EFFECTS OF UTILISATION IN REAL-TIME ON ELECTRICITY CAPACITY ASSESSMENTS (EURECA) Thermal Plant Capacity in a Low Carbon Electricity System

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Background

The decarbonisation of electricity systems will involve integrating increasing amounts of intermittent renewables and, in some jurisdictions, inflexible nuclear capacity. This is likely to reduce the annual load factors of thermal plants (gas and coal) as they are displaced by renewables and other generation technologies with lower short-run marginal costs. The reduced number of operating hours is likely to affect the investment and profitability of future thermal plants.

The flexible operation of thermal plants will be required to provide 'infill' generation after wind and nuclear to meet demand. A proportion of this thermal capacity may have to be fitted with carbon capture and storage (CCS) to reduce electricity sector CO_2 emissions. Large-scale electricity storage may be used to store surplus generation caused when wind and inflexible baseload output exceed demand.

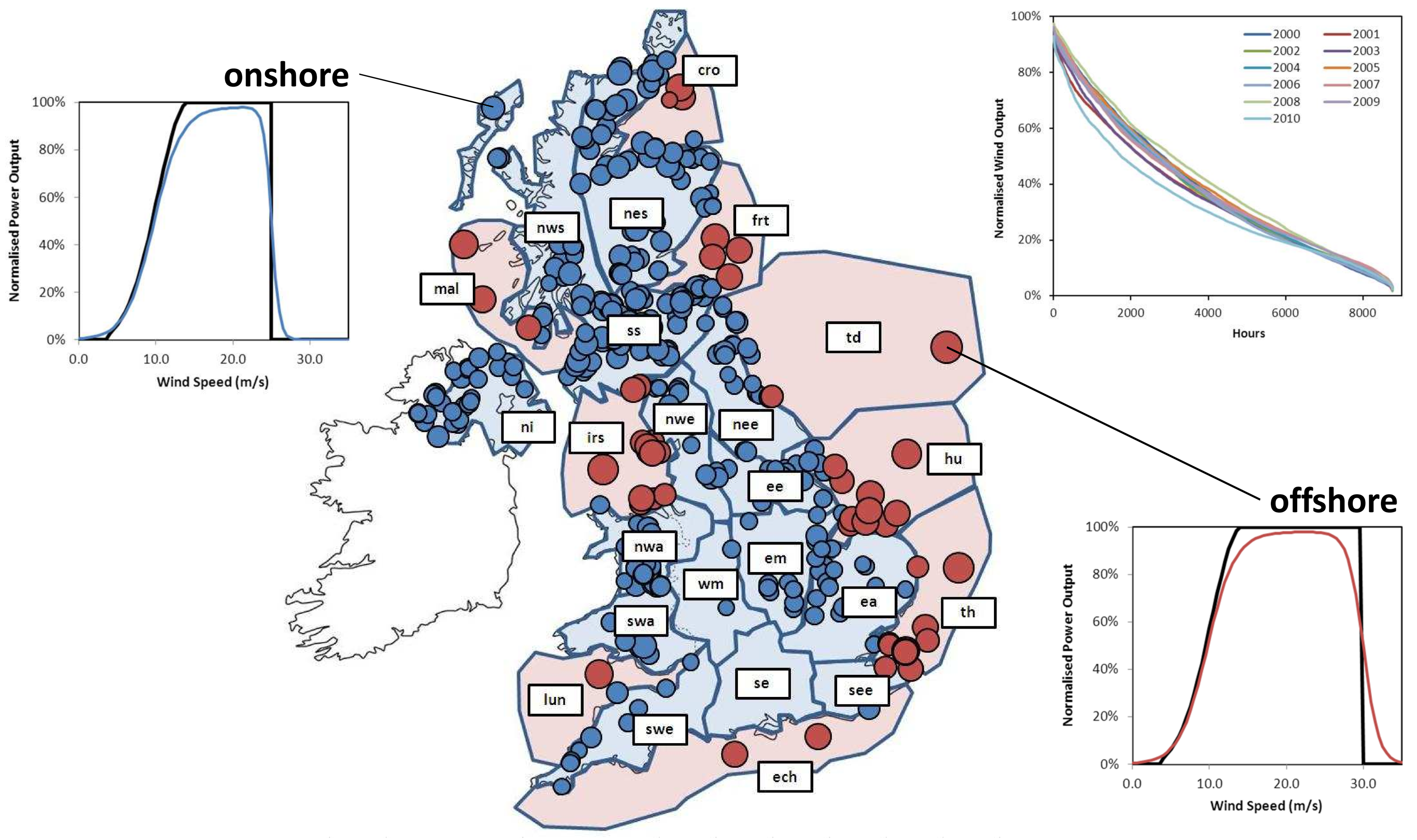

Figure 1: Aggregate power output curves were used to convert wind speeds for 337 onshore and 49 offshore wind sites and (top right) the non-chronological normalised wind output for 11 historic years illustrates inter-annual wind output variability [1][2].

