HOW MUCH TRANSMISSION CAPACITY WILL EUROPE NEED TO PROVIDE ENERGY SERVICES IN 2050?

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(1) Overview

Europe's electricity system needs to become more flexible to cope with end-use electrification and a supply-side shift towards inflexible or intermittent generators. Big-name scenarios from Shell (2013), the IEA (2012) or Desertec (2012) present only headline results, such as annual demand in TWh, which are too coarse allow the implications on the electricity transmission system to be studied. A meaningful analysis needs to account for the hourly price differentials between neighbouring markets and possible power flows down interconnectors, in order to assess arbitrage rents and the incentive to expand transmission capacity.

This paper demonstrates a model of Europe's energy system which can synthesise hourly profiles for the demand, supply and transfer of electricity across the continent. This model is used to explore the shape and scale of the optimal transmission network between 40 countries under different scenarios for 2050.

(2) Methods

We have developed an accessible and transparent model of energy demand, supply and transfer for Europe (Staffell and Green, 2013), which is programmed in Excel and is to be made freely available to the community. This takes broad exogenous projections for population and economic growth, technology shares and efficiencies, and simulates their impact on the electricity markets of Europe and North Africa in four stages:

- Annual demand for energy services (thermal comfort, movement of people and goods, etc.) are projected from 2010 to 2050 levels for eight sectors in 40 countries;
- Technology and fuel mixes are allocated to meet these services, giving the final energy demand for ten energy vectors on an annual basis;
- Hourly electricity profiles are synthesised for each country using a bottom-up methodology, accounting for the sectoral breakdown of demand, correlated weather events across countries and inherent national characteristics;
- The supply and transmission of electricity are simulated using a multi-regional merit order stack model, which minimises the cost of electricity and finds the long run equilibrium generator and interconnector capacities.

We use this model to compare various published scenarios for 2050, exploring the optimal cross-border transmission capacities and the key factors which drive this. We calibrate the model to emulate the annual energy demanded in scenarios from Shell, IEA and Desertec, and investigate the hourly electricity profiles which arise from these. We calculate the long run equilibrium transfer capacities between countries, and assess their sensitivity to key input assumptions.

(3) Results

Synthesised electricity profiles from the model are able to replicate the broad features of national electricity demand in 2010, and project dramatic increases in peak winter demands by 2050 (Fig 1). The increasing prevalence of renewables means that substantial increases in transmission capacity between the electricity markets of Europe would be beneficial.

