A Squirrel's Dilemma: The Value of Distributed Storage in the Transition to a Low Carbon Electric Grid

By Alberto J. Lamadrid, Tim Mount, Wooyoung Jeon and Hao Lu[1]

I. Overview

The transition to a low carbon economy will inevitably involve a much greater dependence on highly uncertain sources of generation from Renewable Energy Sources (RES). Much has been touted about the potential to store energy to offset the variability of RES. However, the generation portfolio available to System Operators (SO) is dependent on their ability to elicit true cost estimates of energy and ancillary services. The variability that is characteristic of RES is likely to increase the need to procure ancillary services required to maintain the reliability of the system. Some SO and Regional Transmission Organizations (RTO's) are considering the design of a market to provision the services required, and especially the ramping required (Navid, Rosenwald, and Chatterjee, 2011). Should the electric grid continue to rely on supply side solutions to problems as it has in the past and treat demand as an exogenous input for operations, or should the potential storage capabilities of demand be used to develop a system in which demand follows stochastic supply? This is the dilemma faced by regulators.

II. Methods

This article combines a theoretical framework, analyzing the increasing costs of ramping and the expanded presence of small gas turbines, with an statistical analysis of historical data. Our focus is the study of the value of different types of storage supporting the role for system operators. We characterize different deferrable demands, including electric vehicles and thermal loads, taking into account the inter-temporal tradeoffs in energy usage. The theoretical analysis uses a stochastic maximization of the total welfare from the point of view of a social planner, and a network reduction alongside specific placement of RES in connected nodes that may have congestion. The optimization use CPLEX to find the solution with a Newton Raphson approximation. For the statistical analysis, we use a dataset that comes from the Eastern Wind Integration and Transmission Study (NREL, 2010), and has data for wind with forecasts and realizations in 15-minute time steps.

III. Results

Our preliminary results show that, the increasing the amounts of wind in a network reaches an inflection point after which the savings in energy cost are offset by the increases in costs of the ancillary services. The modeling of electrical flows using Kirchoff's laws show that the income for wind generators is substantially reduced, mainly drive by increased congestion in the network. This nominal congestion in the day ahead market prevents the wind farm owners from being able to profit of the high prices observed in demand centers at peak times, due to the *de facto* severing of the transmission links available.

We also observed local effects in the management of the fleet that need consideration due to their policy implications. A specific case in point is the increased ramping in load pockets. The point sources are generators close to demand centers with fast ramping capability, but high heat rates.

IV. CONCLUSIONS

We find that there is a need for increased coupling of demand resources to enhance the penetration of RES. Such coupling requires changes in the regulatory structure and the incentives faced by operators of the distribution system.

NOTES

1. Lehigh University, corresponding author ajlamadrid@lehigh.edu

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