On the Role of Electricity Storage in Capacity Remuneration Mechanisms

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Overview

The substantial increase of renewable electricity generation in countries around the world brings along new challenges for the appropriate design of electricity markets. Due to the highly intermittent nature of solar and wind power, a certain amount of dispatchable capacity will likely also be required in the future, i.e., even under very high shares of renewables. At the same time, however, the reduced number of hours with scarcity and therefore price spikes leads to substantial risks for investments in this firm capacity. Driven by such considerations, so-called capacity remuneration mechanisms (CRMs) have been implemented in several regions of the world as an extension to the energy-only market (EOM), in which capacity providers are solely compensated for the amount of electricity they sell on the markets.

Formally, both the European Commission and the Federal Energy Regulatory Commission require technology neutrality from any CRM to be implemented (European Commission, 2013; Sakti et al., 2018). However, while most CRMs in Europe and the US generally allow storage participation, the concrete rules applied differ substantially (Sakti et al., 2018; Usera et al., 2017). This is mostly due to the non-trivial question of whether and how much firm capacity an energy-limited resource like a storage unit can contribute to system adequacy. While it is generally agreed that these technologies have some kind of capacity value, the specific rules of participation in CRMs may hinder them from being competitive against conventional resources. It is thus the objective of this paper, to delve into the question how the concrete design of a CRM may create a bias towards or against storage technologies and thereby affect the future technology mix as well as long-term generation adequacy.

Methods

The methodology applied in this paper is twofold. We first set up a generic capacity auction mechanism and provide a rigorous theoretical discussion, highlighting how bundling a CRM with call options and the choice of a storage derating factor may affect the competitiveness of storage units against conventional power plants. In order to illustrate and confirm our theoretical findings, we then apply PowerACE, an established multi-period long-term electricity market model (e.g., Fraunholz et al., 2019; Keles et al., 2016; Ringler et al., 2017), and run a number of simulations.

Results

Both our theoretical discussion and the simulations carried out show that there is no straightforward answer to whether an EOM or a CRM is the more beneficial market design for electricity storage technologies. Rather than the actual market design, much depends on the concrete specification of the CRM, which always creates a certain bias towards one technology or the other. We show that bundling capacity auctions with call options and the choice of the storage derating factor are important drivers in this regard.

If storage units are not penalized for non-availability during scarcity situations caused by their storage volume running empty, they likely benefit from the introduction of call options with a certain strike price in direct comparison with conventional power plants. Contrary, if the storage units are indeed penalized even in these particular situations or if no call options with strike price are used, there exists a bias towards conventional power plants, as they do not face the risk of a storage running empty and can always provide firm capacity (neglecting forced outages).

We also show that it is crucial to adequately estimate the firm capacity a storage unit can provide and to derive storage derating factors accordingly. Otherwise, the contribution of small storages may be overestimated, leading to issues regarding generation adequacy despite the implementation of a CRM.

Conclusions

Overall, we can conclude, that the actual design of a CRM substantially impacts the future technology mix, even if all technologies are formally allowed to participate in the mechanism. The specification of the CRM may then in turn also have an impact on the goal of achieving long-term generation adequacy. More specifically, we observe that electricity storage does indeed have a capacity value and should therefore be allowed to participate in any CRM, yet with its nameplate capacity adequately derated to reflect the firm capacity it can actually provide.

Moreover, our simulation results suggest, that substantial need for investment in generation and storage capacity exists in Europe in the upcoming years due to decommissioning of old units. Policymakers and regulators are therefore strongly recommended to design or re-specify their CRMs accordingly to allow for storage participation in an adequate manner. In this regard, the time to act is now. Otherwise, a lock-in effect may occur, i.e., once an undesired technology is built, it will likely remain in the system for a long time.

References

European Commission, 2013. Commission staff working document generation adequacy in the internal electricity market – guidance on public interventions: SWD(2013) 438 final. URL: https://ec.europa.eu/energy/sites/ener/files/documents/com_2013_public_intervention_swd01_en.pdf.

Fraunholz, C., Keles, D., Fichtner, W., 2019. Agent-Based Generation and Storage Expansion Planning in Interconnected Electricity Markets, in: 2019 16th International Conference on the European Energy Market (EEM), IEEE, Piscataway, NJ. doi: 10.1109/EEM.2019.8916348.

Keles, D., Bublitz, A., Zimmermann, F., Genoese, M., Fichtner, W., 2016. Analysis of design options for the electricity market: The German case. Applied Energy 183, 884–901. doi: 10.1016/j.apenergy.2016.08.189.

Ringler, P., Keles, D., Fichtner, W., 2017. How to benefit from a common European electricity market design. Energy Policy 101, 629–643. doi: 10.1016/j.enpol.2016.11.011.

Sakti, A., Botterud, A., O'Sullivan, F., 2018. Review of wholesale markets and regulations for advanced energy storage services in the United States: Current status and path forward. Energy Policy 120, 569–579. doi: 10.1016/j.enpol.2018.06.001.

Usera, I., Rodilla, P., Burger, S., Herrero, I., Batlle, C., 2017. The Regulatory Debate About Energy Storage Systems: State of the Art and Open Issues. IEEE Power and Energy Magazine 15, 42–50. doi: 10.1109/MPE.2017.2708859.