Risk implications of investments in demand response from an aggregator perspective

Jonas Katz, Technical University of Denmark, +45 24658855, jokat@dtu.dk
Lena Kitzing, Technical University of Denmark, +45 24659064, lkit@dtu.dk

Overview

A growing challenge arises to provide sufficient flexibility in electricity systems with large shares of intermittent renewable production. This has reinforced interest in utilising the flexibility potential of the demand side. While, technically, this is certainly a feasible option, some issues prevail in exploiting demand-side flexibility in practice. These issues include how to organise market access for the demand side and how to activate consumers who are used to receiving electricity as an unconditional service and often do not attach much significance to contract structure and pricing of electricity. It has therefore often been proposed that end user flexibility should be marketed by an entity aggregating many consumers' flexible units (see e.g. Katz, 2014). Moreover, it has been found that automatic control will be far more effective than relying on an active manual response by customers (Lund et al., 2015).

We investigate in this paper the business model of such aggregators with remotely controlled demand response devices added to appliances of end customers. The operative conditions of aggregators will be highly dependent on variable market prices and their capability to profit from these variations. It is therefore crucial to understand the inherent risks of the aggregators' business model. In our analysis we also explore risk implications of aggregated demand-side response regarding the exposure to uncertain future market prices and how it influences the decision of aggregators to invest in demand response equipment.

Methods

In the business model we propose, aggregators market end user flexibility in the electricity wholesale market, while remunerating their customers in the form of a reduction in their contracted electricity price. In order to be able to access certain customer devices for flexibility purposes, the aggregators equip their customers with remotely controllable switches that should be installed with the relevant flexible appliances. Such switches require additional upfront investment by the aggregators. In this paper we investigate whether such a business model is feasible, i.e. whether the additional revenue from marketing demand-side flexibility is sufficient to justify the required investment. For this, we develop an investment appraisal model consisting of a price module, a demand response module and a cash-flow module (see Figure 1).

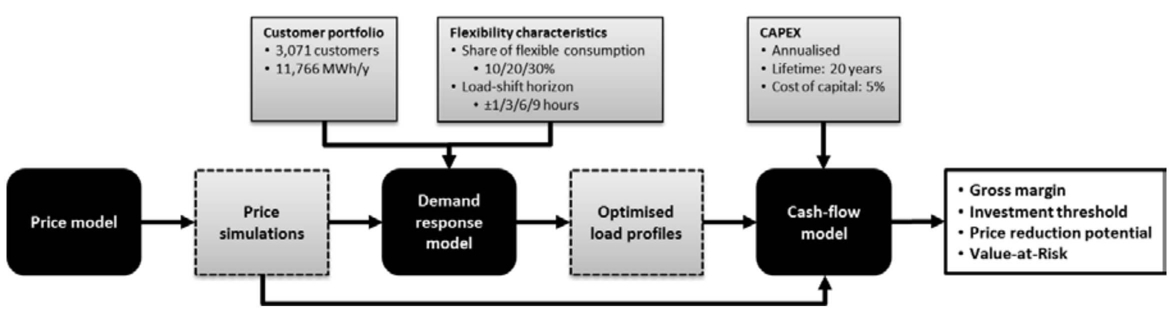

Figure 1: Overall model concept

For the stochastic electricity price model we choose to apply a framework proposed by Lucia and Schwartz (2002). We see this model fit as it provides the possibility to incorporate seasonality into the price process. We calibrate the stochastic process to the Danish electricity market. The realistic results from the specific case application shall help to strengthen our point. The demand response model is an optimisation model based on load shifting, calibrated to historical profiles of Danish residential customers. We explore three different scenarios of the share of consumption available for flexibility (10%, 20%, 30%) and four different scenarios for the load-shift horizon (1h, 3h, 6h, 9h). The cash-flow model is based on a single-period operational gross margin indicator.

Using Monte Carlo simulations we calculate the aggregator's income as well as the threshold levels that indicate the maximum allowable investment costs to ensure a certain expected gross margin for the aggregator. Doing this, we can identify not only the expected average benefits for the aggregators (and their customers), but can also explore the related risks by analysing the probability distribution of the outcomes. Applying a Value-at-Risk approach we quantify the risk of adverse outcome, i.e. when prices develop in a direction where demand-side flexibility is not sufficiently valuable and the investment in equipment leads to a loss for the aggregator. Having determined the maximum allowable investment cost levels under different flexibility assumptions, we compare this to currently available technology and assess whether the business model of an aggregator is viable in the current market environment.

Results

For each set of scenarios, we have calculated the operational gross margin and then analysed it from different perspectives. Here the investment threshold is one of the crucial elements in the analysis. The investment thresholds of each scenario are calculated so that both the margin for the aggregator and the sales price for the customers are kept constant in comparison to the base case without demand response. The investment thresholds presented in Table 1 are thus the maximum allowable cost that have to be undercut for the aggregator business model to become attractive. They should be compared to current investment cost in the range of 50-100 EUR/customer.

Table 1: Investment threshold [EUR/customer]

	Load-shift horizon			
Flexible share	±1 hour	±3 hours	±6 hours	±9 hours
10%	2.65	8.88	15.97	32.88
20%	5.31	17.76	31.94	65.76
30%	7.96	26.64	47.91	98.64

Table 2: Maximum price reduction potential [EUR/MWh]

	Load shift horizon			
Flexible share	±1 hour	±3 hours	±6 hours	±9 hours
10%	0.07	0.25	0.45	0.92
20%	0.15	0.50	0.89	1.84
30%	0.22	0.74	1.34	2.75

As customers in competitive retail markets like the Danish one will have to be convinced of participating, a benefit to the customer is essential. Table 2 provides an overview on the leeway that would exist regarding the sales prices based on the full load-shift effect. Although the absolute price reduction may seem low in comparison to the average sales price of approximately 37 EUR/MWh, one can conclude that some of the scenarios hold a rather attractive relative reduction potential – not considering taxes and network tariffs, though.

In addition, we determine the probability distributions of the demand response effects in each scenario. As the load-shift horizon is extended, the results become more favourable, but also the return becomes more uncertain. Another observation is that all the distributions have a pronounced upside represented by a thicker tail. Overall, we find that the income expectations are rather stable, with margin reductions in the range of 0.1–3% for a 5% Value-at-Risk.

Conclusions

The analysis of a robust business case for aggregators should not only take into account average values, but also consider risks and their implications for income variability and attractiveness of investment. We have developed a model that is capable of analysing the operational gross margin of an aggregator, related investment thresholds and sales price reductions. At the same time, it provides the opportunity to determine probability distributions and thus enables us to do a Value-at-Risk assessment. Applying the model to the Danish market, we find that aggregators have a difficult business case under current market conditions unless they can find a portfolio of customers with a very high flexibility share of their load and very long load-shifting horizons. There is still some way to go for aggregators to assume a significant role as providers of flexibility. With foreseeable cost reductions for smart devices, however, the aggregator business case might soon become attractive for highly flexible customer segments.

References

Katz, J. (2014). Linking meters and markets: Roles and incentives to support a flexible demand side. *Utilities Policy*, 31, 74–84. doi:10.1016/j.jup.2014.08.003

Lund, P., Nyeng, P., Grandal, R. D., Sørensen, S. H., Bendtsen, M. F., le Ray, G., … MacDougall, P. A. (2015). *EcoGrid EU - A Prototype for European Smart Grids: Deliverable 6.7 - Overall evaluation and conclusion*.

Lucia, J.J., Schwartz, E.S., 2002. Electricity prices and power derivatives: Evidence from the nordic power exchange. *Review of Derivatives Research*, 5, 5–50.