RCUK **Centre for Energy Epidemiology**

Hinkley Point C and other third-generation nuclear in the context of the UK's future energy system

Key findings

The electricity system has changed radically in the years since the project to build new third-generation nuclear (Hinkley Point C, Bradwell) in Britain was initiated, with renewables rising from 6% in 2008, to 25% now.

National Grid's Future Energy Scenarios (2016) show a **steadily declining need for 'baseload' generation**; three of NG's four scenarios have at least 70GW of renewables by 2030 (FES 2016, Figure 4.14), the exception being 'No progression' (current peak demand is c. 55GW)

The corresponding wind and solar output (based on detailed half-hourly modelling), means that already **by c. 2030**:

- There are growing periods when wind and solar meet all projected demand
- The capacity of 'firm' inputs (like gas, nuclear, biomass, interconnectors, storage etc) required to operate more than half the year is reduced to 20GW overall

The implication is that for **most of its contracted operating life (which will run out to c.2060), Hinkley Point would increasingly be competing with other, lower-cost low-carbon sources** (including maybe other new nuclear), as well as gas and interconnectors. For efficient system operation it would then have increasingly to 'load follow', adjusting its output up and down to follow changes in demand. It is not clear what such load-following operation would do to either the economics, nor it is clear how such variable operation, if possible, would affect reactor performance[i].

Alternately, baseload nuclear would displace other and cheaper sources, for example forcing wind and solar (or newer and hopefully cheaper and more flexible nuclear) off the grid, **if it cannot operate flexibly, or if the £92.50/MWh (indexed)** contract is allowed to determine its operation (the plant with biggest payment has most incentive to run).

By 2030, around 20GW of capacity is required for less than 10% of year, **to cover peak net demand, for which nuclear power is manifestly unsuitable.** The dominant need in the majority of National Grid scenarios post 2030 will be for adequate responsive capacity displacing coal and gas, and more efficient approaches to balancing demand and supply.

Fundamentals

Most 20th-century grids, including Britain's, were powered predominantly by thermal plant (hydro being the main exception), which were typically classed into three types.[ii] Baseload plants ran 24/7. They were slow to turn up or down; and were the cheapest to run. They could run at full capacity for weeks at a time. Mid-merit plants tended to run once or twice a day. They could react more quickly both up and down, and were more expensive to run than baseload plants. Peaking plants were the most expensive to run. There were called upon to match peaks in demand, and could rapidly respond with higher or lower generation, on request.

The three types play distinctly different roles on power systems, not only in terms of running hours, but also their relative capacity to balance the system, including ramping their output up and down, or to be switched on and off, according to fluctuations in demand.

"Baseload power is the power that is ‘‘always on’’ to meet the minimal amount of electricity demand. Baseload power plants generate electricity at nearly constant power, with output stability, and must operate reliably. This power is typically provided by large coal, nuclear plants and sometimes gas and is often called the ‘‘backbone’’ of the electric utility industry." (Sovacool 2009).[iii]

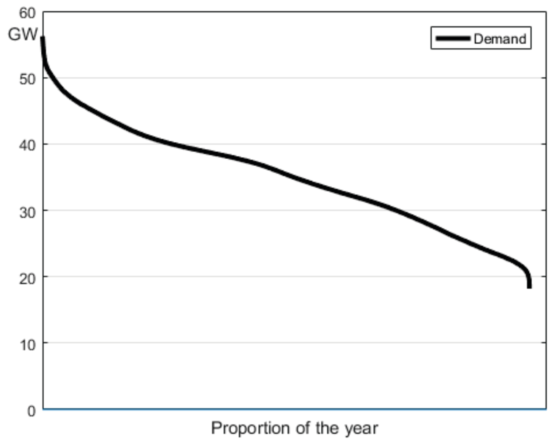

Figure 1 GB load duration curve

The level of baseload demand is indicated at the right-most end of the load duration curve (Figure 1). This visualises how demand is distributed. Instead of sorting half-hourly demand chronologically, it instead sorts these different levels of demand by descending magnitude. Current GB baseload is about 20 GW. (Smith 2016)

The changing energy system

There are now disruptive new entrants to the market that do not intrinsically share the distinguishing characteristics of baseload, mid-merit and peaking plants. Wind and PV have effectively zero short-run marginal cost, and as they are presently designed, do not offer flexibility. This presents a challenge for engineers and policy-makers alike: the comfortable paradigm and terminology of the last 80 years is no longer the most appropriate for how things must be done in future.

