[*ASSESSING THE EFFECTS OF DEMAND-RESOURCE BIDDING MARKET ON GENERATION SYSTEMS AND THE ENVIRONMENT*]

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Overview

Based on high temporal-resolution data on the three-year experience of demand-resource bidding in Korea, in which the system marginal price is paid to registered load aggregators in case of successful bidding, we assess the program's impact on generation portfolios and the environment while taking the economic dispatch behavior into consideration. Particularly, we investigated how carbon dioxide (CO_2) and particulate matter (PM) emissions from the existing power systems have changed with the introduction of the Korea Power Exchange (KPX)'s incentive-based DR program. We robustly found that the DR program indeed help reduce the supply of conventional power generation, marginally abating CO_2 and PM emissions from the power sector.

Figure: Daily electricity generation by technology

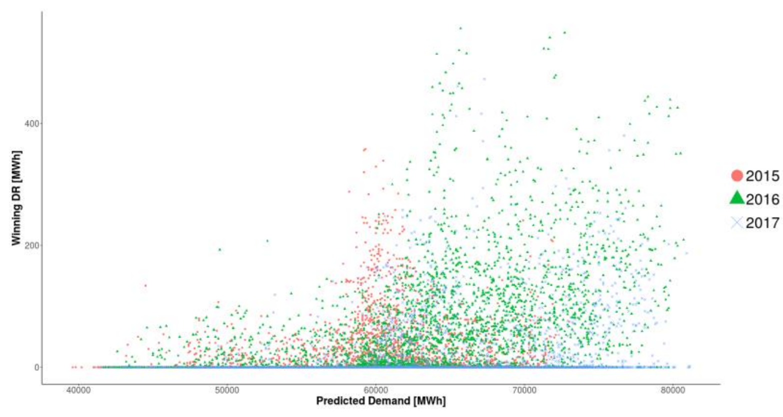

Figure: Relationship between predicted electricity demand and the amount of winning bids for DR

Methods

To represent the dispatch decision made by the market planner, we construct an hourly system equation model in which the electricity supplies from five generation sources (coal, natural gas, oil, nuclear, and hydro) are explained by production-related covariates and weather and time variables. A 3SLS (Three Stage Least Squares) method is employed to estimate the impacts of DR bids won in the market on electricity generation portfolios and resulting emissions while considering possible endogeneity of the bids and contemporaneous correlation across error terms. Models that incorporate time interaction terms are also used to estimate the possible time-varying effects of DR resource on technology choice and associated emissions.

Results

Our 3SLS estimation confirms that winning bids for DR resource are substituted for by various generating sources, most notably by LNG-fired generation. Estimates for other covariates also serve our intuition. Interaction effects between DR resource and peak-hour dummies remain significant for all resource types. At the hourly level, the reduction in coal-fired generation due to DR resource is most pronounced during mid-peak hours, whereas DR replaces other sources most significantly during off-peak hours. At the seasonal level, DR resource replaces nearly all types of generation during the Fall season but only intermediate generation sources, such as LNG- and oil-fired generation, during the Summer and Winter seasons.

Conclusions

Prior studies on DR program remain inconclusive about its possible environmental impacts. Our study reveals that, despite its small presence in the wholesale electricity market, demand-resource bidding can bring about marginal environmental improvements of about 2% and 0.3% reductions in CO_2 and PM emissions, respectively, compared to the case without the bidding. The scale of reduction in PM emissions per year induced by the program is equivalent to shutting down all existing coal-fired plants in Korea for about 2 days. In addition, the time-contingent nature of the environmental impacts suggests that demand-resource bidding should be used with caution as a way to temporarily alleviate environmental stress because the system operator's dispatch decisions made in response to the program would differ by time and season, so that "Green DR" is not necessarily achieved.

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