The Value of ICT Platform Investments within Distributed Energy Systems

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Overview

Investments in information and communication technology (ICT) are indispensable to efficiently operate energy systems with increasing distributed generation and demand-side flexibility. This applies to operations at both the grid and the market (clearing) level. Focusing on the market level, geographically dispersed supplies, loads and flexibilities need to be aggregated, manipulated and successfully placed in the market. The task is to achieve a supply-demand balance across a plethora of individual units within regimes of balancing responsible parties (BPS) or even entire market areas at the lowest possible costs. This requires investments in communication infrastructure between the units involved, appliance automation and ICT platforms for aggregation and control.

However, a number of barriers present disincentives to initiate the required investments. First, the lead time and cost uncertainty associated with ICT developments; second, the fairly low profitability of aggregator business models (e.g., virtual power plants, VPPs) in energy systems to date; third, the significant regulatory risks which threaten the mid- to long-term viability of business models. Moreover, investors may at times fail to acknowledge potential upsides of investing early even under uncertainty, owing to first-mover advantages and flexibility. In light of this, valuation methods to decide over ICT investments in distributed energy systems should account for the uncertainties and the benefits of early investments alike. One way to achieve this is to leverage real options (RO) valuation.

In our research, we develop an RO model to evaluate the opportunities for a risk-neutral operator to set up a VPP in the German power market. The VPP is defined as an ecosystem of distributed generation and flexibility resources as well as (flexible) loads, aggregated and coordinated by means of an IT platform including a control room. Thus, the investment in and development of an ICT platform is understood to be a prerequisite to any acquisition of distributed assets.

Methodology

In the model, the risk-neutral operator wants to decide whether and possibly when to set up the ICT infrastructure for a virtual power plant. This investment would enable, but not oblige the operator, to acquire distributed generation, flexibility assets and possibly (flexible) loads for aggregated operation in a second investment step.

Compound RO valuation methodology is applied to account for the sequential nature of the investment opportunity. The first option ("platform option") is formulated as the opportunity to develop the necessary ICT infrastructure. Uncertainty regarding the project lead time and costs of the infrastructure development are included as stochastic elements influencing the strike price of the option as well as the delay between option exercise and asset availability.

Once developed, the second set of options ("market entry options") becomes available, namely the opportunities to acquire different kinds of distributed assets to begin the actual operation of a virtual power plant in different markets. A number of possible revenue streams for the virtual power plant are considered, whose existence and extent are assumed to depend on market prices and regulatory influences. "Steady state" revenues are inferred from existing research. Potential first mover advantages and regulatory risks are factored into the valuation as parameters that dynamically impact the value of market entry and operation over time.

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Results

While our research is still in progress, some analytical intuitions are already worth a discussion. First, an early exercise of the platform option provides the operator with flexibility. The value of this flexibility primarily depends on the range of revenue streams that the platform allows tapping. The more diverse the markets and assets are which can be leveraged through the platform, the lower the exposure to regulatory and price risks are and the more valuable the acquisition of the market entry options by exercising the platform option is. The flexibility value is further enhanced when considering first mover advantages, i.e., the possibility to obtain higher market shares when entering markets earlier.

On the other hand, risks associated with ICT infrastructure investments provide a clear disincentive to invest. Lead-time risk implies the risk of obtaining a functioning, operational platform later than expected. This, in turn, increases the discount rate applied to future revenue streams and lowers the overall investment value. A similar effect is caused by development cost uncertainty. Finally, regulatory risks have a significant impact on the optimal investment behavior. This applies particularly when assuming that regulatory changes may negatively affect multiple revenue streams simultaneously.

Conclusions

Investments in ICT infrastructure and the establishment of related business models (such as VPPs) are critical for the successful transition towards distributed, "smart" energy systems. Yet, plenty of barriers to adoption exist, while some potential reasons to invest are not easily traceable. This research suggests and formulates an options-based approach to holistically evaluate investments in ICT platforms that enable the operation of VPPs at the interface of distributed energy assets and energy markets. The value of flexibility and early entry are incorporated, while the risks associated with ICT investments are weighed against the benefits. From a policy perspective, the (included) notion of regulatory risk deserves particular attention; in that it can induce significant delays in investments which are needed to master system transition.

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