RELIEVING THE GERMAN TRANSMISSION GRID WITH REGULATED WIND POWER DEVELOPMENT

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Overview

The expansion of capacities in the German transmission grid is a prerequisite for the further integration of renewable energy sources (RES) into the electricity sector. Within the research project *MONA 2030*[1], the simulation model *ISAaR*[2] is applied in order to assess various grid optimisation measures. These measures are compared and contrasted with conventional grid expansion scenarios and assessed as alternatives to grid upgrades. This paper evaluates an approach to relieve the German transmission network by regulating wind power development, which will decrease the necessity for increasing transmission capacities or the demand for other grid optimisation measures. In the scenarios, wind turbines are installed in central and southern Germany instead of onshore and offshore sites the wind-swept north (see **Figure 1**). Hereby, the generated amount of energy is held constant. Due to the poorer quality of locations in central/southern Germany, the installed capacities and consequently the required investment increases. However, advantages with respect to congestion management can be achieved.

Methodology

The FfE energy system model *ISAaR* is a linear optimisation model, which minimises the deployment of power plants to meet the demand for electricity in Europe and for district heating in Germany and Austria. The transmission grid is modelled based on the DC power flow approach (see [1]). Grid data is taken from TSOs ([2]-[6]) and the open-source platform Open Street Map. The 2030 grid model is based on several grid development plans (see [7]-[8]). The reference scenario for the energy system development by 2030 is based on the work in [9]. In a simulation run of the reference scenario, line loadings and curtailment of RES in the energy system are gathered in hourly resolution for the time period of one year. Based on these results, several scenarios for grid expansion (*GE*) and regulated wind power development (*WPD*) are developed and calculated. The share of RES in electricity consumption remains constant at 61 % across all sceanrios. The reduction of curtailment and of redispatch are selected as evaluation quantities and are used as indicators for the grid relieving impact of the proposed measures.

Results

In a first step, upgraded line lengths of two grid expansion scenarios (*GE 1*, *GE 2*) are analysed as well as the shift of installed capacities of two regulated wind power development scenarios (*On WPD, Off&On WPD*). *GE 1* comprises the reinforcement of 5 AC lines in the German transmission grid with an overall length of 170 km. In *GE 2* the extension of further AC lines sum up to an upgraded length of 507 km. Specific investment cost for grid expansion per length are based on the NEP 15 [7]. In both WPD scenarios, the amount of shifted wind energy is set to 4 TWh, which equals 70 % of curtailment in the reference case. Scenario *On WPD* deals solely with onshore wind planning. Here, northern onshore strong-wind turbines with 1820 MW capacity are removed, and 3173 MW of the same turbine-type are added in central/southern Germany. *Off&On WPD* is a scenario with 747 MW less offshore and 511 MW less onshore wind capacities in the north and - due to lower wind speed locations – 1,760 MW larger onshore capacities of largely weakwind turbines in central/southern Germany. In both scenarios, wind capacities on nodes with the highest specific curtailment rates in the reference case are selected for redistribution. Compared to the reference case, both scenarios lead to higher expenses for wind power. Expected cost for on- and offshore wind turbines are extracted from an analysis of the German tender results of 2017[3]. The reduction of curtailment and redispatch is evaluated by comparing grid simulation runs of the above scenarios with the reference scenario. **Figure 2** illustrates the simulation results and corresponding cost. The highest reduction rates are achieved in the *GE 2* scenario. The *Off&On WPD* scenario performs slightly better than *GE 1* and *On WPD*. The assumption of various price levels for offshore wind leads to a range of required investment between € 49 million and € 78 million in *Off&On WPD*. However, compared to *GE 1*, this scenario is considerably more expensive at almost equal grid

[1] MONA 2030: “Merit Order Grid Expansion 2030” (funding code 03ET4015) is co-funded by German Federal Ministry of Economic Affairs and Energy through the funding initiative “Zukunftsfähige Stromnetze”.
[2] Integrated Simulation Model for Planning the Operation and Expansion of Power Plants with Regionalisation
[3] Please regard the long paper version for a detailled description of made assumptions and used values.

relieving impact. The comparable high cost for the *On WPD* scenario can be explained by the unfavourable choice of installed turbine type.

Conclusions

Smart regulation of further wind power development bears the potential of reducing system services and therefore relieving bottlenecks in the German transmission grid. But when considering the large capacities of additionally installed wind power at low-wind speed locations and thus 24 % - 53 % higher annual cost, grid expansion seems to be a preferable choice under current conditions. But taking into account that grid expansion is unpopular with the public [10], regulated wind power development can be considered as a reasonable alternative to a certain degree. This insight should trigger a debate about the acceptance for building either transmission lines or constructing additional wind power plants.

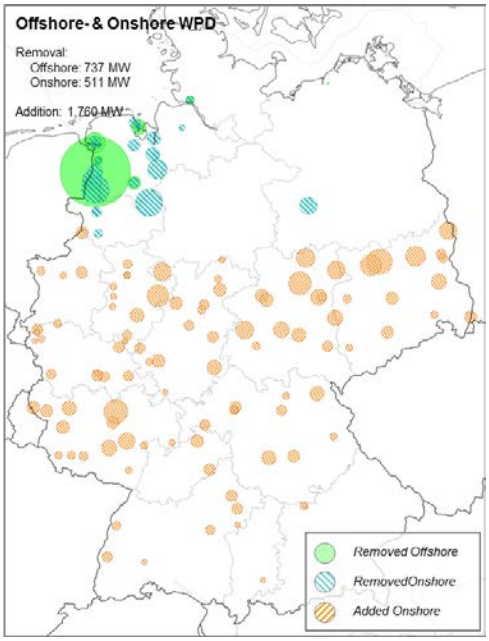

Figure 1. Difference of installed wind power capacities between the reference and the proposed regulated wind power development scenario *On&Off WPD*.

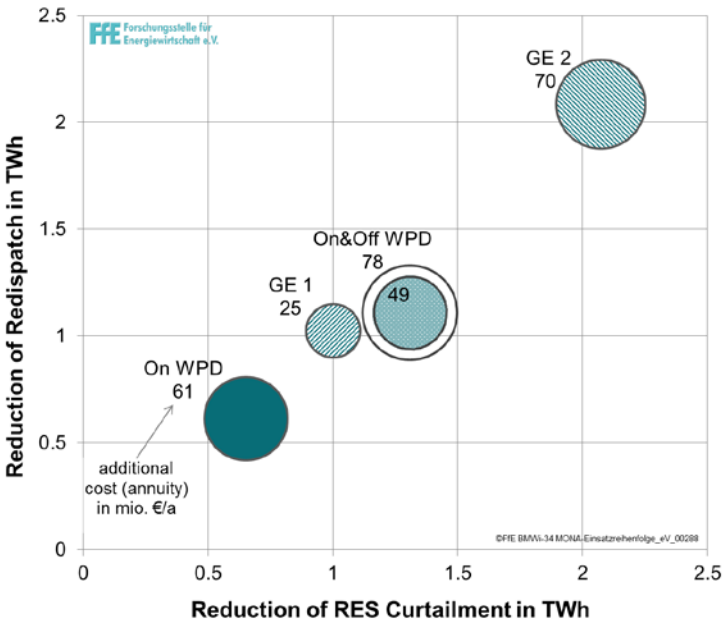

Figure 2. Reduction of redispatch and of RES curtailment with additional investment for the scenarios grid expansion (*GE 1/GE 2*) and regulated wind power development (*On&Off WPD/On WPD*) compared to the reference case.

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