POLICY IMPLICATIONS IN WORLD WITH RENEWABLES, LIMITED DISPATCHABILITY, AND FIXED PRICES

Mathias Mier, University of Oldenburg, Chair of Public Economics, +49 441 798-4108, mathias.mier@uni-oldenburg.de
Klaus Eisenack, Humboldt-University of Berlin, Group Resource Economics, +49 30 2093-46363, klaus.eisenack@hu-berlin.de

Overview

The integration of a large share of fluctuating renewables into electricity systems poses a major challenge for a transition to a low-carbon economy. As the quantity of electricity produced by renewables at a point in time depends on the wind speed or the insolation, and since electricity is difficult to store with current technologies at reasonable costs, fluctuations need to be equilibrated. It is well-established that an increasing share of fluctuating renewable feed-in can cause additional electricity system costs (Lamont 2008). Renewables operate at zero marginal costs and should be used first. But conventional capacity need several hours of down-time and to restart, which places them forwardmost of the merit-order. This is one explanation for eventual requests by utilities to temporarily shut-down renewable generators, or for negative electricity market prices in times of high renewable feed-in. However, if actual feed-in is lower than expected, back-up capacity is needed because conventional capacity is inflexible. Nevertheless, there is yet one additional reason for the increasing system costs involved here: Load of a fundamental part of consumers is stiff due to contractual fixed prices, where load of the other part might be price-sensitive.

Methods

The analysis abstracts different degrees of dispatchability by considering three types of capacity. Highly-dispatchables can instantly adjust to fluctuations. Conventional capacity requires a plan several hours ahead of actual production. Renewables randomly produce electricity but can be adjusted within their bounds of availability. To model renewable generation we consider two extreme cases: (1) weather conditions differ independently for each generator (case of independence), (2) weather conditions are the same everywhere (case of perfect correlation). For most parts of the paper we consider price-insensitive consumers and limited dispatchability for conventional capacity, but for some we also consider price-sensitive consumer and the possibility of conventional capacity to adjust their production at least partly at higher costs. The limited dispatchability of conventional capacity and the different consumer types are reflected by a sequential dispatch decision problem (dynamic adjusted peak-load pricing model (see Crew et al. 1995)). The long-term decision is to select capacities in order to maximize surplus as difference between utility and expected costs. All propositions are derived theoretically, but numerical simulations will strength the intuition by giving quantitative results.

Results

The main focus of the paper is not to show that conventional and renewable capacity exclude each other (see Eisenack and Mier 2016), but to analyze how a system with renewables and highly-dispatchables might be decentralized by competitive markets. The result for a *non-market* solution is as follows: Capacity must be subsidized, but production must be taxed. However, the *market* solutions might be easier to implement. Creating an operating reserve market (Renewable producers must buy electricity produced by highly-dispatchables if their production deviates from their expectations) lead to the surplus maximizing outcome for the case of perfect correlation. For the case of independence in turn, surplus maximizing renewable capacity demands for taxing production and subsidizing capacity. Implementing a retailer between producers and consumers yield the same result. All transfers could be implemented and lead to budget compensation. Modeling price-sensitive consumers increases total surplus and reduces some transfer requirements, but does not change the exclusion of conventional and renewable capacity. Partly flexible conventional capacity does not lead to a complete exclusion of conventional and renewable capacity anymore.

Conclusions

A well-working electricity system could be implemented without demand response, although regulation is still necesssary and surplus is higher with price-sensitive consumers. Allowing for flexible production of conventionals shows the interplay between conventionals and renewables in transisting electricity systems. By underestimating the effect of ramping costs or when costs are already sunk, conventional capacity keeps longer in the system as it is surplus maximizing.

References

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