

An equilibrium model for investments in flexible generation

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Overview

A decarbonized energy system will require sufficient investments in flexible generation capacity. In an energy-only market firms receive a payment for output sold in the spot market. If markets are perfectly competitive and production costs are convex, this will lead to an efficient market outcome both in the short-run (market operation) and in the long-run (investment levels and levels of flexibility). In practice production costs are non-convex, and standard theory does not apply. Our paper intends to study how those non-convex costs affect investment decisions.

Methods

We simulate a long-term market equilibrium in an analytical tractable framework in which firms have start-up costs. Those start-up costs lead to non-convexities in the production cost function. We assume a continuum of small generators bidding into the spot market auction for two time periods, one representing night and the other day production. The cumulative distribution function of the firms' marginal costs is given by $G(c)$. Firms are competitive and take the distribution of prices for both markets $F_i(p)$ as given. The spot market price is determined by market clearing. Demand for energy in both periods is stochastic. In the long run, firms have two decision variable: how much they invest in lowering the start-up cost, i.e. how flexible they make their production plants and how much capacity they build. Free entry will drive down long term expected profits.

Results

We compare the first best investment levels with the private incentives in three different scenarios. (1) An energy only market (2) An energy only market which allows for block-bids (3) An energy-only market with side-payments for start-up costs. With respect to demand we include (a) perfectly inelastic demand, (b) elastic demand, and (c) demand shifting across time periods (i.e. demand flexibility). We will distinguish investment decisions for capacity and flexibility.

Expected Conclusion

We conjecture that an energy-only market with side payments will lead to efficient investments levels of flexibility in a competitive market and with perfectly inelastic demand, as firms are dispatched efficient, are compensated for their start-up costs and taxing consumers to pay for start-up costs does not distort the market. If demand is elastic, then consumers prices will need to satisfy two objectives: (1) pay for the flexibility costs and (2) provide correct signals for reducing the need for flexibility. A form of Ramsey pricing is then required. With a pure energy-only market, generators will have to internalize the cost of flexibility as no side payments are possible, and operational efficiency is reduced. This increases the incentives to build more flexibly generation and decreases overall investment incentives which reduces total capacity.