ACCOUNTING FOR DISTRIBUTED RESOURCES IN RESOURCE ADEQUACY

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Overview

Distributed energy resources and demand response (hereon after referred jointly as distributed resources) are expected to play a key, and increasingly important role in the energy transition. The latest version of the IEA's World Energy Outlook highlights the need for distributed resources in power systems to follow a 1.5°C global pathway [1]. A recent report estimates that there will be 200 GW of demand-side flexibility in the United States by 2030, a share equivalent to 20% of the nation's expected peak load (vs. 60 GW in 2019) [2]. The report estimates that distributed resources could bring generation and T&D deferral benefits to the USA exceeding $10 billion/year. Similarly, the potential for grid balancing through distributed resources in the European Union is expected to reach 160 GW (28% of peak load) in 2030 [3]. Despite these projections, distributed resources are still largely unaccounted for in resource adequacy assessments.

The goal of resource adequacy (RA) is determining the probability of having adequate capacity to meet customer demand at any given moment, while both load and supply vary with a level of randomness. Adequacy is fundamentally influenced by two variables: generation capacity and forecasted demand. Traditional RA methods have focused mainly on capacity and energy availability from supply-side resources, often clustering most demand categories into a single inflexible, and non-responsive, load time series. The purpose of this work is to move beyond standard RA methodologies by assessing whether dynamically modelling a range of different demand-side resources is material to RA outcomes.

Understanding distributed resource impacts on adequacy has the potential to not only reduce investment in supply-side generation, but also increase the economic efficiency and climate neutrality of power system planning by exploiting all available supply and demand-side resources. The two main goals of this work are, (a), developing distributed resource models adapted to adequacy studies, as well as an understanding of the specific modelling and data requirements for capturing distributed resource behaviour, and (b), understanding by what extent distributed resources are material to RA outcomes.

Methods

A test case is developed based on a summer-peaking, vertically integrated system, with an average peak demand of 30 GW, and based on 12 years of historical demand and weather data. The SERVM adequacy tool is employed for the presented analyses, which allows for hourly-resolution modelling, performing unit commitment and economic dispatch decisions, all while accounting for the probabilistic nature of future demand, weather, and generator outage scenarios [4].

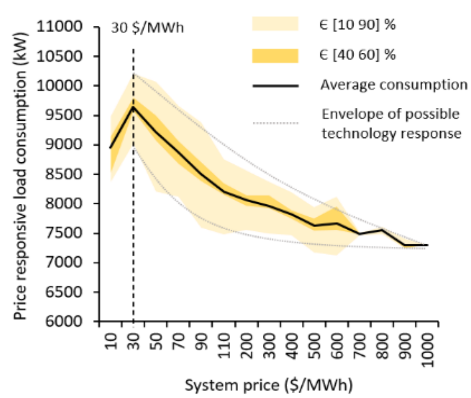

Figure 1: Real-time price load model based on real-life program data

The impact of four different demand-side resources on adequacy is tested in the presented analyses. These are: real-time priced loads, smart thermostats (HVAC)[1], distributed PV (considered under both net-metered and flat rate tariffs), and distributed PV coupled to energy storage (under a flat rate tariff). Models are developed for each of these technologies and customer programs based on real-life customer response data, which has been obtained from either trials or established programs. Figure 1 shows the developed real-time price load model, where real-time priced loads respond probabilistically within a given envelope to increases in system prices above 30 $/MWh by reducing demand.

[1] Heating, ventilation, and air conditioning

Three levels of system shares are individually tested for each distributed resource considered: 1, 2, and 3% of the peak load. That is, 300, 600 and 900 MW shares. These are indicated in the results by using the I, II, III suffixes, respectively.

Results

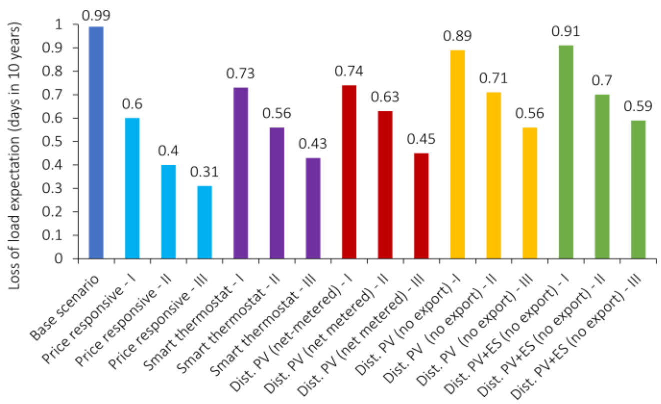

Figure 2: Comparison of loss of load expectation for all customer technologies and programs considered against a base case without distributed resources

Results for simulations carried out based on 12 years of weather and probabilistic demand data are presented in Figure 2. In the base case scenario (dark blue bar) distributed resources are not explicitly accounted for in the simulations.[2] The loss of load expectation (LOLE), that is, the number of days with loss of load events, is set to the standard value of approximately 1 day in 10 years for the base case scenario.

The findings show that **all distributed resources, at all shares considered, are material to RA outcomes,** with reductions in the loss of load expectation starting at the lowest level of technology shares, for all technologies and customer programs assessed. Results show that distributed resources not only reduce the frequency of loss of load days, but also the duration of individual events (in hours), and their magnitude (in MWh).

It can be seen in Figure 2 that the nature of the customer program or technology considered impacts its adequacy value. Smart thermostats are limited to one activation per day, and to a maximum response duration of three hours, rendering the smart thermostat program less valuable to the grid than price responsive loads, which are not limited in their response to system prices. The analyses focusing on distributed generation outline the importance of accounting for customer tariffs when considering distributed PV and storage in adequacy assessments. Due to the summer-peaking nature of the test system considered, net metered PV, where excess PV generation is exported into the grid, contributes to the greatest reduction in LOLE out of all distributed generation and storage scenarios considered. The adequacy contributions from distributed PV and storage are notably reduced when these are solely used and optimized for self consumption under the flat tariff assumption.

Conclusions

Results show that accounting for distributed resources contributes to a notable reduction in the risk of shortfall events under all scenarios considered. These results have significant consequences in terms of power system planning: they imply that accounting for distributed resources in adequacy assessments can reduce the reliance on thermal generation, and therefore the need for capacity markets to send investment signals for thermal generation technologies.

As part of this ongoing effort to characterise the effect of distributed resources in resource adequacy assessments, the adequacy impact of time of use tariffs, electric vehicles, and a wider range of net-energy metering tariffs applied to customers with distributed generation and storage is currently being assessed.

References

[1] IEA, “World Energy Outlook,” International Energy Agency, Paris, 2021.

[2] R. Hledik, A. Faruqui, T. Lee, J. Higham and T. Lee, “The National Potential for Load Flexiblity: Value and Market Potential Through 2030,” The Brattle Group, 2019.

[3] European Commission DG Energy, “Impact Assessment Study on Downstream Flexibility, Price Flexibility, Demand Response & Smart Metering,” DG Energy, European Commission, 2016.

[4] Astrape Consulting, “SERVM: Strategic Energy & Risk Valuation Model,” [Online]. Available: https://www.astrape.com/wp-content/uploads/2021/01/SERVM-BROCHURE_V2.pdf. [Accessed November 2021].

[2] It is recognized that distributed resources may still be “passively” accounted for in the net demand time time series