Designing an operational market for grid supporting use of electric flexibilities in distribution networks

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Overview

With a progressing energy transition, there will be a growing number of distributed energy resources in the distribution grid. These can be on the one hand renewable power plants like wind turbines and photovoltaic systems and on the other hand electric consumers, such as electric vehicles and heat pumps. As a result of this process, there is a huge need for grid enhancements in order to avoid technical problems. In distribution grids, the major problems expected are capacity congestions in electrical lines and transformers as well as overvoltages in some nodes of the grid. (see e.g. [1])

Today's approach of grid enhancement up to the last kilowatt power is economically inefficient and time- and resource-consuming.

Against the background of this soon-to-be situation, a number of practitioners and researchers proposed regional flexibility markets in order to use them in a grid supporting way (e.g. [1], [2], [3], [4], [5]). Flexibility, in this context, can be an electrical producer, consumer or storage that is able to adapt certain technical parameters (e.g., electrical power) in response to a critical grid condition. Although the concept of these so called 'regional flexibility markets' has been discussed much, there still exists no operational market according to the original idea.

The article at hand aims to describe a possible market design of a regional flexibility market. Such a market shall enable distribution system operators (DSO) to procure grid supporting flexibilities and therefore reduce operational cost in the short term and grid enhancement in the long term. For potential suppliers of flexibility, this market is an alternative to the established energy exchange trading and the balancing energy market.

Methods

As a basic work the concept of regional flexibility markets gets processed and brought into the context of the existining (German) energy system. Especially the delimitation between classical energy markets, balancing power market and the to be designed regional flexibility market is an important point of discussion. After that the various aspects of the market design problem with proposals for their possible solution get described.

The main challenge in the market design problem is that so far neither a tradeable product nor a trading mechanism of such a market exist. Thus, there is a wide range of possible design options that need to be canalized in a proper way.

Because the background of the market is a technical problem, the relevant technical conditions have to be identified and analyzed first. More precisely, the question has to be answered what technical behavior is needed to solve the technical problems in the grid as well as who can provide an adequate technical flexibility. Furthermore, an important issue that has to be solved in this context is the technical effectiveness of a flexibility. There exist physically based topological relationships defined by the structure of the grid between the offered flexibility options and a specific technical problem in the grid.

Based on these technical conditions, the market itself can be designed. In more detail, that is the traded products and the trading mechanism. The products can be described with their technical parameters, such as electrical power or energy, a time component, e.g., one day or one hour, and some rule-based parameters, such as minimum offer and so forth. The product design should be as standardized and easy as possible to simplify the trading processes. At the same time, it must be able to solve the technical problems in the background with regard to the aforementioned topological relationships. The trading mechanism or auction design contains aspects of organization (framework of the auction), traded goods (as a meta description), bids (rules and language of offers) and contract award (solving the winner determination problem and pricing rule). Therefore, an implicit or explicit information of the local component (grid node) in each traded product is of outstanding importance.

Results

The main result of this article is the describtion of an operational market for grid supporting use of electric flexibilities in distribution networks with its products and trade mechanism.

The trade products differ from classical schedule energy products (such as traded at the energy axchange) and so can be interpreted as short term capacity products (such as traded at the balancing power market). Nethertheless the capacity products of balancing power and regional flexibility differ in details of their technical describtion. The main reason for this is the divergence of the energy resources providing the flexibility in the respective market.

With regard to auction theory, the designed auction can be described as a combinatorial multi-criteria multi-unit auction. Combinatorial in this context means that bidders can bid on combinations of items. Multi-criteria means that not only the price and quantity, but also other product parameters (here a local topological component) are relevant for the winner determination. Multi-unit means that the amount of the traded goods is bigger than one.

Conclusions

This article makes a proposal for the detailed design of a 'regional flexibility market'. So far the concept of such markets has been discussed, but there is still a lack of operational market designs or even field studies. The type of the designed auction is of a high complexity and so far has been little studied.

As a part of the BMWi funded project 'C/sells' [6], the developed market design will be implemented in a field test in real subnetworks of the DSO "EnergieNetz Mitte" and will continuously be improved.

References

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