Objectives

This interdisciplinary research project aims to investigate the quantity of installed thermal capacity that will be required to act as 'infill' generation for low carbon generation technologies such as intermittent wind and inflexible nuclear generation. The objectives of the project are as follows;

- A large UK wind speed data set (developed at the University of Edinburgh) will be validated and used to simulate likely future wind output for several installed wind capacity scenarios [1].
- Wind and nuclear capacity scenarios will be developed to assess how much installed conventional thermal capacity will be required to meet an assumed GB demand profile.
- Different generation portfolios will be modelled to simulate the likely future operating patterns, overall system costs, fuel costs and CO_2 emissions of the assumed thermal fleet. Extensive sensitivity analysis will be performed to simulate an array of market conditions.
- The ramping capabilities of the future thermal plant portfolio will be assessed and used to inform future operational requirements.
- The impacts of installing increasing amounts of large-scale electricity storage on thermal plant operating patterns will be investigated.

Methodology

- Wind speeds for 337 onshore and 49 offshore sites between 2000 – 2010 were obtained from a fully compressible, non-hydrostatic mesoscale wind resource model [1].
- All existing, in construction, consented, in planning and in scoping wind projects from the Wind Energy Database were aggregated into regions according to distribution network operator boundaries [3].
- Wind speeds were converted into power outputs using aggregate power curves as shown in Figure 1.
- Subtracting wind output from historic demand gives the 'demand net wind', the remaining generation that is required from thermal plants. The load factors and operational patterns of the thermal plant portfolio can be simulated as shown in Figure 3.
- The CO_2 emissions and fuel usage can be derived and used to estimate overall system costs and emissions. It is then possible to estimate the proportion of the thermal plant capacity that will require CCS installed so that electricity sector CO_2 emissions meet agreed targets.

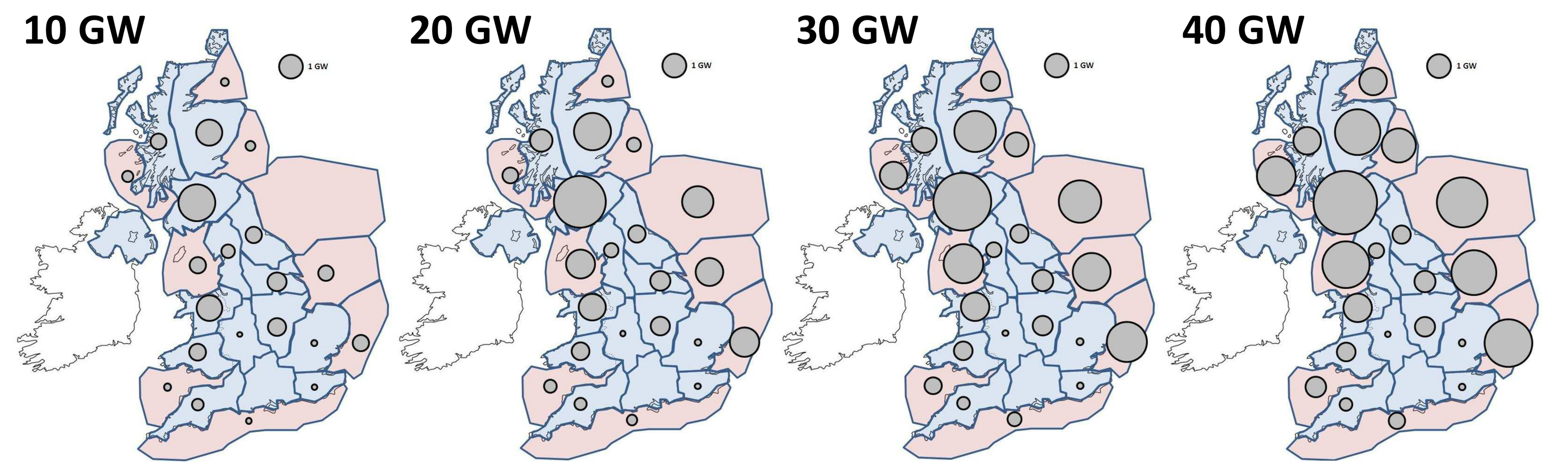

Figure 2: Four example scenarios show the build up of onshore and offshore wind capacity by region in GB based on regional wind capacity projections [3].

