COST MECHANISM FOR DEPLOYING ENERGY STORAGE IN THE SMART GRID ENVIRONMENT

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Overview

The conventional way of estimating the value of energy storage is to analyze the arbitrage benefit, which is to buy energy at night when it is mostly cheap and sell it back at peak hours when it is expensive. However, this arbitrage benefit is far less than the cost of energy storage yet and this prohibits the energy storage to be widely deployed in the power system despite its advantage. The fact is that this arbitrage benefit does not reflect the true contribution that the energy storage can provide to the power system, especially when the power system is integrated with high penetration of wind generation. Wind generation is effective in replacing conventional fossil-fuel generation due to its low operating cost, but its high variability and uncertainty undermine system reliability so it requires high reserve to maintain reliability. Energy storage is effective in mitigating this variability so that it makes additional savings in reserve cost. This paper analyze these actual but not-so-well-considered contributions that energy storage makes to reduce the total system cost of power system. This study uses simulation using a stochastic form of multi-period Security-Constrained, Optimal Power Flow (SCOPF) that reflects the stochastic characteristics of wind resources.

Methods

The study uses simulation using a security constrained, multi-period, Optimal Power Flow (OPF), implemented using Matpower (Zimmerman, Murillo-Sanchez, and Thomas 2011). An analysis is conducted in a reduced network on Jeju Island which is located in the southern area of Korean peninsula. Jeju island is a nice test-bed to study new Smart Grid components as it is a major Smart Grid test island which has high capacity of renewable generation and is planning to adopt many of other new technology component such as energy storage and electric vehicles. In order to determine the stochastic-form wind inputs, Monte Carlo method is applied to generate forecasting profiles for each wind farm and a binning methodology is used for the scenario reduction. The optimization is performed with CPLEX for the quadratic programming parts and an Interior Point Method for the non-linear parts of the optimization.

Results

The results shows that in addition to arbitrage profit, energy storage can generate economic value by lowering 1) the reserve cost of power system by mitigating variability and uncertainty that wind generation causes, 2) the energy cost by adopting more wind generation that used to be spilled due to high wind variability, and 3) the capacity cost by reducing peak capacity needed to meet system adequacy. Also results shows that the value of energy storage is higher in the power system with high penetration of wind generation and also shows that the value of energy storage only considering the energy cost saving is far below the cost of energy storage, but when we consider saving in reserve cost and capacity cost, the energy storage overly achieved the economic validity. In addition, since storage helps adopting more wind into the power system, it helps reducing the use of dirty fossil-fuel sources, therefore it contributes to lower greenhouse gas in the power sector.

Conclusions

Energy storage is considered as a key component in the future electricity market because it can increase the overall efficiency in operating the power system, especially in the system that the non-dispatchable generation sources such as wind and solar are major. Hence, it is important to correctly estimate the true contribution that energy storage makes in order to develop more reasonable incentive system in the electricity market. When energy storage can be compensated correctly as proposed in this study, we will be able to accelerate the deployment of energy storage and build the sustainable smart grid system that customers can afford.

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