Evaluating Cost-reflective Distribution Network Tariffs: Social Welfare and Allocation of Network Costs

Floris van Montfoort, University of Groningen, Phone: +31(0)636532588, f.j.van.montfoort@rug.nl
Sina Ghaemi, Aalborg University, email: sigh@energy.aau.dk
Machiel Mulder, University of Groningen, email: machiel.mulder@rug.nl

Overview

Due to electrification and increased level of renewable energy resources (RESs), distribution networks are regularly faced by congestion issues. Distribution system operators (DSOs) can introduce nodal pricing to achieve efficient short-term allocation of network capacity (Hakvoort and De Vries, 2001). However, application of nodal pricing fails to fully recover sunk network costs along with addressing the impact of current network use on long-run network expansion costs. This paper seeks to investigate how the principles of nodal pricing can be translated into distribution grid tariffs that reflect congestion, while meeting regulatory principles of tariff design.

Methods

We use a model of a typical medium-voltage grid in the Netherlands developed in Ghaemi et al. (2023) to evaluate various tariff designs, considering different scenarios regarding grid utilisation and congestion. This model uses bi-level mathematical programming to formulate a single-leader-multiple-followers game. At the upper level, the DSO, implements the various distribution network tariffs, calculating tariffs at each node of the distribution network for both generation and load. At the lower level, network users, including generators equipped with electrolyzers, price responsive consumers, and heat consumers respond to tariffs by altering their load and generation profiles. The tariffs consist of a combinations of multiple components, such as dynamic congestion charges, variable charges reflecting energy losses, and long-term charges capturing fixed network costs. They are determined in such a way that they are consistent with regulatory principles (i.e. non-discriminatory and cost reflective) besides of providing incentives for grid users to change behaviour in cases of grid congestion. The model estimates the welfare effects (caused by changes in the efficiency of dealing with congestion) and distributional effects (caused by the allocation of grid costs among the grid users) of the various tariff designs.

Results

The grid model allows us to evaluate effectiveness of various tariffs in terms of overall social welfare and allocation of network costs among grid users. To achieve this, results will be provided for different types of tariff designs as well as various scenarios, that differ in terms of installed capacities of RES and presence of flexible sources, such as demand response.

Conclusions

Distribution networks are likely to be more often faced by congestion issues due to electrification and high penetration level of RESs. Therefore, providing price-responsive users with incentives for efficient short-term allocation of network capacity becomes more vital. However, there are important trade-offs with other regulatory principles, such as cost-recovery, available that need to be addressed.

References

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