UCL has modelled the impact of onshore and offshore wind energy, and PV, on the GB electricity system, by scaling the actual observed half-hourly output from these sources over the past few years. We find that with current patterns of electricity demand in GB, the need for baseload vanishes once the GB system secures an average of around 30% *of electricity generated* from wind, and 10% from PV. The UK Secretary of State has indicated that the UK expects to achieve around 35% of its electricity from renewables by 2020, though this also includes controllable renewables such as biomass.

National Grid's Future Energy Scenarios (2016) span a range of projections. Their Gone Green scenario by 2030 has 28 GW of offshore wind, 18 GW of onshore wind, and 29 GW of PV, which represents 37% wind, 8% PV output, which is more than enough for the wind+solar output to sometimes exceed national electricity demand.

However, as we show in Figure 2, this happens not only in the 'Gone Green' scenario: in fact, only in the 'No Progression' scenario is there space for 10GW of 'baseload' to operate more than 90% of the time. 'Slow progression' has a very similar pattern to 'Gone Green', and the pattern of 'Consumer power' scenario is between these and 'No progression'.

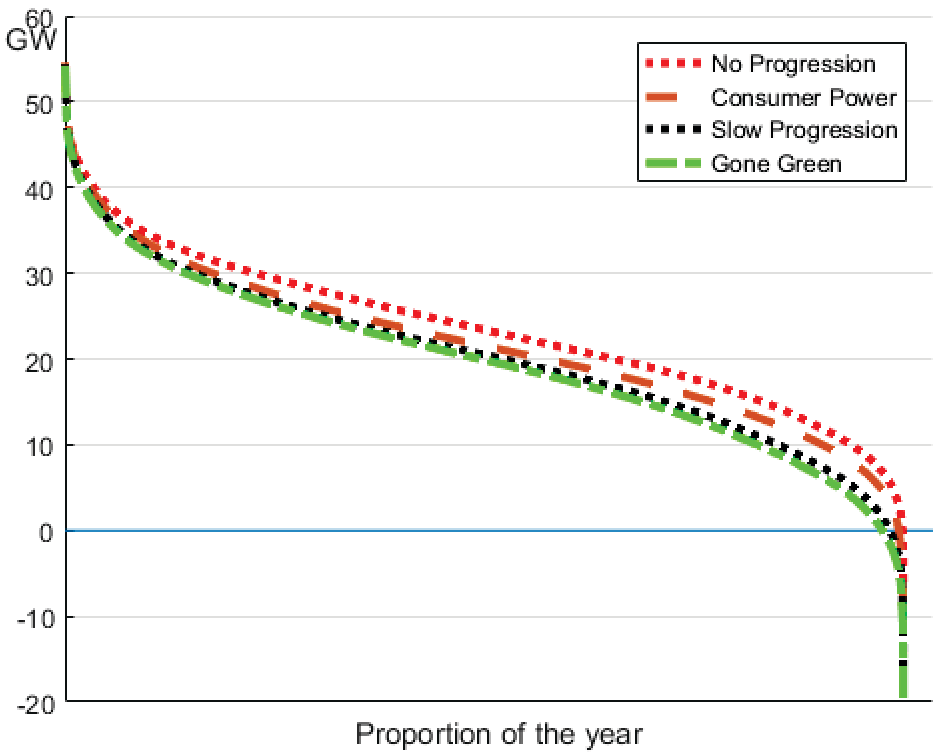

Figure 2 residual load duration curves

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[i] Load-following was deliberately and explicitly excluded from the approval process for new nuclear plants, the Generic Design Assessment (GDA): "Load-following is out of scope of GDA.", quoted from http://www.onr.org.uk/new-reactors/reports/step-four/technical-assessment/ukepr-rc-onr-gda-ar-11-024-r-rev-0.pdf

[ii] Competition Commission (1981) discusses the plans of that time for future investment in plants; Turconi (2014) discusses the changing role of thermal plants in a grid with increasing amounts of wind; and Green (1996) considers the impact of increasing competition on mid-merit and peaking plants after privatisation of the British electricity market.

[iii] That operating model does vary with national conditions. France for many years has run some of its nuclear plants as mid-merit plants, as available nuclear generating capacity frequently exceeds demand. Increased interconnection has decreased the costly exercise of ramping nuclear up and down.