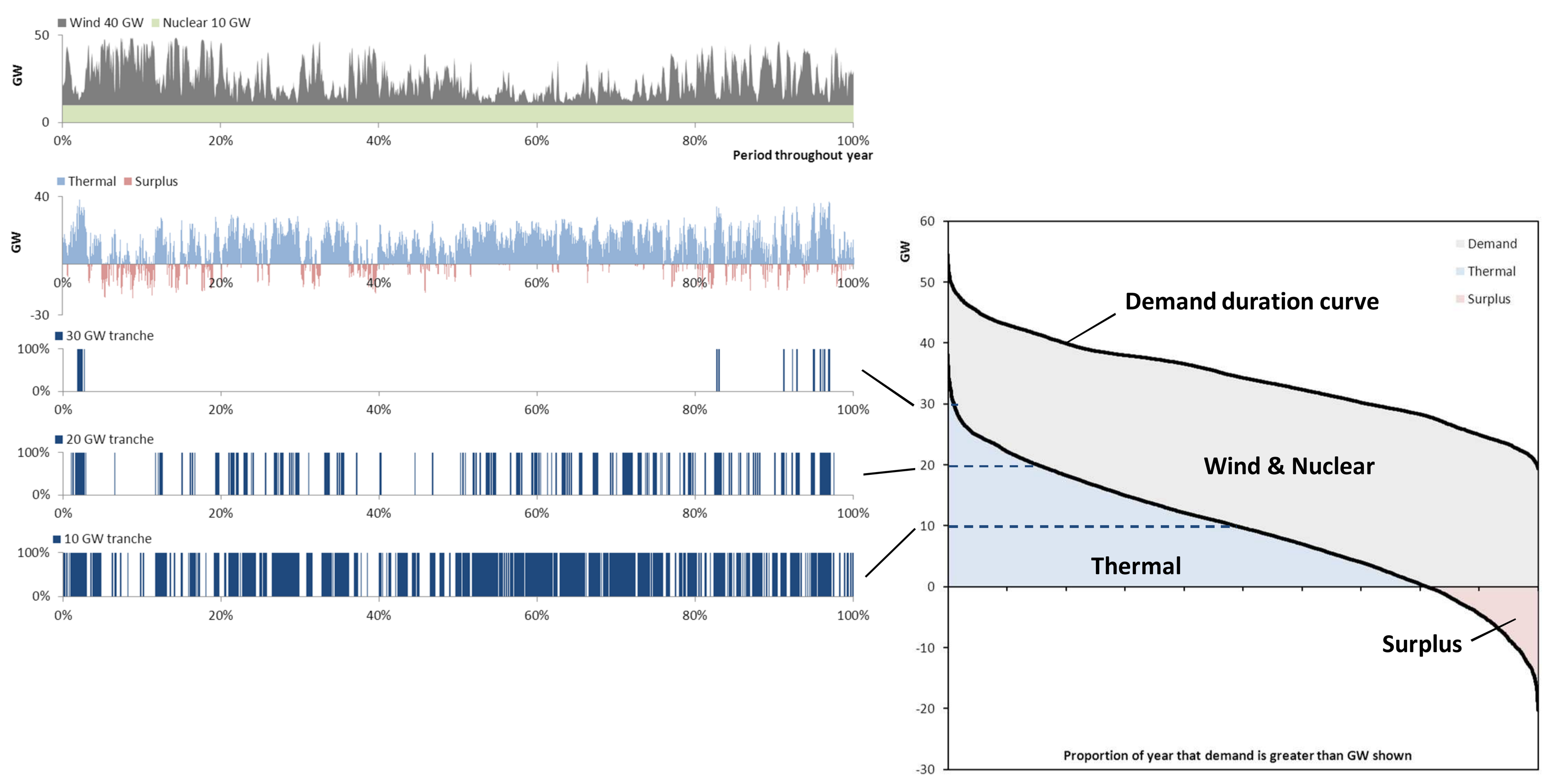

Figure 3: Illustrative operating patterns for thermal plants operating at 10 GW, 20 GW and 30 GW tranches in merit order, (left) and duration curves for 40 GW wind and 10 GW nuclear capacity for the year 2000 (right).

Initial Results and Conclusions

From the illustrative scenario presented in Figure 3 (10 GW nuclear, 40 GW wind), it is possible to derive the likely operating patterns and capacity of future thermal plants. A thermal plant 30 GW along the thermal merit order will only be required to operate during anti-cyclonic weather conditions in winter months. All thermal plants will have to go through more extreme loading cycles. This analysis does not include any operating reserve requirement. Further work will assess the role of storage, demand side management, operating reserve requirement and residual emissions during start-up and shut-down.

References
[1] Hawkins, S., 2011, *A High Resolution Reanalysis of Wind Speeds over the British Isles for Wind Energy Integration*, Ph. D. Thesis, University of Edinburgh, UK.
[2] Norgaard, P. and Holttinen, H., 2004, *A Multi-Turbine Power Curve Approach*, Nordic Wind Power Conference, Gothenburg, Sweden.
[3] RenewableUK, 2012, *UK Wind Energy Database*, viewed 31/08/2012 <http://www.bwea.com/ukwed/>.

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