# Germany's nuclear phase-out: Sensitivities and impacts on electricity prices and $CO_2$ emissions

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Executive Summary

**Motivation:** Following the nuclear reactor accident in Fukushima Daiichi, the German Parliament decided in summer 2011 to phase-out nuclear power by 2022. This involved a controversial public discussion and also raised a lot of attention on the international level. When this decision was taken, a number of model-based scenarios investigated the influence it would have on electricity prices and $CO_2$ emissions. We look back at the time before the nuclear prolongation was revoked and evaluate the different policy options that were discussed then. We further evaluate these scenarios with hindsight by contrasting the assumptions that were valid at that time with current development of electricity prices, $CO_2$ prices and renewable deployment.

**Research performed:** We use a power market model to evaluate different phase-out years and replacement options (for example, giving priority to coal or gas-fired power plants). As model results depend heavily on input assumptions, these paths are tested for their

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robustness in sensitivity analyses in which individual assumptions are varied. This is completed by a comparison with electricity prices from other model-based studies. In addition, we relate the model-based analysis to the current situation. The comparison of different studies in combination with the results from the sensitivity analysis allows us to assess the range of results for the situation-as-is and their potential underlying causes and to distil some policy implications over the whole portfolio of available scenarios. We find that some of the assumptions taken at that time are no longer valid and widen the perspective from the isolated effect of the nuclear phase-out towards the challenges of the overall Energiewende.

Model-based scenarios that were conducted at the time of the decision of the nuclear phase-out found that $CO_2$ emissions would be kept at levels that are in line with national reduction targets but that the phase-out would result in an increase in wholesale electricity prices. A sensitivity analysis reveals that these results crucially hinge on some fundamental model assumptions. In particular the development of fossil fuel and $CO_2$ prices can induce larger variations of the electricity price than the nuclear phase-out itself. Contrary to what had been expected in 2011, $CO_2$ prices have decreased and deployment of renewables has exceeded government plans since then. Mainly because of this the earlier model projections differ from current observations, which on one hand partly counteract the expected the negative effect of the nuclear phase-out on electricity prices, but on the other hand increased the challenges for the mitigation of $CO_2$ emissions and security of supply. This implies that it is not possible to isolate the effect of the phase-out decision on electricity prices and $CO_2$ emissions but that the broader picture must be taken into account. This underlines the importance of sensitivity analyses and suggests that policy-makers need to consider scenarios that analyze the whole range of possible future developments.

**Main conclusions and policy implications:** The modeling studies presented have tried to isolate the effect of the nuclear phase-out by reflecting other important drivers through exogenous assumptions. Three years after the decision to phase-out nuclear it turns out that some assumptions valid at that time have changed and in consequence other challenges than expected have become more important. This in particular applies to the developments of the EUA price and the deployment of renewable capacities. While the latter requires action and better planning by the German Government, the former suggest that to some extent a European solution is needed. The EU ETS should be considered as crucial element for a German mitigation strategy and more effort should be put on re-strengthening this instrument. The further development of the EU emissions trading system is extremely important for future climate and energy policy, although it might be difficult to implement a scheme with a high enough carbon price and one that is able to cover all emissions. With this in mind, an early agreement on a European GHG reduction target for 2030 should be an urgent issue on the policy maker's agenda. The security of supply also needs to be considered in a European perspective to avoid lock-ins into national mechanisms considered necessary to ensure adequate capacity. It goes without saying that this requires European coordination beyond the current extent.