Contribution ID: **75** Type: **not specified**

Coal Exit, Gas Expansion, and the Energy Trilemma: System Implications of German Energy Policy

Friday, March 27, 2026 11:50 AM (20 minutes)

Motivation
The energy transition is being driven primarily by the electrification of mobility, heat supply and industrial processes. At the same time, the expansion of renewable energies (RE) is progressing in order to ensure a cheap and clean electricity supply. In Germany in particular, large conventional power plants will be taken off the grid or transferred to the capacity reserve by 2038 at the latest for political, ecological and economic reasons, for example in the course of the nuclear phase-out or the coal phase-out.

In order to guarantee security of supply at all times, the German government is therefore planning to add 20 GW (H2-ready) of gas-fired power plants by 2030 (Deutscher Bundestag, 2025). These are intended to replace the lost capacity and contribute to grid stability. At the same time, recent studies raise questions about the level and economic viability of additional capacity, the cost advantage of decentralized solutions and the implicit technological predetermination (Forum Ökologisch-Soziale Marktwirtschaft, 2025; Frontier Economics, 2025; Kienscherf et al., 2025; Roland Berger, 2025). The subsidies required for the implementation of the additional dispatchable capacities have also raised concerns under EU state aid law. In a basic agreement, the German government and the European Commission agreed on the approval of 12 GW of additional dispatchable capacity (Bundesmministerium für Wirtschaft und Energie, 2026).

This study therefore examines the implications of the current power plant strategy in terms of energy policy dimensions such as security of supply, affordability (especially energy poverty) and sustainability. Quantitative analyses are applied to conduct a comprehensive assessment in order to scientifically examine the central aspects of the political discourse.

Methods
Based on the Electricity Grid Development Plan 2037/2045 (2025) (NEP2024) (Übertragungsnetzbetreiber, 2025), this study analyses two key measures: the implementation of the coal phase-out in either 2030 or 2038 and the expansion of 20 GW of gas-fired power plants.

Various models are used for the quantitative assessment of the implications for the energy system. The analysis of security of supply is based on a probabilistic simulation model and meta-modelling using machine learning (Nolting et al., 2020; Nolting & Praktiknjo, 2020). The models assess security of supply on an hourly basis by calculating the probability that the power plant fleet will be able to cover the expected electricity load. In particular, uncertainties relating to the feed-in of renewable energies, power plant outages and imports are taken into account. Based on these simulations, changes in the two security of supply indicators, Loss of Load Expectation (LoLE) and Expected Energy not Served (EEnS), are analyzed.

The electricity market simulation is based on a fundamental model that determines prices from a merit order in economic dispatch, taking into account cross-border exchanges, seasonal commodity prices and weather uncertainty, through time-coupled optimization as a unit price (Priesmann et al., 2019). The results are hourly electricity prices for an annual horizon through power plant and storage dispatch that minimizes total costs.

The analyses of affordability for private households are based on a microsimulation using representative household data from the Federal Statistical Office of Germany and the results of the electricity market simulation. Realistic reactions to price and income changes are taken into account for different income groups (Priesmann & Praktiknjo, 2025). This enables a differentiated assessment of affordability across the income distribution.

The hourly emissions from electricity generation in Germany are quantified from the resulting hourly dispatch time series, the average efficiency of the various types of power plants and the corresponding emission factors.

The emission factor used for the sustainability assessment is global warming potential.

Results
The results of the simulations show that accelerating the phase-out of coal by 2030 without adequate replacement by dispatchable capacities will significantly worsen the level of security of electricity supply in 2030. While the LoLE ranges from 2.1 up to 121.6 h/a, the EEnS reaches from 9.8 up to 1338.2 GWh/a.

End consumer prices for private households will remain at a moderate level at 55,7 EUR/MWh in average, even if scarcity prices occur. Energy poverty indices do not change significantly compared to the current situation. Furthermore, it remains difficult to assess the impact on energy costs and the associated international competitiveness of German industry. In addition to possible regulatory adjustments, the cost of electricity is increasingly linked to the underlying procurement strategies.

From a sustainability perspective, no major effects can be observed. As expected, the use of gas as an energy source instead of coal for electricity generation reduces emissions up to 20%. However, the effect remains moderate in terms of absolute emissions due to low full-load hours.

Due to the expected low full-load hours of thermal power plants, in addition to converting coal-fired power plants into capacity reserves, supplementing energy-only markets with capacity markets, for example, could facilitate a technology-neutral and cost-efficient implementation of the urgently needed capacity expansion. Nevertheless, the question of how to finance the regulatory instruments for mitigating undersupply risks remains open. Technology-specific subsidies, for example for gas-fired power plants, are effective but may be economically inefficient. Ultimately, various options such as capacity mechanisms or the demand more flexibilization in terms of scale and timing should be carefully weighed up and coordinated in order to minimize overall system costs.

Authors: Prof. PRAKTIKNJO, Aaron (RWTH Aachen University); SCHÖTTLER, Johannes Alois (RWTH Aachen University); Mr SEEGER, Karl (RWTH Aachen University); Mr TILLMANNS, Marius (RWTH Aachen University); Ms ELSOBKI, Menna (RWTH Aachen University); Mr DAUN, Philipp (RWTH Aachen University)

Presenter: SCHÖTTLER, Johannes Alois (RWTH Aachen University)

Session Classification: Energy Security & Crisis