FLECH - CLEARING HOUSE FOR CONGESTION MANAGEMENT

Silas Harbo, Danish Energy Association, Rosenørns Alle 9, DK-1970 Frederiksberg, +45 35300488, SIH@danskenergi.dk
Peter Meibom, Danish Energy Association, Rosenørns Alle 9, DK-1970 Frederiksberg, +45 35 300 400, PME@danskenergi.dk
Lars Henrik Hansen, Dong Energy A/S, Teknikerbyen 25, DK-2830 Virum, +45 99558168, LARHA@dongenergy.dk

Overview

According to the Danish Government electrification of transportation and residential heating is expected to cause major challenges for the Danish Distribution System Operators (DSOs). DSOs may face significant capital investment for lower voltage level grid reinforcements with limited utilization factors [1]. Flexibility in Distributed Energy Resources (DERs) offers what might be a cost effective solution managing congestion for many DSOs. Within the Danish unbundling regulation a DSO is not allowed to have a direct commercial contact to customers connected to their grid. Nor are DSOs interested in organizing thousands of flexible consumers. The Danish Government has tasked the DSOs to develop a market model for congestion management in lower voltage level grid structures [2]. We propose a FLExibility Clearing House (FLECH) as a platform for trading ancillary services between DSOs and aggregated DERs. FLECH is designed to perform the auctioning of DSO flexibility contracts, keep track of agreements, verify delivery, and manage settlement.

The study is based on a selected flexibility service developed by [3], called PowerCut Planned. This service is used to handle the predictable peak loads for daily capacity issues in a given node. PowerCut Planned is relevant to the DSO's asset management in cases where the DSO foresees a capacity issue leading to congestion on a feeder or line during a peak load period in the medium-term horizon (6 months to 3 years).

When trading flexibility for congestion management at FLECH, the settlement between the DSO and Aggregators occurs twice. First, the foreseen congestion issue can be used for setting up a reservation contract auction. The DSO receives the bids and evaluates whether the Aggregators' proposals can solve the load issues and the expected Total Cost of Activation against the value of deferring the grid reinforcement investment.

The second time is when the flexibility is actually going to be activated. Once the day or hour of operation gets closer, the DSO will have such a fine picture of the load reduction needs that they can ask an Aggregator to follow a certain load schedule, the activation. This calls for setting up two markets, a reservation market and an activation market, which are highly different in nature and mechanisms.

Methodology

The purpose of this study is to derive the critical decision points and best solutions for the market design of FLECH. This is done by matching a DSO and a commercial aggregator and by highlighting opportunities, advantages and drawbacks based on theoretical economic analysis behind the critical decisions supporting the most efficient design of FLECH. Combined with matching up the interests of the two core stakeholders, we get the respective conditions they would require in order to demand and provide a specific flexibility service.

This approach is part of the management economic discipline, and provides: (1) **Process support** to structure the management issues, i.e. range of alternatives and criteria to choose upon, and determine conflicting interests within the DSO-Aggregator relationship. (2) **Decision making support** by providing sufficient information to assess the management issues and contribute to the comparison of strengths and weaknesses that can seem incomparable at first sight. (3) **Legitimizing support** for the decisions made. As the decisions have implications for various stakeholders (DSO, Aggregator, policy makers, utility companies, etc.) some may feel disadvantaged by the outcome. A clear rational behind decisions on the design of FLECH is crucial to legitimize why certain outcomes were preferred.

Results

Timing of the Reservation Market depends on the time required to reinforce the grid structure – in the vicinity of 3 months. The Aggregators need time to mobilize flexible consumers and develop their reservation bids, which will require an additional 3 months. Consequently a 6 months lead time on contracts is required from posting to closure. The reservation contract length negotiation centres around the trade-off between certainty in delivery for the DSO versus dependency on a single provider and stirring competition and an efficient behaviour from the Aggregator [4].

