THE IMPACT OF INCREASING RENEWABLE GENERATION ON THE OPERATIONAL COST IN THE BRITISH ELECTRICITY TRANSMISSION SYSTEM

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Overview

The distance between the biggest centres of electricity demand in Great Britain and places that have the best generating conditions for renewable electricity is often too long to be useful. Wind conditions in remote areas in Scotland are often perfect to suffice for demand of cities like London, however, the distance between the two locations makes any connections between them unpractical due to constraints of the existing transmission network and transmission losses in addition to costs that increase with distance. For this reason, before embarking on any large scale projects of such sort, it is necessary to calculate the transmission costs and cost which would result from congestion in a transmission network, which is not scaled to the maximum feed-in of renewable energy sources (RES).

Scenarios promoting an optimistic future outlook such as the Gone Green scenario in National Grid's (NG) Future Energy Scenarios (FES) predict a significant increase in renewable, volatile generation from wind and solar resources. Although Great Britain contains locations with prime resources that are ideal for the fast develoment of renewable energy generation, such locations are usually located far away from major consumption centres, making it difficult to fully benefit from their energy potential that could prove crucial in a time where energy demand is on the rise again. Further, existent renewable energy auctions for renewable capacity don't consider network restrictions such as transformer or transmission line overloading as well as transport of electricity as a limiting constraint.

In this paper we investigate the effect of increasing renewable generation on the operational costs in the transmission network which occur in the form of transmission losses and curtailment of volatile generation.

Methods

In order to analyse and quantify the operational cost of the transmission network, the developed model incorporates the current transmission network of Great Britain with voltage levels of 400 kV and 275 kV as well as the projected network expansion measures presented in NG's Electricity Ten Year Statement (ETYS). These measures cover various projects until the year 2025, which aim to change the topology of the transmission network to a significant extent.

The year 2025 is analysed in an hourly time resolution to account for the spatially and temporally varying generation and demand patterns in a system with a high share of RES. The generation profiles of RES required in this context are generated according to the projected scenarios by applying a decentralised renewable expansion planning model. Along with regionally distributed electricity demand from households and industry, they are assigned to the transmission network substations using a graph-based representation of the distribution network. The development of capacities of thermal power plants as well as dispatch decisions based on the previously calculated volatile generation is calculated using an agent-based modelling approach of the electricity market.

Results

The results show that an unconstrained increase of generation from RES leads to a concentration of these units in areas, which are situated a considerable distance away from today's most requiring demand centres. As the transmission network in these areas has usually very limited capacities, both transmission losses and the required curtailment to ensure safe network operation increase. Due to the cost-minimising approach used in the model formulation, the model results show a optimal dispatch in order to minimise the occuring operational cost in the British transmission network system.

Conclusions

The paper aims to bring into focus the issues arising when potentially overestimating the potential of inflexible generation scenarios. Although an island like Great Britain may possess rich natural resources, the localisation of the consumption centres due to industrial and population clustering, could pose substantial issues and resulting costs related to the required transmission of electricity. The results obtained from our analysis go along with what are considered the ideal locations for the positioning of renewable energy generation. Given these areas' often northern most positioning in Great Britain, delivering the electricity they generate to areas with high demand causes an increase in cost of network operation, we conclude could be minimised opting for a more stragetic approach towards renewable energy planning.

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