Utilising demand flexibility in electricity distribution networks

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The transition to sustainable energy sources like wind and solar and the introduction of electric vehicles and heat pumps are putting a growing strain on our electricity distribution networks. To prevent overloading and reinforcing the network, which is costly and time-consuming, regulators are increasingly looking to new and flexible ways of controlling demand. Ph.D. researcher Rik Fonteijn of the department of Electrical Engineering has developed practical tools that can help distribution system operators utilize demand flexibility in their daily operations. Fonteijn will defend his thesis on Friday 29 October.

The energy transition is gaining momentum, with sustainable sources like wind turbines and solar panels increasingly being introduced in distribution networks. Simultaneously, the introduction of electric vehicles and heat pumps has put an extra load on existing distribution networks.

Traditionally, distribution networks are designed and reinforced based on the expected peak load, to prevent overloading or network congestion. Alternatively, distribution system operators (DSOs) can use demand-side flexibility to avoid or postpone costly reinforcements, or to bridge the time it takes to complete reinforcements. This is an application which the Dutch regulator is currently in the process of enabling.

In past research, various mechanisms (e.g. price-based schemes, tariff changes, flexibility markets, direct control) to control customer demand have been considered, analyzed and tested in the field. This has shown that demand flexibility can solve congestion problems (either completely or partially).

Daily operation

However, integrating the different aspects and providing DSOs with the necessary tools to utilize flexibility for congestion management in daily operation, is a topic that has not yet been extensively researched. Rik Fonteijn's thesis therefore focused on flexibility utilization in daily operation from a distribution system perspective.

He developed a framework to operationalise flexibility and implemented it in a pilot setup. The framework consists of four steps: data acquisition, load forecasting, decision-making and flexibility mechanism interfacing. The implementation of the four-step framework shows that by using load forecasting and a decision-making algorithm that considers the cost of lifetime reduction in case of overloading, the DSO can make a fair evaluation on whether to buy flexibility or to accept an overloading. This results in competitive prices of flexibility compared to prices occurring on existing wholesale and balancing markets.

Compensation

After the DSO has obtained flexibility from market parties, the delivered flexibility needs to be financially compensated. When flexibility is provided, the behavior of the flexibility source can be captured by load measurements. It is, however,

not possible to also measure the behavior of a flexibility source in case no flexibility is provided.

The expected behavior is therefore captured by a so-called baseline, based on which the DSO can settle the delivered flexibility. Traditional baselining methods are not suitable for remunerating variable flexibility sources such as (curtailment of) solar power.

Fonteijn proposes an alternative approach to determine a baseline for settlement between DSO and aggregator. This approach combines the historical method with weather data of the moment flexibility is provided. It is shown that this can improve the baseline of solar power compared to traditional methods.

Practical tools

By integrating, adapting and expanding on existing research, Fonteijn has developed practical tools necessary to start utilizing flexibility in daily operation to DSOs. These tools are integrated in an integral framework of a four-step approach and enable the DSO to request their flexibility needs from market parties. This research illustrates that the proposed concepts can work not only in theory, but can be adapted and used in a practical (pilot) context.

More information: Rik Fonteijn, Utilising flexibility in distribution system operation, First supervisor: Han Slootweg, second supervisors: Phuong Nguyen, Johan Morren.

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