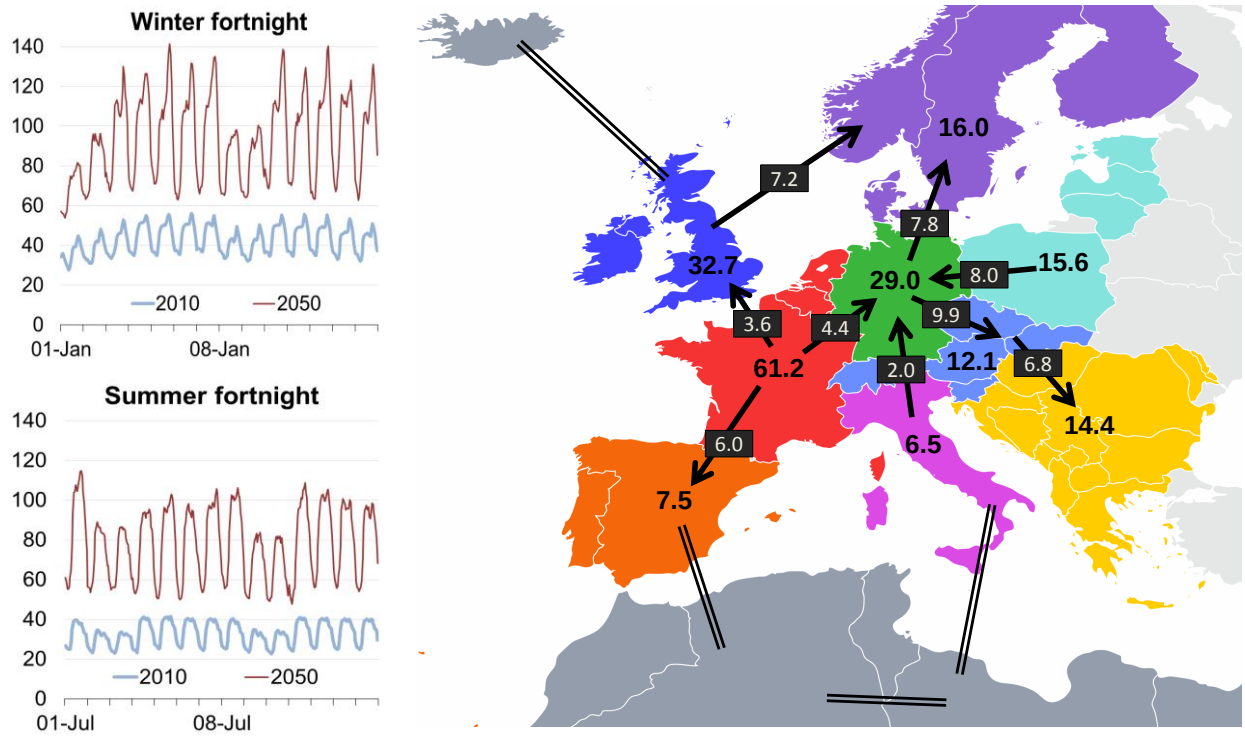

Fig. 1: Sample time series for electricity demand (GW) in the UK *(left)*, and a snapshot of values for the supply from dispatchable generators (GW, after accounting for renewable sources) and power transfer between regions *(right)*.

The annual variation in power flows on key transmission lines is substantial (Fig 2), and is driven by uncorrelated output from renewables, and differences between preferences for heating and vehicle technology. The revenues that can be earned through arbitrage increase substantially from 2010 levels, with major North-South corridors between France and Iberia, plus Germany and Italy emerging.

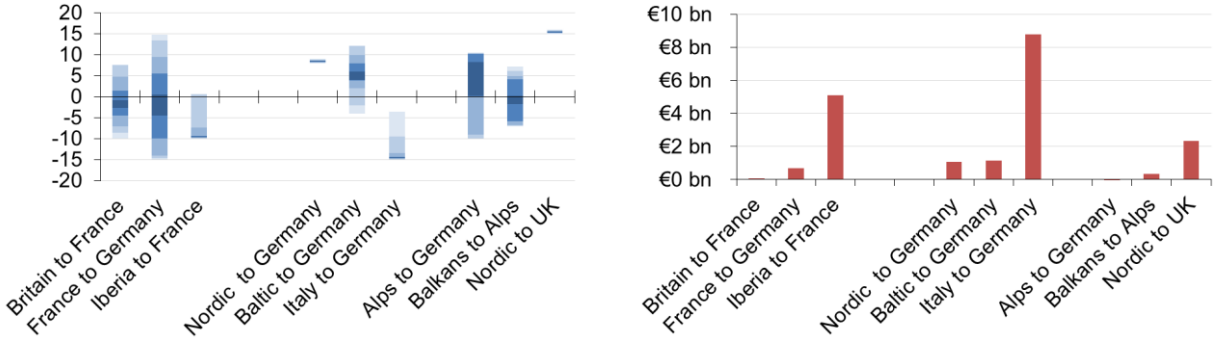

Fig. 2: The distribution of power flows down selected transmission lines in GW *(left)*, and annual revenues from arbitrage *(right)*.

(4) Conclusions

Europe will have to invest heavily in transmission capacity to accommodate the anticipated rise of renewables, electrified heating and vehicle technologies. In particular, the phasing out of coal and uranium from the EU electricity mix will greatly increase the need for interconnection to balance out volatility in supply. This research will enable the electrical feasibility and implications of future energy scenarios to be analysed in greater depth.

References

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