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# INTEGRATION OF RENEWABLE ENERGIES IN THE GERMAN ELECTRICITY MARKET IN 2030/2050

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## OVERVIEW

One major contemporary strategic challenge for electricity supply systems is the integration of substantial amounts of renewable energy sources. Within the German sustainable energy strategy, a target of 80% renewable electricity production has been set for the year 2050.
However, the impact of such an extensive use of (especially fluctuating) renewable resources on the electricity system has not been analyzed in detail up to now. Different scenarios describing possible future developments of renewable capacities in Germany are the starting point for this analysis (e.g. Leitszenario of the BMU [1]). The capacity development of renewable energies within these scenarios is multiplied by the expected feed-in profiles for different renewable resources. Subsequently, the residual load is derived for the year 2030 and 2050 based on different correlations between the load and the renewable feed-in. The residual load is defined in this paper as the difference between the electricity load and the feed-in from fluctuating renewable resources. This residual load is the starting point for a peak-load pricing model, which determines an optimal power plant mix under various renewable feed-in scenarios. A comparison of the different scenarios shows the impact of a renewable energy feed-in on the conventional electricity system.

## METHOD

In this contribution an econometric time series model is applied to simulate hourly-resolved renewable energy feed-in curves for the different renewable technologies for the years 2030 and 2050 (see Möst et al. [2]). The hourly simulated renewable energy feed-in curves (based on a Monte-Carlo simulation) serve as input for a peak-load pricing model (see Boiteux [3]), which determines an optimal power plant mix taking existing power plants (and their expected lifetime) into account. The peak-load pricing model is implemented in GAMS (see Brooke et al. [4]) as a linear (mixed-integer) optimisation model. Based on the residual load, the peak-load pricing model determines the necessary conventional capacities (including storage capacities) and allows an economic evaluation of the renewable feed-in and its impact on the conventional system.

## RESULTS AND CONCLUSION

Results show the influence of renewable energies on the economics of conventional power plants within a peak-load pricing model. Here, both the existing power plants (with a detailed capacity-decommissioning graph) and investments in new power plants are taken into account. This enables the question of the extent to which other (future) technologies are required (e.g. turbines) for a secure electricity supply, which necessitate lower full load hours per year to be still economical, to be answered. Moreover, the model provides an analysis of the influence of the renewable feed-in on the electricity price (so-called merit-order effect, see for example Sensfuß et al. 2008 [5]). Thus, the model enables the difference between market prices and feed-in tariffs for the different renewable technologies to be determined.
First results for the residual load for the year 2030 are shown in fig. 1. The black line shows the expected demand duration curve. In a second step different correlations between the

demand and the renewable feed-in are assumed (the renewable feed-in will be simulated on the basis of a time-series model instead of taking just these simple correlations between load and feed-in, however these first results should give an impression of the analysis in this paper). In the best case, the highest renewable energy feed-in occurs at the highest load. This results in quite a flat resulting demand duration curve (red-line), which means that nearly no peak-load technologies are required. The opposite case is depicted in the figure by the green line, assuming that the highest renewable feed-in appears at the lowest load. In this case, a high amount of peak-load and storage capacities would be required. The realistic case (based on a realistic correlation between the feed-in and the load) is depicted in fig. 1 by the blue line, which also shows that additional peak-load and storage capacities would be required.

Comment [G1]: In bezug auf best case

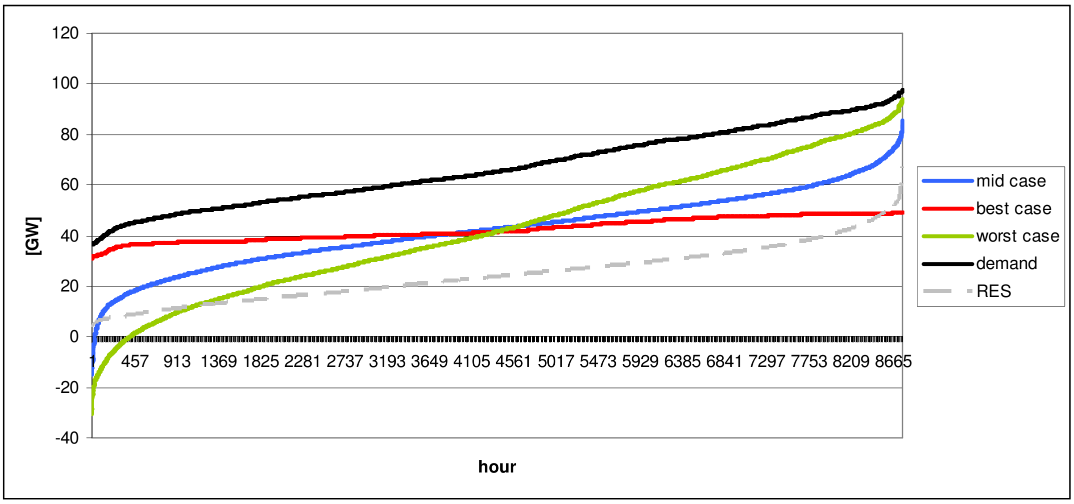


Fig. 1. Resulting demand duration curve in 2030 in Germany

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