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Wind Energy in Integrated Assessment Models

A significant share of electricity demand world-wide can be potentially supplied by wind energy in the future. In Denmark, the government has already formulated a goal to increase the share of wind-generated electricity to 50% by 2020. On a larger geographical scale, European Wind Energy Association envisions that wind energy could meet half of EU expected electricity demand in 2050. If this becomes reality wind energy will cut a large portion of GHG emissions of the energy system and will have an important role in limiting the extent of climate change.

Integrated Assessment (IA) models are commonly used to investigate effects of climate policies. They are particularly suitable for it since they consider energy technologies and energy systems development on regional (global) level in the framework of energy-economy interaction and account for natural resource use, as well as international trade with emission allowances, materials and fuels. The IA models show that renewable energy sources have a crucial role in limiting GHG emissions; however the respective contribution of wind energy is normally lower than can be envisioned.

One of the reasons for that is that detailed site-specific knowledge about wind resources is needed in order to reflect available wind power potential and the cost of its utilisation. Local terrain characteristics, i.e. changes in elevation and surface roughness, and presence of obstacles, have a significant impact on small scale variability of winds. Taking these local characteristics into account gives a more realistic and often higher wind power potential.

Another reason is the absence of clarity regarding the amount of wind energy that can be integrated into an energy system and the related costs. Since wind power output can change dramatically and often irregularly from hour to hour (and also within an hour), with an increasing share of wind energy there will be an increasing need for generation units that can ramp-up (down) rapidly their output. A lack of such units could undermine grid stability. Therefore penetration of wind energy in IA studies is normally constrained to a safe amount.

Finally, taking into account spatial distribution of installed wind power capacity would increase competitiveness of wind energy. Studies have shown that increasing the geographical distribution of wind power generation capacity decreases aggregate variability of its output. It is normally explained by the fact that the further wind resources are located from each other the less correlated their output. In turn, this reduces the balancing needs of the system, due to smoothening of the variability, and therefore lowers the costs.

Representing wind resource availability, its spatial distribution, and effects on the energy system are some of the challenges which need to be addressed in IA modelling. This will allow performing more sound analysis of climate change mitigation policies and reflecting ambitious wind energy development paths.