On the Role of Risk Aversion and Market Design in Capacity Expansion Planning

Christoph Fraunholz,[a] Kim K. Miskiw,[b] Emil Kraft,[b] Wolf Fichtner,[b] and Christoph Weber[c]

In competitive power markets, market participants base their investment decisions on thorough profitability assessments. Thereby, investors typically show a high degree of risk aversion, which is the main argument for capacity remuneration mechanisms (CRMs) being implemented around the world. Such mechanisms aim to reduce the risks for new investments by offering capacity providers supplementary income on top of the earnings from selling electricity on the market. The additional firm capacity is then expected to help improve resource adequacy, i.e., to avoid shortage situations.

These developments illustrate that the interdependencies between investors' risk aversion and market design are crucial when analyzing transformation pathways of electricity systems. However, existing capacity expansion planning models do not cover all aspects relevant for a realistic representation of real-world electricity markets, which are amongst others characterized by heterogeneous risk-averse actors and – particularly in the European case – cross-border effects of asymmetrical market design implementations.

In our article, we therefore extend the agent-based electricity market model PowerACE to account for long-term uncertainties, such that capacity expansion planning can be carried out from an agent perspective and with diversified risk preferences. For this purpose, we construct model-endogenous scenario trees and implement a new decision metric that comprises the expected profitability and the corresponding conditional value at risk (CVaR) of a potential investment. As an exemplary source of uncertainty, we consider the impact of different weather years on the feed-in of renewables and electricity demand.

The enhanced model is then applied in a multi-country case study of the European electricity market. We carry out simulations with different degrees of investors' risk aversion as well as two market designs, namely a European energy-only market (EOM) design and asymmetrical CRM implementations. This allows us to quantify the impact of risk aversion on capacity expansion, wholesale electricity prices, and resource adequacy under both investigated market designs.

For the case of risk-neutral investors, we find substantially higher investment incentives in the countries using CRMs, while the remaining countries relying on EOMs are confronted with negative cross-border effects. As a direct consequence of the model-endogenous capacity expansions, average wholesale electricity prices decrease slightly in the countries with CRMs. At the same time, the levels of resource adequacy increase. In line with intuition, the opposite is true for the countries without CRMs.

Assuming risk-averse investors proves to affect the capacity expansion planning by slightly reducing investments. Interestingly, we find the impact of risk aversion to be substantially higher in an EOM compared to a CRM. This finding stands in line with previous results from the literature. However, our simulations also illustrate that while CRMs dampen the impact of risk aversion in

a Corresponding author. Chair of Energy Economics, Karlsruhe Institute of Technology (KIT), Hertzstraße 16, 76187 Karlsruhe, Germany. E-mail: christoph.fraunholz@kit.edu.

b Chair of Energy Economics, Karlsruhe Institute of Technology (KIT), Hertzstraße 16, 76187 Karlsruhe, Germany.

c Chair for Management Science and Energy Economics, University of Duisburg-Essen, Universitätsstraße 12, 45141 Essen, Germany.

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the countries using these mechanisms, neighboring countries without CRMs are affected by negative cross-border effects and risk aversion becomes even more relevant there than in the case of a European EOM. This is reflected by higher wholesale electricity prices as well as a lower level of resource adequacy in these countries.

Based on our findings, we strongly recommend that policymakers and regulators consider the impact of risk aversion when evaluating different market design options. While an EOM and a CRM may lead to similar outcomes under rather strong theoretical assumptions, this may no longer be the case when considering the characteristics of real-world electricity markets with risk-averse actors. In light of our simulation results, this could imply that in real-world electricity markets, long-term resource adequacy cannot be maintained when relying on a pure EOM. Moreover, particularly in the European setting, it is crucial to account for – potentially adverse – cross-border effects of a market design. Consequently, decisions on national market designs should always take into account the design of the interconnected market areas. It also seems advisable to consider a coordinated European CRM as an alternative to national attempts to secure resource adequacy. Such a coordinated market design is likely to stand better in line with the European Commission's goal of creating an internal electricity market in Europe.