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Large scale integration of wind power – influence of geographical allocation

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Abstract.

This paper investigates the influence of geographical allocation of wind power generation in Northern Europe, assuming large scale integration of wind power. The work applies a linear cost optimization model of the heat and power sector with a 1-hour time resolution. The model minimizes the sum of running costs to meet the heat and power demand and the wind power and transmission investment costs. Wind data are taken from modelled wind speed data from the Swedish Meteorological and Hydrological Institute. The Nordic countries and Germany were divided into regions and the 200 sites with the highest yearly output were chosen to represent the region. The model gives the most favourable distribution of wind power between the regions. In addition, the paper provides an assessment of the effect of geographical distribution of wind power with respect to influence on the aggregated wind power production (only considering the wind power generation itself).

The modelling results show that the largest investments in wind power are made in the windy region of Southern Norway. However, depending on the cost of transmission allocating wind power near large load centers in Germany may also be favourable. As for the assessment of distribution of wind power, the wind data gives that if the 400 best sites in Europe were used, this would result in a capacity factor of 38.5% and a lowest output of 2.5 % of rated power (applying 2009 wind data).

Key words

Wind power, Large-scale integration, Geographic allocation

1. Introduction

Wind power is considered a key technology to decrease carbon dioxide emissions from the electricity generation sector. Thus, large investments in wind power are expected in the European electricity generation systems in order to comply with the EU renewables (RES) directive (by year 2020 there should be a 20% share of energy from renewable sources for the EU). Also globally, wind power is expected to make a substantial contribution to greenhouse gas reductions [1]. Yet, wind power is an intermittent (variable) source of energy and such large scale integration of wind power is not straight forward with respect how to find an efficient integration in the existing electricity generation system (generation, distribution and consumption). However, several studies point out that as the share of wind power increases, the capacity credit decreases (see [2] and references therein). The capacity credit is the contribution of wind power to system security. A lower capacity credit means that each kWh of electricity produced from wind will be more expensive. Thus, if the capacity credit can be made higher for a certain share of wind power, it entails a system cost reduction.

Important aspects to consider when integrating a large amount of wind power in the electricity system are:

- Geographical allocation of wind power sites.
- The amount of storage capacity.
- Investments in transmission capacity.
- Possibilities for demand-side management.
- Flexibility in the dispatch of the other power plants in the system, including other renewable generation.

To keep system costs at a minimum, while at the same time introducing a share portion of intermittent wind power, a combined effort of these factors need to be considered. [3].

The balance between investments in wind power capacity and transmission capacity has been investigated by Giebel et al. [4] who conclude that there are economic incentives to allocate the wind investments at sites with good wind conditions, even in cases where this results in investments in long transmission lines. This is confirmed by Göransson and Johnsson [5] who found that a cost minimizing allocation of wind power capacity would imply a concentration of new wind farms to windy regions. Yet, Göransson and Johnsson also conclude that