VALUE OF DEMAND RESPONSE FOR WIND INTEGRATION IN GENERATION UNIT COMMITENT AND EXPANSION PLANNING: MODELING AND IMPACTS OF PRICE RESPONSIVE LOAD

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Demand response, defined as the ability of load to respond to short term variations in electricity prices, plays an increasingly important role in balancing short-run supply and demand, especially during peak periods and in dealing with short-term fluctuations in renewable energy supplies. However, demand response has not been included in standard planning models for optimizing generation investments or in unit commitment scheduling memthods.

In the case of generation expansion planning, three different methodologies are proposed to integrate short-term responsiveness into a long-term model considering operational constraints. Elasticities are included to adjust the demand profile in response to price changes, including cross-price elasticities that account for load shifts among hours. As energy efficiency programs also influence the load profile, interactions of efficiency investments and demand response are also modeled. Comparison of model results for a single year optimization with and without demand response shows peak reduction and valley filling effects, impacting the optimal amounts and mix of generation capacity. Increasing demand elasticity also increases the installed amount of wind capacity, suggesting that demand response yields environmental benefits by facilitating integration of renewable energy.

In the case of unit commitment modeling, price-based demand response is included using quadratic mixed integer programming. Consumers are assumed to adjust their load in response to price shifts, modeled using hourly elastic demand functions. Increasing consumer’s responsiveness to price deviations on the one hand reduces peak demand levels, avoiding expensive peak and high peak load power generation. On the other hand, demand valleys with low electricity demand or excess wind power generation can be filled, increasing the output of less expensive power generation. Consequently, the capacity factor of base load generation increases, whereas peakers see reduced capacity factors. In addition to those cost reductions, price variability is lower and the integration of non-dispatchable wind power generation is improved, as measured by the amount of wind spillage avoided.

Finally, a flexible demand-side proves to be efficient in dealing with the unpredictability of real-time wind power injections. A stochastic unit commitment model indicates that the costs of wind power forecast errors can be significantly reduced by demand-side flexibility. As the instantaneous system power balance is no maintained by supply-side flexibility alone, greater amounts of wind power can be integrated into the system with fewer problems from forecast errors.