

Characterization of Flexible Electricity Resources in Power and Energy Markets

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The term flexibility has been widely used in supply-side power market studies for many years and more recently also in the consumer side. This is supported by technologies and business models for load shifting, reduction, and curtailment. In this characterization of power and energy markets flexibility research, we take into consideration four fundamental flexibility resources: supply-side, demand-side, storage, and grid-side flexibility. All of these can have a centralized or decentralized location in addition.

For this research, our aim is the characterization of flexibility resources in energy and power markets along three dimensions: Time, spatial, and flexibility provider. First, we examine flexibility provision considering the relevant time horizon for the flexibility product. Second, resources are investigated from the perspective of geographical relevance. The last dimension considers which actors in the value chain that can provide the flexibility product. Our research aims to examine how these flexibility products may have relevance in different markets and how well these markets incentivize optimal resource allocation in the short-run, and investments in the long-run.

Location of a resource is a substantial question during transmission and distribution process of electricity. Due to limited capacity of the grid, using local resources or non-local resources is a matter of decision for system operators at both DSO and TSO level. Furthermore, locations of power resources are related to the quality of provided power e.g. the inverse correlation between reactive power and distance of transmission.

The needed activation time and duration for flexibility in the energy system should match with relevant products and markets. Flexibility providers (vendors) have their own time of availability for provision in different time scales, from seconds to years. Energy system needs are uncertain, especially in real-time markets with high integration of variable renewable resources. Moreover, time scales of power markets are not fully sequential and may be overlapping e.g. forward and day-ahead markets, intraday markets and balancing markets. Therefore, assignment of flexibility products to markets is non-trivial, because of the time coupling and the possibility to use same flexibility source for different flexibility products in different markets.

Lastly, we consider pricing and valuation of flexible resources and their trading processes. Modeling for resource allocation and pricing handles coordination of resources during bidding process in multiple markets. In addition, researching the adequacy of current markets in pricing and valuation of flexible products from heterogeneous providers is needed in terms of short-term resource allocation and long-term resource allocation (investments and expansion). The right incentives for flexibility provision are substantial with respect to optimal market design and pricing.