Impact of Wind Topologies on the ISO-NE Nodal Electricity Prices

Jesus Nieto-Martin[1,2], Carlo Brancucci Martinez-Anido[2] , Timoleon Kipouros[1] , Anthony Florita[2] , Bri-Mathias Hodge[2] , Mark Savill[1]

[1] Cranfield University, College Road, Cranfield, UK, j.nietomartin@cranfield.ac.uk

[2] National Renewable Energy Laboratory, 15013 Denver West Parkway, Golden, CO, United States

Keywords: Power planning, wind power, electricity prices

Abstract

The work presented in this paper aims to study the impact of a range of penetration levels of distributed wind on the operation of the electric power system at the transmission level.

The increasing number of stakeholders involved in the energy sector enlarges the complexity of the problems to solve. Power planning sector objectives are naturally conflicting; consequently in some cases there is not a single planning solution that will satisfy all stakeholders.

One reason wind integration in the U.S. power system is hindered is because the best wind resources are commonly located far from the main load centres. Developing new transmission lines to connect large wind power plants to load centres often requires difficult regulatory and legal hurdles as well as substantial financial investments. A potential alternative is to increase wind penetration in the power system by developing utility-scale wind turbines connected to existing distribution networks—or, in other words, by developing distributed wind.

Given the wind integration challenges described above, the work presented in this paper aims to study the impact of a range of penetration levels of distributed wind on the operation of the electric power system at the transmission level. This paper presents a case study on the power system in Independent System Operator New England (ISO-NE). Despite its present low wind penetration, "New England has multiple wind-rich areas ripe for development, making renewable energy an exciting possibility for the region's future".

A multi-objective problem with conflicting objectives has no single solution, but a set of solutions, known as the Pareto set. Using a Multi-Objective Genetic Algorithm (MOGA), NSGA-II, complex stochastic evaluations can be performed.

The paper involves:

- Real-scale power network optimisation using multi-objective evolutionary computation to visualise complex interdependences

The study presented in this paper explores different topologies of distributed wind power for a reduced impact on nodal electricity prices. Production costing models are used extensively in the electric power industry to forecast the expected amount of electricity produced by different power generation units and the expected cost of producing that electricity for a given power generation system.

The topology is evaluated by analysing the impact of different distributed wind power topologies on nodal electricity prices using a production cost model of the power system operated by the ISO-NE. One of the challenges of integrating wind power generation into the power sector is geographical locations. The best wind resources are generally located far from the load centre. Suitable locations for distributed wind power turbines depend both on topological and network conditions. In many cases, that provides an uncertainty degree for transmission asset investments.

PLEXOS, a commercial software, is used to represent the production cost model of the ISO-NE power system by simulating the day-ahead (DA), an intraday 4 hours-ahead (4HA) and real-time (RT) markets. Tens of yearly simulations are run for different wind power topologies in order to evaluate the nodal electricity price variability and electricity productions costs.

The analysis of the outcomes of the simulations performed in the work presented in this paper result in the following conclusions. Electricity prices decrease and electricity price volatility increase with wind penetration.

The impact of wind power on volatility is larger in the shorter term (RT) compared to 4HA or DA markets. The results presented in this paper have led to several insights in terms of the impact of: 1) Wind topologies on nodal electricity prices and total generation costs, 2) How large penetration of wind (up to 32%) will impact on ISO-NE generation mix reducing coal and gas consumptions.

This paper has also paved the way for new research questions. Future work could, for instance, investigate how the impact of wind power on electricity prices changes in power systems with different market rules and different generation mixes. For instance, how would the results presented in this paper vary if the 4HA market is not considered and CC power plants are committed in the DA market? Or, how would the results vary if instead of modelling the power system of ISO-NE, which has a very large share of gas-fired power plants in their electricity generation mix, we would model a power system with, for instance, a higher share of base load generation?