# Smart Market-based congestion management design for electricity markets

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## Overview

High resource prices for gas and oil have stressed the strong need to replace conventional generation of electricity by renewable sources in Europe. However, feed-in from these sources is highly volatile and results in technical challenges for the transmission grid infrastructure such as congestion issues, since markets are organized in a price-zone configuration without consideration of internal network constraints. Congestion management is used to adjust generation ex-post to make market results feasible. Recent European legistlation demands market-based procurement of congestion management as the central way to deal with redispatch from all member states. However, not all states use a market-based system yet. The main reason is the risk of strategic bidding behaviour (so called "increase-decrease-gaming" [1]) of market participants and potentially high cost. Countries such as Germany use a exception in legislation to postpone the setup of market-based procurement. However, even for these countries a short-term need for such a setup is given. One solution to comply with EU legislation is the so called "Smart Market"-approach [2]. This approach means the introduction of timely and spatially limited markets, which trade a decentralized adjustment of power feed-in to avoid congestion issues in the transmission grid [3]. In contrast to standard redispatch measures, the Smart-Market-approach does not rely on technical conditions such as a minimum power requirement. Thus, multiple business models can be implemented, that include all kinds of flexibility options. If these markets are not able to deal with all congestion issues, the standard cost-based redispatch can be kept as an ex-post option, while the European legislation is complied with. In this conference paper, we analyse possible market design options for the Smart-Market-concept and apply them to a multi-level electricity market model. Questions on how these markets can be opened and how they are defined are addressed. We use an aggregated grid model for the German electricity market and transmission grid to analyse effects regarding cost-efficiency, the integration of electricity from renewable sources and the procurement of regionally differentiated price signals within the zonal market design of the European electricity system.

## Methods

A multi-level electricity market model is used to analyze the integration of the Smart-Market-concept in the order of the market structure. Results will focus on the total cost of congestion management, the integration of electricity from renewable sources as well as investment decisions in generation and transmission capacity. We expand the existing three-staged GATE-model (Generation And Transmission Expansion) [4] [5] by an additional stage for the market-based procurement of congestion management on Smart Markets:

(1) A central network planning entity performs investment into the transmission grid. Trade on the spot market for electriciry as well as resulting congestion management are anticipated
(2) Independent, privately owned generation companies trade electricity on the spot market. They decide on short-run generation supply as well as mid-term investments into new generation capacity as well as decommissioning of existing capacities. The spot market is modelled in terms of the European zonal market design. We assume perfect foresight and competition.
(3) Decentralized flexibility options trade adjustments of power feed-in on Smart Markets. The requested adjustements as well as a willingness-to-pay for these are calculated from the expectation of congestion management. The market clearing works pay-as-cleared.
(4) Cost-based redispatch is performed ex-post to deal with final congestion issues in the grid, if necessary. The Smart-Market solution is considered on a nodal level.

This multi-stage model can be transformed into a three-staged problem by combining the first and the third stage into one optimization problem [6]. The resulting three optimization problems are implemented as linear or mixed-integer problems in GAMS. We use scenario-data for the year 2030 from the TYNDP for generation and demand. The analysis covers Germany and the direct neighboring countries, whereas congestion management demands data on the transmission grid and is only implemented for Germany. In addition to that we use data on decentralized flexibility options, such as P2G, demand side flexibilization and storage units.

## Results

We quantify the effects of implementing Smart Markets as a tool for market-based congestion management within an aggregated network for Germany and the neighboring countries. The results show, that integrating Smart Markets affects both short- and mid-term overall results.

On a short-term perspective, additional decentralized flexibilities can be integrated and used for ex-ante congestion management. In some cases, total cost reductions can be achieved, depending on how the market design for Smart Markets is formulated. Since Germany faces structural congestion in some parts of the grid, price signals on Smart Markets are stable in certain areas and incentivize regionally differentiated investments in flexible capacities. In addition to that, curtailment of electricity from renewable sources can be reduced, which implies a better integration of renewable energy sources.

On a mid-term perspective, regional adjustments of power feed-in potentially affect investment decisions in transmission capacity. Since grid congestion is counteracted before redispatch, grid expansion needs change. It depends on the the availability of flexibility options, whether expansion cost reductions can be achieved.

## Conclusions

Model results show, that the implementation of Smart Markets as a way of market-based procurement of congestion management can be useful. First, they act as a comprehensive concept to comply with EU regulation and can be implemented parallelly to the existing market orders and grid operation. Second, the Smart Markets are able to provide regionally differentiated price signals, which are not existent in the European zonal market design. Thus, investment incentives are provided as well as more efficient distribution of flexible capacities in the long-run. Overall cost reductions can be achieved even in comparison to cost-based redispatch measures. However, this depends both on the availability of cheap flexibility options as well as the grid situation at a certain point of time. The Smart Market design, that we provide in this conference paper, is one possible solution for implementation. Since the topic of regional flexibility markets has recently grown in interest, more research about different implementation options can be conducted in the future.

## References


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