FLECH transactions will be conducted like auctions, rather than market transactions, due to the unique and local nature of each DSO service contract. The DSO's call for flexibility includes the expected number of activations ($N_{Expected\ Activations}$), specified as kWh and reflecting both the capacity and duration of each expected activation. Based on that information the Aggregator can formulate a minimum price as specified in eq. 1), where $C_{Reservation}$ is the cost associated with reserving the flexibility from consumers, $C_{Activation}$ is the costs associated with delivering the

flexibility services based on the Aggregators contracted resources, and $C_{Associated\ Overheads}$ is the additional cost associated with the administration of the flexible portfolio.

1) Aggregators Minimum Price = $[C_{Reservation} + (N_{Expected\ Activations} \times C_{Activation}) + C_{Associated\ Overheads}] \times$ Profit Margin

Similarly, the DSO can form a maximum reservation cost, which will constitute a ceiling on the total reservation contract cost. The DSOs maximum reservation price can be formulated as in eq. 2) where $C_{Reinforcement}$ is the value of deferring the capital investment for grid reinforcements over the contracted period, $P_{Activation}$ is the activation price, $C_{Transaction}$ is the transaction costs, and (1-uncertainty premium) reflects the risk associated with DSO forecast errors.

2) Max Reservation Price = $[C_{Reinforcement} - (N_{Expected\ Activations} \times P_{Activation}) - C_{Transaction}] \times$ (1- Uncertainty Premium)

As Aggregators submit bids based on their own cost structure, the most efficient auctioning format will be a First-price Sealed Bid [5] . Aggregators submit simultaneous "sealed" bids to FLECH. The bid minimizing the Total Cost of Reservation and Activation wins the contract and gets paid the reservation fee on a periodic basis.

Timing of the Activation Market has a very important practical role as the coordination between the TSO and DSO level services lies in the timing. Because the TSO has access to a wider scope of ancillary service providers it is evident that the availability of DSO service providers are prioritized. This is done by letting the DSO activation market clear an hour prior to the TSO markets, day-ahead of operation. The argument can be turned around, to say that the DSO can allow contracted DERs to compete for TSO services day-ahead, by clearing the DSO market first.

This activation price clearing mechanism is a simple merit order sorting of resources which only considers the price per kWh for the period considered. The DSO is obliged to purchase flexibility from the reservation contract, in case no bid is more attractive than the contracted maximum activation price. Likewise, the Aggregator is obliged to deliver the service at this price. In this sense, the reservation contract is very similar to a call option, where the DSO pays for the opportunity to buy the service at certain strike price. If an Aggregator can gather a bid from its portfolio which is cheaper than the contract, it will submit it to FLECH. FLECH will identify the cheapest bid combination, and reward it with the activation request and subsequent service delivery.

In a competitive setting there is a direct trade-off between market efficiency and DSO surplus when comparing System Marginal Pricing (SMP) and Pay-as-Bid (PAB) [6]. Due to the inelastic nature of the DSO's demand for flexibility services, the positive market efficiency effects are limited. On the other hand, the DSO benefits from PAB in peak situations are limited due to the reservation contract price ceiling on the activation market. This favours a SMP regime. In a monopolistic setting – more likely the case of the DSO markets – PAB limits the exercise of market power and it leads to a higher DSO surplus. PAB can cause inefficient behaviour leading to weakly reduced output but ensures a more efficient distribution of output. Under monopolistic conditions PAB should be preferred as it reduces prices and increases both DSO surplus and welfare. See [7] and [8] for details.

Conclusions

Based on the characteristics of the DSO service *PowerCut Planned* and the DSO's medium-term planning cycle a FLECH market mechanism was derived to match the practical realities and market efficiency that will make a future DSO market setup more appealing to stakeholders and provide maximized socio-economic welfare.

FLECH is one of the major deliverables from the Danish iPower project. In April 2014, the FLECH IT-platform was demonstration by IBM and in November 2014 there will be a physical live demonstration of the FLECH functions and capabilities, on a real congestion challenges and a green house, hosted by Dong Energy.

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