Residual load and flexibility in electricity systems with intensively integrated fluctuating feed-ins

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Abstract

Motivation for the paper: The recent turnaround in Germany's energy policy aims an electricity supply based on a high share of wind and photovoltaic installations. Their fluctuating feed-ins challenge the balancing of the target triangle of energy policy: sustainability, cost-efficiency and security of supply. While the high share of wind and photovoltaic promotes sustainability, it also rises the demand for flexibility in the residual electricity system affecting both, cost-efficiency and security of supply.

Objectives: Residual load and its gradients represent an quantitative indicator for this flexibility-demand. Thus, residual load's values (2012), their further development (2023, 2033) and characteristics of formation are subject of this study. Also, the conventional power plants' capability to supply electricity flexibly is a major objective.

What was done and how it was done: In order to obtain reliable values of Germany's residual load curve on hourly basis, firstly, a comprehensive system for load curve calculation starting from ENTSO-E load values is proposed. Secondly, a new method for calculating load data of offshore wind parks integrating smoothing effects of wide-spread wind parks is developed to complement easily accessible onshore wind and photovoltaic data. Regarding the residual power plants, a descriptive analysis of their current flexible usage is accompanied by a fundamental and basic simulation of their future flexible operation.

Major results and conclusions: In 2012, extreme gradients (above 5 GW/h) of the residual load occurred mostly in the morning, maximum values of 10.54 GW/h and -6.22 GW/h existed. According to the simulations for 2023, these large gradients take place more often in the afternoon when photovoltaic generation decreases. Thus, an ambivalent effect of photovoltaic on flexibility-demand is found: while decreasing it in the morning new extreme gradients in the afternoon arise. Maximum gradients then rise to 12.18 GW/h and -11.56 GW/h. Regarding the power plant operation, a structural change can be seen: While during 2012 primarily coal and gas power plants compensated for big gradients of the residual load, lignite-fired power plants get involved in the compensation of these gradients in all simulations, changing its current baseload-operation significantly — if Germany's energy system keeps following its current rules their repowering will be necessary.