THE SOCIAL VALUE OF DEMAND RESPONSE AND ITS INTEGRATION IN CAPACITY MECHANISMS

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Overview

Various market failures inherent to electricity markets have led regulators to take actions to make sure the power system can meet demand peaks. Two distinct strategies can be implemented. On the supply side, one can support capacity through a Capacity Remuneration Mechanism (CRM). On the demand side, Demand Response (DR) technologies to reduce demand at times of system stress can be rolled out. Many European countries are supporting both schemes, and the question of DR participation in CRMs has arisen.

In times of scarcity a transmission system operator (TSO) can identify consumers who need electricity the least, and have their load reduced in exchange for a financial compensation. This strategy may prove very effective: Gray Davis, governor of California during the California electricity crisis of 2001 noted that he could have solved the crisis in 20 minutes had he been able to pass through the rising prices to consumers, a statement confirmed by numerous academic studies such as Borenstein (2005), Faruqui (2009). ENTSO-E stresses that DR "often has a high capacity value relative to its energy value in many countries. Participation in reserve capacity markets therefore opens significant opportunities for the development of DR and provides an additional revenue stream for DR capacities that can match technical requirements". In turn, the EU state-aid guidelines state that Demand-side management development should be an explicit target of any CRM scheme. Thus, the question of DR participation to adequacy and its integration in CRMs needs to be tackled. The subject has however been surprisingly under-studied in the academic literature. Much of the focus of previous research has been on assessing the technical potential of DR, but little has been done on market design. Regulators and TSOs are thus left with little theoretical guidance, leading to a patchwork of assorted designs. The present paper aims at filling that gap. We observe in particular that a side effect of the price cap is that prices sometimes fail to provide adequate information for DR activation. As a consequence, we show analytically that even absent asymmetry of information on volumes (what would have been consumed by operators absent a DR technology is public information), current designs fail to screen DR technologies and dispatch them optimally. To address this issue, a simple menu of optimal capacity payments to DR is proposed, essentially suggesting to de-rate payment to DR according to the ranking of the DR operator in the load-shedding order.

After a brief introduction, the second section reviews the literature relevant to our analysis. Section 3 introduces notations and outlines the model. It is solved, and a menu of optimal contracts is proposed in section 4. Section 5 makes cases studies illustrating the previous findings. Section 6 concludes.

Methods

The originality of the present work is to link the concepts of DR and CRMs, in order to show how the former can be integrated in the latter. In our model, capacity remuneration is needed because of the presence of a price cap, which in turns makes prices and DR activation inefficient. We develop an analytical model that clearly highlights the motivation for a CRM, and to what extent DR should be rewarded as capacity. The paper contributes to the literature on demand response, capacity mechanisms, and priority services as described by Chao and Wilson (1987), from which the main features of the model are borrowed.

In light of this model, we highlight the flaws of current market designs with case studies.

Results

The status-quo regulation is to say that DR is technically not capacity, and therefore should not receive any remuneration from the CRM --set aside implicit remuneration through energy market prices. Another extreme is to consider that DR is exactly like capacity, and should therefore receive a full payment. Most technology-specific CRMs (Spanish capacity payments to new combined-cycle gas turbines, German strategic reserve composed of ageing coal plants...) or generation-only schemes fall by default in the first category. Market-wide CRMs that allow explicit DR participation such as the British, French or PJM CRMs are in the second category.

However, our paper argues that the optimal solution lies between those two extremes, with an optimal payment that should depend on the ranking of the DR service in the activation order.

- If a DR operator commits to activating at least when prices are at the price cap, then this service is indeed equivalent to the one offered by thermal generation and the DR operator should receive a full payment for capacity.
- If DR activation is not prompted by market prices, but awaits a TSO order, then the payment should be smaller, as it is not activated as often as market-based DR is. The least it is activated, the least valuable the service, and the least the payment should be if the TSO wants to make sure there is optimal investment in DR.

Conclusions

The paper shows that all schemes currently experimented fail to properly account for the social value of DR, leading to inefficient deployment. Indeed, DR participates to security of supply only if (1) the system is tight and (2) activation has been requested by the TSO. The implications of the second aspect has been overlooked by current designs. The paper concludes that the capacity payment to DR should be weakly decreasing in the operator's position in the load-shedding order. If DR is not allowed to re-sell power in the energy markets, payment should be strictly decreasing.

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