EFFICIENT DE-RATING IN MODERN CAPACITY MECHANISMS AND THE INTERDEPENDENCE WITH RELIABILIY METRICS

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Overview

Capacity mechanisms are now deemed a regulatory mainstay in liberalised power system decarbonisation. These regulatory instruments are introduced to reinforce the energy market signal and attract the power system investments needed to guarantee resource adequacy. The latter can be analysed through different reliability metrics. Classic metrics that focus on unmet demand, as the LOLP (Loss of Load Probability) or the EENS (Expected Energy Non-Served), will have to be progressively replaced by metrics that account for the increased elasticity of electricity demand and internalise the price dimension, for instance, by measuring the expected energy supplied above a price threshold. Brito-Pereira et al. (2022) presented a theoretical discussion on the impact that the reliability metric used to evaluate resource adequacy has on the firm capacity that is assigned to resources through their de-rating factor (or capacity credit). As also demonstrated Pérez-Arriaga and Meseguer (1997) and Bothwell and Hobbs (2017), the firm supply of a resource should be defined as its expected contribution to the reliability target set by the regulator.

This study is based on a mathematical model that assesses the resource adequacy of the power system through a unit commitment simulation. Real data from the Spanish power sector is used to populate the model. The first objective is to quantitatively assess the impact that the reliability metric has on the firm capacity recognised to different resources, expanding the qualitative analyses presented in Brito-Pereira et al. (2022). The second objective is to compare the theoretical-best method to assess the firm capacity (i.e., measuring the change in the reliability metric when marginally increasing the installed capacity of the resource) with the second-best method introduced in Brito-Pereira et al. (2022), in which the contribution to reliability of each resource is assessed through its production during the scarcity conditions identified according to the reliability metric.

Methods

The firm capacity of resources will be analysed through a centralised deterministic unit commitment model that aims to simulate a fully competitive short-term market through minimisation of electricity supply costs. Monte Carlo techniques are used to model forced outages and the availability of intermittent renewable energy sources.

In the theoretical-best method, the firm capacity of each technology is assessed by applying a marginal increment of its installed capacity and analysing the change in the reliability metric. In the second-best approach, the firm capacity of each technology is defined as its production during scarcity conditions as identified by the reliability metric being used (e.g., if the reliability metric is EENS, in instances when there is non-served demand). The theoretical difference between these methods is shown in Figure 1, using a price-based reliability metric defined as the energy served above a reference price, which includes of course non-served energy.

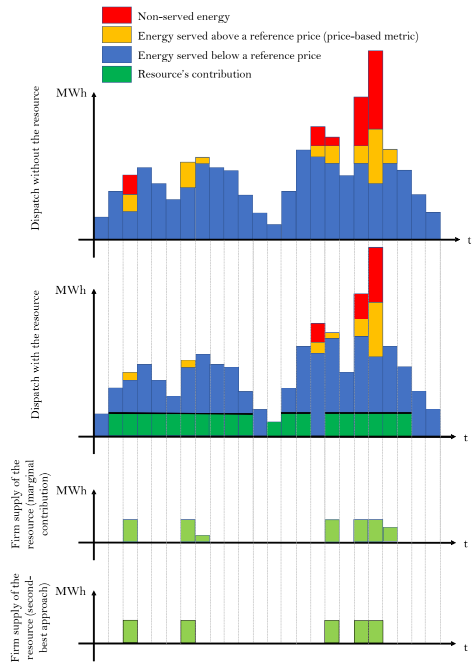

Figure 1: Graph showing the theoretical and second-best methods for calculating firm supply

As many availability scenarios are analysed (both for the theoretical- and the second-best approach), a probability distribution function of the variables of interest will be obtained and the results are to be condensed in a single value through a statistical measure, as the mean, median, or more complex measures such as the Conditional Value at Risk (CVaR), which focuses on the tail of the distribution function, i.e., in the worst reliability scenarios.

Results

This assessment is repeated for different reliability metrics (LOLP, EENS, and price-based metrics) in order to show the intricate relationship between the reliability metric and the firm supply recognised through de-rating factors. Furthermore, the theoretical and second-best methods to assess firm capacity are compared to evaluate whether the second-best approach is able to reduce the computational effort while providing results that present a minor deviation with respect to the theoretical-best approach.

The outcome of the model shows how, when defining the reliability metric, the regulator is also defining the direction in which she/he wants to steer the system in terms of resource adequacy. For the design of the capacity mechanism to be efficient, the reliability target and the firm supply should be defined accordingly, remunerating resources for their contribution to the reliability metrics.

Conclusions

Capacity mechanisms have become the main entry point for new investments in modern power systems; however, most capacity mechanisms present design flaws that prevent an efficient implementation. This study aims to demonstrate that the reliability metric and the firm supply of resources are inevitably linked. The expected findings are i) that the reliability metric chosen to assess resource adequacy should also be used to assess the firm capacity of resources and ii) that the second-best method to assess firm capacity provides similar results to the theoretical-best approach while reducing computational effort.

References

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