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CONTROLLABLE DEMAND FOR ELECTRICITY SYSTEMS WITH HIGH WIND PENETRATIONS

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Overview

The objective of this paper is to analyse the design of market mechanisms that provide support for the adoption of renewable energy sources (RES) into the electricity system. Once RES become a significant share of the generation portfolio, the reliable and secure operation of the electricity system is threatened. The underlying question is how to better manage the uncertainty of these RES, specifically wind, in an equitable way, so social planners can optimally operate and contract for energy and ancillary services, and make use of the available network resources, such as energy storage systems (ESS) and deferrable demand (DD).
While using storage collocated with wind farms is a supply side mechanism that allows reducing the variability in outputs from RES, the use of deferrable demands actively engages the demand side of the market, , thus bringing benefits in terms of the transmission congestion observed and other system metrics, such as the amount of capacity needed to reliably cover the demand.

Using a reduced network on the North Eastern Power Coordinating Council, an analysis is conducted to illustrate the aforementioned effects.. A wind penetration close to the renewable portfolio standard (RPS) for this area (i.e. 20%) is placed in an area close to the geographical location of the real generation found, according to information from the Renewable Energy Laboratory in the Eastern Wind Integration Study (EWITS 2010). The system co-optimizes the provision of energy and ancillary services for load following reserve and contingency reserve. Storage resources and deferrable demand can provide both energy and reserves into this formulation, with hourly steps used for a representative day.

The paper is organized in five sections, with an introduction and relation to literature in Section 1, a summary of the framework formulation in Section 2, a description of the calibration of the model, the wind modelling and the network in Section 3, the presentation and discussion of results in Section 5, and the concluding remarks in Section 6.

Methods

The study uses lagrangian relaxation and simulation using a security constrained, multi-period, Optimal Power Flow (OPF), implemented using Matpower (Zimmerman, Murillo-Sanchez, and Thomas, 2011). The determination of the wind sites in the reduced network uses a principal component analysis (PCA), and the scenario reduction uses a k-means methodology. The optimization is performed with CPLEX for the quadratic programming parts and with an Interior Point Method for the non-linear parts.

Results

The use of demand resources shows a big potential in the reduction of the capital costs and the generation capacity required for the secure operation of the power system. In addition to energy, the sale of ancillary services for intertemporal reserves provides additional resources that can be used for covering the cost of capital of infrastructure. Such infrastructure can take the form of ice batteries, decoupling the time of storage from the time of usage and therefore changing the overall load profile. The accrued revenue from ancillary services is especially important because the elimination of the variations in demand over the day will tend to be decreased, and therefore the income from price arbitrage is reduced. Hence, the importance of income coming not only from the sales of energy, but also from reserves.

The use of supply side resources such as transmission upgrades is effective in reducing the overall operational cost of the conventional fleet, and increases the amount of wind that can be accommodated in the network. These improvements are achieved thanks to the reduction in intermittency of the wind resource, which allows treating these resources as dispatchable generation to some extent. However, the congestion in the system at peak hours is not eliminated, and consequently the need for higher capacity needed to reliably cover the contingencies considered. A further consideration in the decision of the instrument is choosing the one that provides the highest system benefits in terms of the information available in the forecasts of the stochastic resources, and how the mitigation of uncertainty can contribute to the better utilization of these resources. Our results show

Conclusions

The policy debate of whether to invest in upgrading transmission versus using gains in energy efficiency and demand response as ways to make the use of the current generating and transmission infrastructure more efficient is an ongoing and unresolved question. It is, however, an important question due to the pressing need to integrate more renewable sources of generation on the grid and meet the policy goals of climate change. Upgrading transmission has a high capital cost and siting new transmission corridors, particularly if they cross state lines, generally meets substantial opposition from regulators and the public. On the other hand, the public's reaction to the first steps in building a smart grid for demand response, such as the Advanced Meter Initiative, has been largely negative. The modification of the tariff structure to reflect the congestion in the system, and therefore change the load profile, is necessary to provide larger benefits for customers and to ensure that second-best solutions, such as supply side transmission upgrades, are displaced by superior mechanisms.

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