The Effect of Capacity Payments on Peaking Generator Availability in PJM

Stein-Erik Fleten, Norwegian University of Science and Technology, stein-erik.fleten@ntnu.no
Benjamin Fram, Norwegian School of Economics, Benjamin.Fram@nhh.no
Magne E. Ledsaak, Norwegian University of Science and Technology
Sigurd Mehl, Norwegian University of Science and Technology
Ola E. Røstum, Norwegian University of Science and Technology
Carl J. Ullrich, James Madison University, ullriccj@jmu.edu

Overview

This paper aims to study the effects of capacity payments on the operational decisions of plant managers for peaking units in the PJM Interconnection.We achieve this through a structural estimation of maintenance and switching costs between the operational state, the standby state and retirement of generating units. We have focused on the period from 2001 throughout 2016 — a period where we have identified some significant changes in the power market dynamics. We conduct a counterfactual analysis on the level of capacity payments to study the effects of introducing a capacity market in 2007. The reliability of the power system depends crucially on the availability of flexible peaking units to cover load in periods of high demand. Therefore, an understanding of the real costs facing the owners of these units is essential in order to enforce policies that ensure sufficient peak capacity in the power system. Capacity markets are introduced as a means of compensating capacity, and our study aims to analyze the effects of this additional market on switching behavior.

The empirical data shows less switching between states after the introduction of capacity remunerations. We find that the role of peaking units has changed, with the units being dispatchedmore often. In the counterfactual analysis, we find a clear connection between the level of capacity payments and switching. We conclude that the current level of capacity payments in PJM incentivizes peaking units to stay in the operational state.

Methods

In order to design a market where peak generators are compensated appropriately to secure sufficient investment activity, a regulator must have a thorough understanding of the generators' cost structure as well as the market dynamics. Regulators make cost estimates, but empirical testing of such estimates is difficult. Generator costs are influenced by exogenous factors that can be hard to observe. Also, the cost structure of a power producer is business sensitive information, as this determines the lower limit of their bids in market auctions. Therefore, the empirical estimation of generator costs is one of few viable options for investigating the real costs faced by generators. The business decisions of an owner of a peaking unit are readily formulated as a sequential decision process in time, where choices about the operational state of the generator must be made before each consecutive time period. Markov decision processes provide an excellent framework for modeling sequential decision making under uncertainty (Rust, 1994). Under the assumption that the generator owners act rationally, dynamic programming provides a way of identifying the optimal decision rule for choosing how to operate one's generator. The agent can be represented through a set of economic primitives, describing their utility function, transition probabilities and discount factor for future states. The primitives convey information about the decision process of the generator owner as well as the uncertainty of the decision environment. Structural estimation provides a framework for robustly estimating such primitives.

Results and Conclusions

We find evidence that market conditions for peaking units in the PJM has changed significantly after 2007, and identify three market trends influencing the behavior of peaking units. Technological advancements have changed the supply side of the natural gas market, giving a persistent drop in fuel prices for gas-fired turbines. New environmental regulations have forced old coal-fired baseload into retirement, presenting new market opportunities for gas-fired units. We also see that the regulations have led to the retirement of old combustion turbines. The introduction of capacity payments has led to less switching and a higher amount of peaking plants being ready to operate.

The first trend, the penetration of shale gas in the US gas market, significantly reduced the fuel price for many generators. We conclude that this has disrupted the traditional market dynamics where coal-fired plants serve as baseload, and combustion turbines cover peak demand. Gas-fired turbines have become more competitive in serving baseload, and besides, traditional baseload has been punished harder by stricter environmental regulations than gas units. Consequently, peaking units are nowdispatched more often, increasing the wear and tear on the mechanical equipment. This is a plausible explanation for the increase in the estimatedmaintenance cost for generators after 2007. The second effect that influences the switching behavior of peak generators is the introduction of stricter environmental regulation schemes. In years where regulatory changes are expected, our estimates show that the perceived cost of startup decreases and the perceived cost of shutdown increases. This tendency to prefer to operate in years with new regulations must be seen in light of the fact that environmental regulations are imposed on all actors in the power market. Coal-fired baseload is more polluting than most other technologies and is therefore affected more severely by stricter environmental regulations. Gas is cleaner, has become cheap, and gas plants are quick to bring online. This makes it possible for gas-fired units to replace the retiring coal-fired baseload, a fact reflected in the environmental regulation coefficient estimate.

Finally, after the introduction of the RPM, less switching is observed, and the share of operational peaking generators is larger, with few generators being in the standby state. The results from the counterfactual analysis indicate that the switching behavior is affected by the level of the capacity payments. Lowered capacity payments will give more switching, whereas increased payments cause minimal change. Overall, our findings indicate that the system operator is successful in incentivizing peaking generators to stay in an operational-ready state through capacity payments.

References

Rust, J. (1987). Optimal Replacement of GMC Bus Engines: An Empirical Model of Harold Zurcher. Econometrica, pages 999–1033.