***Capacity Markets in Europe – Assessing the Benefits of Coordinated Mechanisms versus National Approaches***

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## Overview

In several European countries there is an ongoing debate on the introduction or further development of capacity mechanisms. Especially in France, United Kingdom and Poland the considerations are at an advanced stage. While the last named countries are planning to introduce capacity markets other countries rely on mechanisms like strategic reserve or administrative capacity payments. Others in turn (e.g. the Netherlands) postponed the introduction of a capacity market and decided to wait for new developments in neigbouring countries. As the EU Commission strives for an internationalization of the electricity sector and an integration of national power systems the implementation of independent national capacity markets is not expedient. We therefore model the impacts of capacity markets in Europe with different levels of coordination between the considered countries. In first analyses, we compare a Europe-wide capacity market with independent national capacity markets.

## Methods

For a quantification of the economic effects of coordinated capacity mechanisms on the European power market, a fundamental model is used. Beforehand we **calculate the capacity requirements** with a stoachstic approach. In order to do so, we assume that the probability of a capacity shortage or a residual capacity $ψ$ less than or equal to zero may not exceed a pre-defined security level $α$ (e.g. 1 hour in 10 years). The residual capacity is determined by a convolution of the distributions of demand and of the available capacity of all units. On the basis of simplified assumptions and especially under the hypothesis of a normal distribution for the available capacity (suitable approximation from 30 units up), this requirement can be approximately described by a linear constraint as in equation (1). The required minimum capacity $P\_{0 }$ is thereby determined iteratively, so that $\tilde{F\_{ψ}}\left(0;P\_{o}\right)=α$ applies. $P\_{0 }$ specifies the minimum capacity to ensure the pre-defined security level and describes the capacity demand for a capacity market.

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|  | $$P\geq P\_{0}⇒\sum\_{Geo}^{}\sum\_{Unit}^{}P\_{Unit} \geq P\_{0}$$ | (1) |
| $$where$$ | $$P\_{Unit}\in  \left\{Nuclear, Lignite, Coal, Gas, Oil, Biomass, Water\right\}$$ |  |
|  | $$Geo:geographical Entity (Europe, CWE, Country)$$ |  |

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The capacity restriction includes installed capacities $P$ of conventional thermal units and predictable renewables like hydro and biomass. According to equation (1), the sum of the installed capacities must at least correspond to the given capacity requirement.

The capacity constraint is then implemented into the **stochastic European Electricity Market Model** **(E2M2s)**. Assuming functioning competitive markets, market results are determined through optimization in the E2M2s model. That leads to an assignment of cost efficient power plants to cover demand. The model is formulated as a linear, stochastic problem with different regions and different time steps. Detailed technical limitations like start up costs, part load efficiencies or transmission capacities are considered in further side constraints of the power system.[[1]](#footnote-1) In scenarios with a capacity constraint, power plant investments may be refinanced not only by revenues on the energy only market and markets for balancing services, but also by revenues on the capacity market.

## Results

## We compare the introduction of independent national capacity markets with a Europe-wide capacity market. A Europe-wide mechanism may be difficult to realize given national energy policies and ambitions to achieve national self-sufficiency. However, this case provides a benchmark against which the other scenarios should be compared. Table 1 shows the computed capacity requirements. The results indicate that independent national capacity markets lead to higher capacity requirements, as firm capacity to meet peak demand has to be provided by every country independently ignoring synergies between integrated national power markets. The joint provision in case of a Europe-wide capacity market reduces the capacity requirements by roughly 10 % (660.98 relative to 726.90 GW).

Table 1: Capacity requirements national versus Europe-wide capacity market



The lower capacity requirement is in turn reflected by the results of the E2M2s model. At the European level the Europe-wide capacity market leads to annual savings of about 4 billion Euro or 1.5 % of the total system costs. Furthermore we find a partial relocation of power plant investments in consideration of available transmission capacities between the modelled countries. For instance in France cold winter months and a high share of electric heatings cause high peaks in demand. While independent national capacity markets result in a higher need for peak units especially in France, the capacity is provided by units in neighbouring countries (Germany, Switzerland and the Netherlands) in case of a Europe-wide capacity market. Moreover we observe indirect effects on the generation mix. As the Europe-wide capacity market results in a lower addition of gas turbines, CO2 abatement costs increase. Along with this the utilization of existing conventional units increase and more renewable capacity is installed. In addition lower revenues on the capacity market can be partially compensated by higher revenues on the energy only market. However, in spite of higher electricity market prices, total system costs are lower with a Europe-wide capacity market.

## Conclusions

In this analysis, we developed a stochastic approach to determine capacity requirements and modelled the impacts of a Europe-wide capacity market and independent national capacity markets on the European power system. In case of a Europe-wide mechanism we find annual cost savings amounting to several billion Euros. We also observe a relocation of power plant investments due to the joint provision of capacity and locational advantages in more centrally located countries. Further analyses will focus on other coordinated solutions like a regionally coordinated capacity market in the CWE-area[[2]](#footnote-2).

## References

Swider/Weber (2007): The Costs of Wind's Intermittency in Germany: Application of a Stochastic Electricity Market Model. In: European Transactions on Electrical Power (2007) Nr. 17, S. 151-172.

Spiecker/Weber (2011): Integration of fluctuating renewable energy — A German case study, Power and Energy Society General Meeting, 2011 IEEE; 08/2011.

Spiecker/Vogel/Weber (2013): Ökonomische Bewertung von Netzengpässen und Netzinvestitionen, uwf UmweltWirtschaftsForum 05/2012; 17(4):321-331.

1. For a detailed description of the E2M2s model see Swider/Weber (2007), Spiecker/Weber (2011) or Spiecker/Vogel/Weber (2013). [↑](#footnote-ref-1)
2. CWE: Central Western Europe (France, Germany, Belgium, the Netherlands, Luxemburg) [↑](#footnote-ref-2)