SOLAR PROSUMAGE: INTERACTIONS WITH THE TRANSMISSION GRID

Christoph Weyhing, Workgroup for Infrastructure Policy, Technical University Berlin, +493031421649, cw@wip.tu-berlin.de
Wolf-Peter Schill, German Institute for Economic Research (DIW Berlin), +49 30 89789 – 675, wschill@diw.de
Dana Kirchem, German Institute for Economic Research (DIW Berlin), +49 30 89789 - 677, dkirchem@diw.de
Christian von Hirschhausen, Workgroup for Infrastructure Policy, Technical University Berlin, +493031425048, cvh@wip.tu-berlin.de
Mario Kendziroski, Workgroup for Infrastructure Policy, Technical University Berlin, +493031426932, mak@wip.tu-berlin.de

Overview

In many electricity markets, increasing numbers of consumers are engaging in decentralized self-generation of solar electricity. Often coupled with battery storage, this phenomenon is referred to as solar prosumage [1]. While the effects of solar prosumage on other generation and storage capacities in the power sector have been analyzed before [2-4], its interactions with the transmission grid are not fully understood so far. Concepts with decentralised generators, such as prosumage, are seen by some authors as a risk for higher system costs, since economic self-interest would counteract cost-efficient market outcomes [5]. In this study, we combine two open-source energy models, DIETER and POMATO, in a three-stage modeling framework to quantitatively illustrate possible effects for future scenarios of the German power sector. In our analysis, we look specifically at the impact of prosumage on power flows in the transmission grid.

Methods

First, we use the transmission system model POMATO [6] to generate wholesale price time series for mid-term future scenarios of Germany by solving linear dispatch and redispatch optimisation problems. The Power Market Tool (POMATO) is open source and enables research on interconnected modern and future electricity markets in the context of the physical transmission system. POMATO solves a multi-step electricity market model, including a zonal market clearing with subsequent redispatch. The resulting wholesale price time series serve as input for the prosumage module of the capacity expansion planning model DIETER [7]. The prosumage module derives optimal prosumage investment and dispatch decisions for alternative future tariff design assumptions for individual households at each node of the transmission grid. Different pricing mechanisms such as nodal and zonal pricing as well as real-time-pricing are simulated. In a final step, the repercussion of prosumage decisions on the transmission grid are evaluated with POMATO again. The models offer a high level of temporal spatial detail by modelling all hours of a full year for all nodes of the German transmission grid.

Preliminary Results

Preliminary results show that investments in prosumage are highly sensitive to future tariff design assumptions. Retail tariff designs with higher volumetric components lead to higher investments in prosumage compared to tariff designs with higher fixed parts. Nodal and real-time-pricing schemes tend to reveal more grid feasible market results that mitigate congestion but need to be further investigated. Nodal pricing schemes take into account the transmission costs and hence lead to dispatch decisions by prosumagers that efficiently use transmission lines. Real-time-pricing schemes lower the power feedin to the grid in times of high renewables availability and power withdrawal from the grid in times of low renewables availability, which minimizes nodal grid injections and relieves transmission lines.

Interim Conclusions

Our paper gives insights into the role of prosumage for the electricity system and the transmission grid for future mid-term scenarios of the German electricity sector. Preliminary results lead us to the following conclusions: Effects of prosumage on the transmission system and the electricity market depend on the tariff design. Higher fixed tariff components as well as spatially and temporally invariant pricing schemes lead to lower investments in prosumage.

More differentiated temporal and spatial price signals lead to higher investments in prosumage and lower-cost dispatch decisions for the electricity system.

References

[1] C. von Hirschhausen, Prosumage and the future regulation of utilities: An introduction, Economics of Energy & Environmental Policy 6 (2017) 1 – 5. doi:10.5547/2160-5890.6.1.cvh.

[2] W.-P. Schill, A. Zerrahn, F. Kunz, Prosumage of solar electricity: pros, cons, and the system perspective., Economics of Energy & Environmental Policy 6 (1) (2017). doi:10.5547/2160-5890.6.1.wsch.

[3] K. Say, W.-P. Schill, M. John, Degrees of displacement: The impact of household PV battery prosumage on utility generation and energy storage, Applied Energy 276 (2020) 115466.doi:10.1016/j.apenergy.2020.115466.6

[4] C. Günther, W.-P. Schill, A. Zerrahn, Prosumage of solar electricity: Tarriff design, capacity investments, and power sector effects, Energy Policy 152 (2021) 112168. doi:https://doi.org/10.1016/j.enpol.2021.112168.

[5] Agora Energiewende, Energiewende und Dezentralität. Zu den Grundlagen einer politisierten Debatte, (2017), 08/04-A-2017/DE.

[6] R. Weinhold, R. Mieth, Power Market Tool (POMATO) for the analysis of zonal electricity markets, SoftwareX 16 (2021) 100870. doi:https://doi.org/10.1016/j.softx.2021.100870.

[7] A. Zerrahn, W.-P. Schill, Long-run power storage requirements for high shares of renewables: review and a new model, Renewable and Sustainable Energy Reviews 79 (2017) 1518 – 1534.doi:https://doi.org/10.1016/j.rser.2016.11.098.