Agent-based modeling of demand response for the German electricity sector

Themenbereich (4) Aktive Endkunden-/Prosumerpartizipation

Johannes Kochems[1(1)], Christoph Schimeczek[(1)]
[(1)]Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR), Institut für Vernetzte Energiesysteme, Abteilung Energiesystemanalyse

Overview

The energy transition demands for increasing flexibility to level out fluctuations from variable renewable generation units. Demand response is one of the options to provide this flexibility. While its techno-economic potentials have already been assessed in some fundamental power market model studies [1-3], the corresponding microeconomic point of view has not fully been considered, yet. Especially, effective power prices for load adjustments may strongly differ from theoretical system cost terms and, additionally, limited information might lead to deviating decisions. Hence, we extend the agent-based electricity market model AMIRIS [4] and include demand response, i.e. load shifting and load shedding, in order to study the effects of different policy schemes and incentives on demand response potentials in upcoming analyses. In this contribution, we focus on the modelling approach itself and compare it to storage-alike demand response implementations from fundamental power market models.

Methods

Building on a prior meta-analysis of technical demand response potentials [5] which we use for parameterization, we add an implementation for load shifting as well as load shedding into AMIRIS. The intertemporal decisions of load shifting are modeled using discretized states and a dynamic programming approach to foster fast numeric solution. This approach is similar to the modelling of storage operation in AMIRIS. In contrast to storage operation, however, load shifting measures are not considered to cause additional losses but to cause additional costs and to require balancing actions within a certain timeframe. Load shedding is depicted by modelling more granular bids on the demand side. Therefore, the overall demand is sliced into smaller demand segments which are attributed with the value of lost load of the respective load segment. We choose a flexible architecture allowing us to analyze arbitrary demand response portfolios. Besides that, we compare our approach to existing storage-alike implementations in fundamental power market models, thereby building on prior analysis in [6].

Results

Both, load shifting and load shedding were successfully integrated into the model AMIRIS leading to a novel and computationally efficient representation of the demand-side flexibility which shows both, similarities and differences compared to storage-alike implementations in fundamental power market models. In subsequent analyses, we will show that limited information may lead to decisions which differ from a theoretical cost optimum. Besides that, by varying power tariffs and studying selected policy measures, we will obtain some indication on the sensitivity of microeconomic demand response potentials towards them.

Conclusions

A novel approach for agent-based modeling of demand response has been introduced and will be applied to further analyses. We hereby want to study the microeconomic perspective of demand response and the decision behavior of agents and will include policy measures and different tariff design options into the analyses. This could enable policy makers to derive, how incentives should be set to attract an amount of demand response activity that is close to the macroeconomic cost optimum.

Bibliography

[1] Curiestraße 4, 70563 Stuttgart (Germany), Telefon +49 711 6862-8521, johannes.kochems@dlr.de, https://www.dlr.de/ve

[1] H. C. Gils, „Balancing of Intermittent Renewable Power Generation by Demand Response and Thermal Energy Storage“. Dissertation, Universität Stuttgart, 2015.
[2] M. Steurer, „Analyse von Demand Side Integration im Hinblick auf eine effiziente und umweltfreundliche Energieversorgung“. Dissertation, Institut für Energiewirtschaft und Rationelle Energieanwendung (IER), Universität Stuttgart, 2017.
[3] T. Ladwig, „Demand Side Management in Deutschland zur Systemintegration erneuerbarer Energien“. Dissertation, Technische Universität Dresden, 2018.
[4] M. Reeg, „AMIRIS – Ein agentenbasiertes Simulationsmodell zur akteursspezifischen Analyse techno-ökonomischer und soziotechnischer Effekte bei der Strommarktintegration und Refinanzierung erneuerbarer Energien“, Dissertation, Technische Universität Dresden, 2019.
[5] J. Kochems, „Lastflexibilisierungspotenziale in Deutschland - Bestandsaufnahme und Entwicklungsprojektionen“. Langfassung. In: IEE TU Graz (Hrsg.): EnInnov 2020 - 16. Symposium Energieinnovation. Energy for Future - Wege zur Klimaneutralität. Graz, 12.-14.02.2020.
[6] J. Kochems, „Demand response potentials for Germany: potential clustering and comparison of modeling approaches”, Presentation at the 9th international Ruhr Energy Conference (INREC 2020), 10.09.2020.