Overview

In the United States, FERC has embraced the concept that generation imbalances are to be penalized based on a price that varies with size of the generation imbalance. An imbalance within a tolerance band can be ignored. Larger imbalances are to be priced at 75% or 125% of the nominal price being paid to the generator. Positive imbalances receive the 75% adjustment factor. Negative imbalances face a 125% adjustment factor. The result is effectively a 25% penalty for all imbalances. Thought imbalances may warrant being punished, sometimes imbalances are a boon to an electric system and should be rewarded, not punished. There needs to be a way to reward good imbalances while punishing bad imbalances.

Methods

I obtained metered generating data from a wind farm in Alaska at a one second interval. I used the one second metered data to calculate average wind generation during defined periods. I used that average wind generation in lieu of a schedule for wind. The difference between the one second metered data and the average wind generation was treated as a generation imbalance. This generator imbalance was evaluated relative to the 25% penalty factor concept embraced by FERC.

I also obtained metered data from a utility in Alaska, though at two second intervals, both for the utility’s Area Control Error (ACE) and for the system frequency. I created a model that combined the wind data and the utility data, first allowing the wind data to be an insignificant part of the combined system, then a minor part of the combined system, and finally a major part of the combined system.

Using the model of the combined system, I created a competitive market model. The competitive market model had the same adjustment factors embraced by FERC but were driven by the size of the imbalance on the combined system instead of the imbalance on the wind system.

- When the combined system had a positive imbalance, the adjustment factor for the wind imbalance was 75%, indicating that electricity was less valuable. This 75% adjustment factor was applied to the wind imbalance whether the wind imbalance was positive or negative.
- Conversely, when the combined system had a negative imbalance, the adjustment factor for the wind imbalance was 125%, indicating that electricity was more valuable. This 125% adjustment factor was applied to the wind imbalance whether the wind imbalance was positive or negative.

Wind imbalances were thus rewarded and deemed good when they were in the opposite direction of the imbalance on the combined system. Wind imbalances were thus punished and deemed bad when they were in the same direction of the imbalance on the combined system. Thus, with a simple change in the variable driving the adjustment factor, I converted a penalty mechanism into a crude pricing mechanism.

I then refined the pricing mechanism by changing the 25% step functions into a continuous price. I used a negative hyperbolic sine function driven by the imbalance on the combined system. I applied the resulting price to the wind imbalance. The hyperbolic sine function is the difference between two exponential functions, one with a negative sign in front of the exponent and the other with a positive sign in front of the exponent. Accordingly, the hyperbolic sine has point symmetry, grows very fast when the independent variable gets large, and goes equally very negative as the independent variable goes negative. When the independent variable is near zero, the hyperbolic sine appears to be linear. To achieve the correct adjustment, I used a negative sign in front of the hyperbolic sine function.
Results

The FERC embraced mechanism for imbalances resulted in a significant amount of energy being penalized, either as a surplus being paid only 75% of the standard price or as a deficit being charged 125% of the standard price. The amount of energy that was penalized depended on the assumptions as to the length of the scheduling period. A daily scheduling period resulted in a greater amount of the energy being penalized than did an hourly scheduling period, or a five minute scheduling period.

The crude competitive market model resulted in much less energy being penalized. Indeed, some energy imbalances were actually rewarded, either with a surplus paid at 125% of standard or with a deficit only being charged 75% of the standard.

The refined competitive market model using the hyperbolic sign function produced results similar to the crude competitive market model, thought the results varied depending on the coefficient of the independent variable.

Conclusions

The FERC embraced method for handling generation imbalances is a penalty, in that imbalances are always punished. The penalty price can be converted into a market price by changing the independent variable used to set the price. The result is that some imbalances receive prices that are favourable to the generator instead of always receiving an unfavourable price.

The pricing of imbalances depending upon the concurrent condition of the system can provide the builders of wind generators with an economic signal as to how much wind a network can handle instead of just relying on engineering principles.