Developing a Smart Grid that Customers can Afford: The Impact of Deferrable Demand

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With more electricity generated from renewable sources, the importance of effective storage capacity is increasing due to its capability to mitigate the inherent variability of these sources, such as wind and solar power. However, the cost of dedicated storage is high and all customers eventually have to pay. Deferrable demand (DD) offers an alternative form of storage that is potentially less expensive because the capital cost is shared between providing an energy service and supporting the grid.

This paper presents an empirical analysis to illustrate the beneficial effects of Plug-in Hybrid Electric Vehicles (PHEV) and thermal storage on the total system cost and customers' bills in an electricity market with high penetration of wind generation using data for a hot summer day in New York City. The optimization model used in this study assumes the system operator controls PHEV and thermal storage to minimize the total system cost of energy and reserves. This paper also introduces the econometrics model to distinguish Temperature-

Sensitive Demand (TSD) and Non-Temperature Sensitive Demand (N-TSD) from base electricity demand, and uses TSD as a base for cooling demand that thermal storage can contribute to reduce.

The results shows how customers can reduce total system costs and their bills by 1) shifting load from expensive peak periods to less expensive off-peak periods, 2) reducing the amount of installed conventional generating capacity needed to maintain System Adequacy, and 3) providing ramping services to mitigate the variability of generation from renewable sources. The system cost of the optimum case with PHEV and thermal storage is reduced by 19% compared to the case without storage. The payments for customers who own thermal storage, PHEV, and both thermal storage and PHEV are decreased by 13%, 17%, and 29%, respectively compared to customers without storage, when they are charged according to optimum payment policy for energy, reserves and capacity. When flat payment policy is applied, customers with both thermal storage and PHEV pay most and customers with no storage pay least. In other words, the flat payment policy provides perverse economic incentives and the free riders with no storage are the winners.

Our main conclusion is that regulatory changes will be needed to ensure that customers with DD capabilities pay rates that reflect their true net-cost to the grid and provide the financial incentives for investing in the DD capabilities needed to realize the cost savings described in this paper. To illustrate this conclusion, we show that the standard regulatory practice of charging a flat retail price for energy in effect subsidizes customers with no storage and penalizes customers with DD. Although managing DD and selling ramping services require substantial knowledge of how power systems operate, we assume implicitly that the grid will have a hierarchical structure and that aggregators will manage the DD appliances of individual customers. The incentive for customers with DD is that their electric bills will be lower and they will still get the same energy services delivered when they need them. The system operator will provide each aggregator with market signals and will treat the combined demand from individual customers as a single wholesale customer for billing purposes.

In summary, we conclude that it is essential to develop a regulatory environment in which all participants in the different markets for electricity and ancillary services, including customers and aggregators, pay for the services they use and are compensated for the services they provide. This will establish the economic incentives needed to develop a smart grid that customers can afford.