Compounded Real Options for Sequential Decision-Making in the Case of Electricity Distribution Networks

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Overview

Flexibility contracts for distribution networks present themselves as viable solutions for potential production-load balancing and network stability issues. These types of contracts will invariably improve reliability and reduce reinforcement needs on both types of networks (ENEDIS (2019) and Eurelectric (2020)). Several European demonstrators have shown the interest of including flexibility in fault mitigation and provisional planning for distribution networks (Interflex, Nice grid, etc.).

In response to this rising need for integrating flexibilities in their long-term planning, the French DSO[2] use a discrete DCF[3] analysis that takes into account the DR[4] activation for undistributed energy reduction in the case of an outage. Enedis and ADEeF (2018) define this flexibility as a type of load curtailment that has no cost of activation. However, accordingly to Radecke et al. (2019), within the context of local flexibility markets this assumption does not hold. The flexibility activation prices can range from regulated to free bid prices.

In addition, the changing roles of LV[5] consumers, projected increase in electric vehicle numbers, and migration towards local energy communities[6] amplify load variation uncertainty. Following the real options theory (Dixit and Pindyck, 1994), the DCF valuation under uncertainty should consider managerial decisions as flexible and allow the decision-maker to treat them as options rather than obligations.

Through this work, we aim to extend the models provided by the DSO by adding a compound real options layer in a continuous time framework. This layer replicates the choice of activating/deactivating flexibility and reinforcing the distribution network structure sequentially. Furthermore, we take into account the cost of activating DR and add it to the operational expenditures in case flexibility is activated.

Methods

In the real options layer, the DSO is presented with three options: activate flexibility when load power exceeds a certain fixed activation limit, deactivate when it is less than the limit, and investing in network reinforcement at the optimal investment trigger. Together, the first two options aim to artificially keep costs associated with the load power within a certain interval, namely between zero and the DR activation limit. This behaviour is analogous to a collar option for which we define a mix of call and put options that are valued depending on the load power. The third is analogous to a call option.

These options are not independent as the actions they evaluate are sequential. Indeed, the DSO arbitrates between flexibility and investment in order to ensure a maximisation of cost savings, and consequently the social surplus that ensues. The relationship between these options is depicted in figure 1 where $P_{\lim DR}$ is the flexibility activation/deactivation limit and P_{opt} is the optimal investment trigger. After having defined these options, we aim to determine the usefulness of flexibility, its cost and the role of the activation limit on the optimal reinforcement trigger.

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[2] Distribution System Operators
[3] Discounted Cash Flows
[4] Demand Response
[5] Low Voltage
[6] 3500 European renewable energy communities as of 2020 (Caramizaru and Uihlein, 2019)

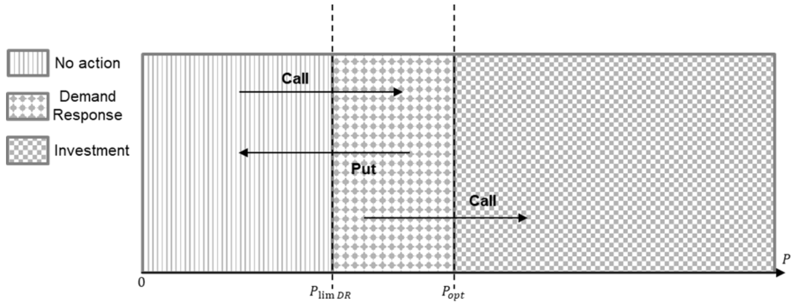

Figure 1: Call on collar option

Results

Our results show that a low DR cost and activation limit for a chosen medium voltage network actively postpones the investment. However, our analysis shows that for large flexibility costs or activation thresholds, the decision-maker prefers to invest in network reinforcement rather than flexibility. Meanwhile, for a very low cost of DR, the decision-maker completely avoids reinforcement, even though this means they could shed a significant portion of the load.

Conclusions

This work aims to provide decision-makers in long-term planning of electricity networks with an analytical continuous-time model including the positive value of uncertainty. By tweaking some of the DSO’s base assumptions, we were able to conclude that when the DR cost is non-zero, we have certain cases where reinforcement is more interesting than flexibility. We also conclude that capped flexibility volumes are necessary to avoid asking indefinitely consumers to shed their load whenever it is best for the DSO. Future research treating this subject may include DR cost volatility in the case of free bid prices and simultaneous use of different types of flexibilities.

References

Caramizaru, A., Uihlein, A., 2019. Energy communities : an overview of energy and social innovation. https://doi.org/10.2760/180576

Dixit, A.K., Pindyck, R.S., 1994. Investment under uncertainty, Investment under Uncertainty. https://doi.org/10.2307/2329279

ENEDIS, 2019. Flexibilities to enhance the Energy Transition and the performance of the Distribution Network.

Enedis, ADEeF, 2018. Valorisation économique des Smart Grids Contribution des gestionnaires de réseau public de distribution 2017.

Eurelectric, 2020. Recommendations on the Use of flexibility in distribution networks.

Radecke, J., Hefele, J., Hirth, L., 2019. Markets for Local Flexibility in Distribution Networks.