POSSIBLE REGULATORY FRAMEWORKS FOR ENABLING MULTIPLE USE OF STORAGE DEVICES BY REGULATED AND PRIVATE MARKET PARTICIPANTS IN SMART GRIDS

Christian Sölch, University Erlangen-Nürnberg, +49 (0)9115302-669, christian.soelch@fau.de
Veronika Grimm, University Erlangen-Nürnberg, +49 (0)9115302-224, veronika.grimm@fau.de
Manuel Haußner, University Erlangen-Nürnberg, +49 (0)9115302-9412, manuel.haussner@fau.de
Roland Ismer, University Erlangen-Nürnberg, +49 (0)9115302-353, roland.ismer@fau.de
Gregor Zöttl, University Erlangen-Nürnberg, +49 (0)9115302-767, gregor.zoettl@fau.de

Overview

In many liberalized electricity markets network operation and operation of generation and storage utilities are separated via unbundling regulations. While network expansion and operation belongs to the activities of regulated transmission or distribution system operators, private firms invest in generation and storage technologies and trade electricity at a spot market. An increasing share of decentralized renewable generators as well as charging stations for e-mobility in distribution grids may lead to network congestion. Missing congestion management tools in distribution grids might then result in an excessive need of network expansion or the expansion of other system relevant devices like for instance power transformers. Many studies claim that arising network congestion can alternatively be alleviated by using storage devices. However, it is also shown that the exclusive installation and operation of storage devices for ensuring network stability by a DSO is not economic (if it is compared to network expansion). Additional trade of energy by the DSO at a spot market is prohibited by unbundling regulations.

Methods

In this paper we propose an equilibrium model that allows to compare different regulatory frameworks which enable the multiple use of storage devices by a regulated DSO and a private storage company and which are in line with applicable law. Our framework takes into account both storage investment and operation decided upon by private investors and network expansion and operation decided upon by a regulated DSO. In order to take into account the different objectives and decision variables of those different agents in our equilibrium framework, our approach exhibits a bi-level structure. We analyze the case of different regulations allowing the DSO to interfere in storage operation in case of network congestion. The resulting investment and operation decisions can be compared to an equilibrium model in the absence of such regulations. Furthermore, the results are compared to a system optimum where an integrated planner decides on both network and storage investment and operation.

To provide economically and politically relevant statements based on our computation, we calibrate our framework for a case study of a city district with around 100 households and an installed photovoltaics capacity of 1 MW. For the hourly residual load of this district we use measurement data from a smart grid filed study. We assume the district to be a copperplate but consider the network capacity that connects this district with the higher network level.

Results

Our results reveal that in the system optimum a mix of network and storage capacity expansion would be chosen to reduce total system costs. The reference scenario without the option for multiple use of storage devices does not give incentives for a system friendly installation and operation of storage and requires an extensive network expansion. Implementing a regulatory framework that enables multiple use of a storage device can give the right incentives for a

system friendly storage operation and thus reduce the need for network expansion. We show that widening the freedom of the DSO to interfere in the storage operation more often can result in outcomes that are close to the system optimum. On the other hand, giving the DSO more freedom also contrasts with the unbundling regulations.

Conclusions

In this paper a bi-level equilibrium model is proposed and calibrated for a case study of a city district with around 100 households to compare different regulatory frameworks which enable the multiple use of storage devices by a regulated DSO and a private storage company. It is shown that in the system optimum a mix of storage and network capacity expansion is optimal. In contrast, investment incentives for storage capacity are missing under the current regulatory framework without the option for multiple use of storage devices which in turn results in an extensive network expansion. Giving the DSO a possibility to contract storage capacity which can be used in periods of network congestion can lead to a reduction of necessary network expansion and generate sufficient incentives for private companies to invest in storage capacity.

Contracts or auctions which enable multiple use of storage devices have to be in line with unbundling regulations. Giving the DSO the possibility to interact with private storage operation too often, would indeed result in outcomes close to the system optimum. On the other hand, it might be in contrast to applicable unbundling regulations. These would rather imply that storage interference by the DSO only happens in very rare situations as a last resort of congestion management. This, however, reduces the efficiency of the joint storage operation. Therefore, it is important for policy makers to consider this trade off when deciding on new regulatory frameworks for enabling multiple use of storage devices.

References

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