Marian Klobasa, Mario Ragwitz and Carlo Obersteiner

STRATEGIES FOR AN EFFICIENT INTEGRATION OF WIND POWER CONSIDERING DEMAND RESPONSE

M. Klobasa, Breslauer Strasse 48, D-76139 Karlsruhe, E-mail: M.Klobasa@isi.fraunhofer.de
M. Ragwitz, Breslauer Strasse 48, D-76139 Karlsruhe, E-mail: M.Ragwitz@isi.fraunhofer.de
C. Obersteiner, Gusshausstrasse 25-29/373-2, A-1040 Vienna, E-mail Obersteiner@eeg.tuwien.ac.at

Overview

Currently published studies about wind energy integration into electricity systems emphasized that increased efforts are necessary to balance and control the power system, when wind penetration is increasing (Dena 2005, Consentec 2003, Auer 2005). Strategies to deal with high penetration of wind power generation studied so far are mainly driven by the supply side or by the introduction of storage options.

In the presented paper the impacts of wind power integration are analysed for two fundamental different power systems – the Austrian hydro-thermal system and the dominant thermal system of Germany. The main focus lies on the simulation of interactions between wind power production, operation of the conventional power plants, the demand side as well as the power grid. Based on the simulation results (i.e. additional power reserve and balancing energy requirements and corresponding cost and CO_2-emissions for various scenarios) strategies for a cost efficient integration of wind power are derived. Potentials and technical aspects of demand response are considered as an additional option. Finally the current market design in Austria and Germany is critically reviewed with respect to the needs for an optimal integration of wind power.

Methods

The impacts of wind power integration for the two analysed power systems are simulated using an energy system model with an hourly time resolution. Time series of wind power generation are calculated based on historical data of over 180 wind speed measurement sites in Germany and Austria (Sensfuss 2003). As another main input a database containing time series of total demand and potentials of flexible demand in different consumption sectors is used. The additional balancing power requirement is derived considering both, forecast errors of wind power generation and demand. For the allocation of corresponding cost a cost-based approach is used that considers opportunity cost of providing power reserves and efficiency losses for part-loading thermal power units. The net CO_2-emission reduction due to wind power is finally determined by comparing the operation of the conventional power plants with and without wind power and by considering the corresponding CO_2-emissions for keeping additional power reserves.

Results

The simulation results show that the additional reserve requirements and corresponding cost because of wind power are considerably depending on the quality of the wind power forecast (Fig. 1). Though even if the current forecast error of wind power in Germany is significantly lower than in Austria, the corresponding specific cost are higher for the dominant thermal system for comparable wind power penetrations.

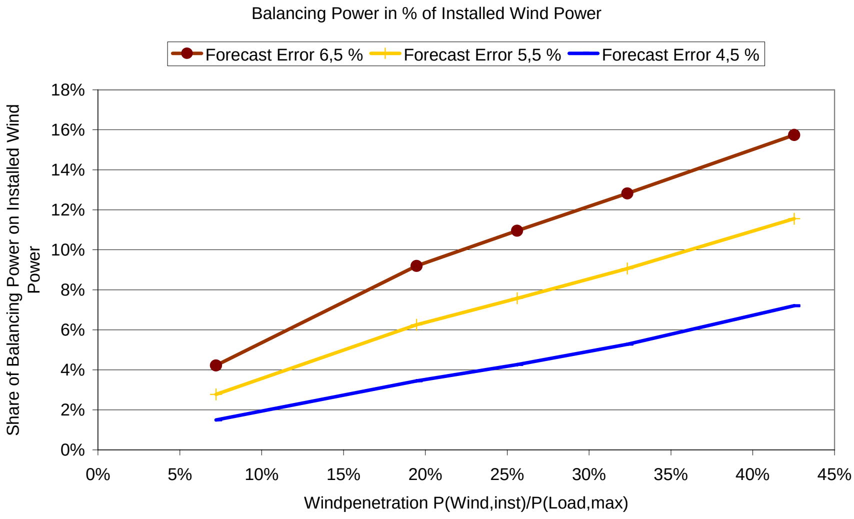

Fig. 1: Share of balancing power with increasing wind penetration in Germany with day ahead forecast

The additional costs for balancing the system increase from 2.4 € to 2.9 € per MWh wind energy in Germany, but only from 0.9 € to 1.3 € per MWh wind energy in Austria. CO_2-emissions due to higher power reserve requirements are marginally, compared to the specific CO_2-emission reduction of wind power due to the replacement of conventional generation. This specific CO_2-emission reduction decreases from 800 g CO_2 per kWh wind energy to 630 g in Germany and from 690 g CO_2 per kWh wind energy to 420 g CO_2 in Austria. The technical potential for demand response in the analysed sectors is high enough to meet the future balancing requirements even for high wind penetration.

Conclusions

In the short to medium-term, system related cost of wind power integration can be lowered by the use of better wind forecast tools. The current market designs in Central Europe however do not allow a cost effective integration of intermittent power generation. The key for a better integration might be a liquid intraday market, as already implemented in the Nord Pool, to allow the correction of positions until few hours before delivery. The analysis of demand side options for balancing power shows that flexible demand could play a significant role in balancing future electricity systems. The major motivation however is not to maximize the CO_2-emission reduction but to balance the system more cost effectively and to support system security.