Smart grid congestion mechanisms meet network regulation: How to align incentives?

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Overview

This paper addresses misalignments of incentives that emerge from the flaws in the market design when implementing smart grid congestion mechanisms. Problems stemming from misaligned incentives have been observed recently in the context of the renewable generation curtailment. It has been argued that an efficient implementation of this network congestion mechanism requires policy adjustments that distort the incentives for distribution network investment. However, if these policy adjustments are avoided, inefficient investment incentives for renewable generation result (Jacobsen & Schröder, 2012). This misalignment of incentives between the network operator and renewable generation does not seem to be specific to the renewable generation curtailment only. It is expected to emerge also in the context of other smart grid congestion mechanisms discussed in Europe, such as different designs of local flexibility markets.

Using the concept of locational marginal pricing as an efficiency benchmark, proposed paper develops a concept of a "buffer fund", i.e. an intermediary step for financial flows between the network operator and renewable generation, which is utilized to align incentives between the two parties. The suggested approach is demonstrated on the case of the renewable generation curtailment remuneration and evaluated in the broader context of the local flexibility markets. The paper suggests that the redistribution effects stemming from the "buffer fund" allow reproducing efficient incentives of locational marginal pricing in case of renewable generation curtailment and potentially even in the presence of the local flexibility markets.

Methods

Microeconomic modeling is used as a main method in the proposed paper. The locational marginal pricing model is introduced as an efficiency benchmark (Schweppe et. al., 1988). Following the representation in Joskow & Tirole (2005), we rely on a simple two-node model.

This model is presented within the first step. Renewable generation is located in the north; i.e. this node is characterized by the net supply function in the model. Demand and conventional generation are located on the south node, which presents the net demand in the model. Assuming congestion on the line connecting the two nodes, respective nodal prices are derived from the model. Efficient levels of network and generation investments implied by the nodal prices are also discussed in this step.

Second, efficient design of renewable generation curtailment is discussed. Optimal remuneration of the curtailed generator is defined with the aim to reproduce the nodal price of the north node. Similarly, assuming the presence of an incentive regulation, optimal curtailment remuneration to be paid by the network operator is defined as the difference between the nodal prices. Following, optimal remuneration to be paid by the network operator is shown to stand in conflict with the optimal remuneration of the curtailed generation. In other words, an optimal curtailment remuneration payment from the network operator to the curtailed generator seems to be impossible to define. Perverse incentives caused by the deviations from the optimal remuneration levels are also described.

Third, a buffer fund is introduced in addition to the renewable generation curtailment. The concept is based on the idea of an universal service fund discussed in the context of the telecommunication and postal sector liberalization (Blankart & Knieps, 1989; Knieps, 1987). Remuneration payments of the network operator are directed at the buffer fund instead of the generator. Herewith, efficient investment incentive for the network operator can be realized while providing the curtailed generator with the optimal curtailment remuneration. Efficient use of the network payments collected in the fund is also discussed in this context.

Results

The results of the paper are two-fold:

- The paper confirms the difficulty to establish an efficient remuneration mechanism for renewable generation curtailment in the presence of network regulation. The difficulty stems from the misalignment of incentives between the renewable generation and network operator, i.e. from the fact that an economically efficient remuneration of curtailed generation provides perverse incentives to network operator under the incentive regulation and vice versa.

- The paper demonstrates the possibility of introducing efficient network and generation incentives, i.e. the possibility of aligning the incentives, within the case of renewable generation curtailment by introducing the concept of a "buffer fund" (analogously to an universal service fund known from the discussion on telecommunication and postal sector liberalization). In other words, an alternative efficient congestion mechanism (substitute) to locational marginal pricing is developed.

Conclusions

Locational marginal pricing represents an efficient solution towards the congestion occurring in the energy networks. Unfortunately, this solution appears to be rather difficult to implement within the liberalized energy sector policy framework in Europe. Therefore, academics and practitioners are increasingly discussing alternative network congestion mechanisms. Renewable generation curtailment represents one of the most straightforward solutions towards managing the network congestion. Taking this mechanism as a case study, this paper studies misalignments of incentives between energy sector agents that emerge due to conflicting requirements of network regulation and the proper renewable generation curtailment implementation. It confirms the difficulty to define an efficient level of curtailment remuneration as well as describes perverse incentives that are likely to emerge due to the deviations from the optimal remuneration levels (market design flaws). Furthermore, the paper develops an efficient market design for renewable generation curtailment, which can be implemented instead of locational marginal pricing. Guiding principles of an efficient renewable generation curtailment design are suggested to apply for local flexibility markets as well. Elaborating this point is left as an issue for further research.

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