least 78 TWh in 2040. This is a lower-end estimate, as it only considers increases in redispatch that occurred at the node where electrolysis was installed. In reality, redispatch triggered by hydrogen production could be even larger, also because our scenarios assume a correlation between installed renewable capacity and electrolyser deployment. This is currently not mirrored in the European legislation, which requires that green hydrogen production is only matched by renewable generation in the same bidding zone – and could well be on the wrong side of a bottleneck.

To address these challenges, we suggest to improve both operational and investment incentives. To achieve a better balance at the system level, it is necessary to steer better where renewable capacity and hydrogen generation is located. Whenever these projects receive financial support through an auction mechanism, this can be done by adding a locational component to the auction. Adding such a component to existing and planned capacity remuneration mechanisms may further prove important to maintain the feasibility of redispatch, as it ensures that capacity is available in the right places. In addition, grid charges can incentivize investment in the right locations if they include a locational component.

Further, the operational price signal can be improved by increasing the spatial resolution at which the European power markets are cleared. The BZR offers an opportunity to take structural congestion into consideration at the border of newly drawn zones. Further assessment is necessary whether increasing spatial granularity in an evolutionary manner, through bidding zone splits, is sufficient for a successful energy transition, or whether a transition towards an LMP system could become necessary.

Related and future JRC work

In 2020, the JRC published a qualitative assessment of the introduction of nodal pricing in the Internal Electricity Market (Antonopoulos et al., 2020). In the context of the European market design debate of 2022, the JRC has proposed an overhaul of renewable and capacity auctions to include locational information in the auctioning process (Thomaßen et al., 2023). The JRC is further providing scientific support to ACER on European assessments such as the Bidding Zone Review (BZR) and the European Resource Adequacy Assessment (ERAA), employing its power sector modelling capabilities and tools. Further work on this topic will include a quantification of the impact of locational renewable auctions, as well as the impact of smaller zonal configurations or even locational marginal pricing.

[1] Inc(rease)-dec(rease) gaming refers to exploiting arbitrage between two market sessions, where one session is cleared at a higher spatial resolution than the other, which can end up increasing congestion in the grid. For further information, we refer the reader to section 5.2 of the main report.

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