ANALYZING EFFECTIVE COMPETITION IN ENERGY MARKET USING MULTI AGENT MODELLING

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Abstract

Energy market structure in most of the European countries is highly influenced by market reform from centralized to more open and competitive structure. The electricity market reform was intended to encourage more competition among different market participants. Now, Europe's electricity markets are facing rapid changes which bring some new challenges and make it necessary to modify current market design. One of these changes is continuous increases in electricity generation from renewables. The share of renewables in electricity generation increased from 12% in 1990 to 21% in 2010. It is expected that the electricity generation share from new renewables such as wind and solar will be more increased in near future.

Higher share of renewables have some effects on the market. The first effect is that supply from some of renewables such as solar and wind is highly fluctuating and intermittent and not reliable enough. Fluctuating implies that steep downward and upward ramps can be observed in renewables generation profile. Also, intermittency nature of renewables leads to more uncertainty and less predictability of the generation profile.

The second effect is that the utilization of conventional generators decreases. Most of European electricity markets are energy-only markets. In this market, generators get revenue based on the amount of electricity they sell. All generators are sorted according to their marginal cost bids in the merit order curve. Without renewables, base load generators like nuclear and coal plants place at the left side and peaking units such as gas-fired plants at the right side of the merit order curve. Since electricity generated by renewables has very low marginal cost, it places in left side of merit order curve and shifts the conventional generation to the right side. It means that some of the conventional generators may not be scheduled and goes out of the market. The third effect is lower market clearing price. Since renewable generation push the supply curve to the right side of merit order curve, the intersection of supply and demand curve will result lower market clearing price.

All above mentioned effects lead to less utilization and less profit for conventional generators. It implies less incentive to invest in conventional generation. On the other hand, generation from renewables is intermittent and not reliable enough. Then, the market will face the supply security problem which means the generation adequacy in the market will be jeopardized. The main question is that how market can solve this problem by establishing an effective competition to provide backup for intermittent generation and a reasonable revenue stream for conventional generators. The purpose of this paper is to provide a model-based analysis of some of the mechanisms and ideas which are used or can be used in energy market to alleviate supply security issue.

Regarding to supply security problem, different forms of capacity mechanisms have been suggested and applied in different electricity markets. Among capacity mechanisms, capacity credit mechanism and reliability options are used when a separate capacity market is established in addition to the energy-only market. In these mechanisms, suppliers have to purchase capacity credits or option contracts in capacity market to cover the total forecasted demand plus a reserve margin.

Capacity payments and strategic reserve are two other mechanisms which are implemented in energy-only market. Capacity payments are determined by market administrator and depend on available capacity and the reserve margin in the market. Higher excess capacity in the market means lower capacity payments. In strategic reserves mechanism, an auction is held on a certain amount of capacity which is withdrawn from regular energy market. This reserve capacity is only dispatched in

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specific scarcity situations. By increasing the amount of renewable generation, scarcity situation will happen rarely. The price and the amount of acquired reserves are key parameters to measure the effects of this mechanism and an inefficient scarcity prices will lead to underinvestment.

Increasing demand response and storages in energy market could be possible solutions to alleviate the supply security problem. An active demand side participation in the market reduces the necessity of conventional capacities. Also, it brings more flexible by enhancing the responsiveness of electricity demand to market prices. A new market design should consider the expected increase of demand side participation in European energy markets by both household and industrial consumers. Also, an efficient support scheme for renewables in future electricity market design can mitigate the supply security problem.

In this study, we want to discuss on a well-functioning energy only market which could be able to provide cost recovery for all types of generators to ensure the security of supply. The well-functioning energy only market includes an active demand side participation, utilization of storages and encouraging more effective competition among suppliers, especially in scarcity situations.

To this aim, an agent based model equipped with a game theoretic framework will be applied to study the interactions in electricity market as a complex system. An important feature of the agent based approach is its ability in modeling of complex systems. In proposed model, different types of agents are equipped with multiple learning capabilities. Agents improve their decisions by learning both from dynamic market change and collaboration with other agents. Also, by using game theoretic framework, agents will have ability for strategic decision making which means that each player will make decision by considering the decisions that other players may make. Based on this proposed model, we will discuss how the well-functioning market with mentioned characteristics can encourage more effective competition and provide right mixture of incentives for investment to alleviate supply security problem. As the expected result, the proposed model can be used as a basis for future energy market structure in Europe.

References

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