prospect

Making the case for New Nuclear

A briefing from
Prospect trade union

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Making the case for new nuclear

Summary

The UK's current electricity generation capacity could be reduced by 30% by 2030 because of the planned coal phase out, decommissioning of nuclear plants and the potential closure of aging Combined Cycle Gas Turbines (CCGT) plant. This would leave the UK increasingly reliant on a mix of non-despatchable variable renewables and imports.

Unless action is taken, this changing capacity mix would leave the UK highly exposed to two key risks during winter peak periods: a combination of high demand and low wind and the unreliability of imports via interconnectors.

Modelling of high demand/low wind/unreliable interconnector scenarios suggest that the UK could be exposed to serious system stress by 2030, with potential supply shortfalls of between 9% and 21% during winter peak periods.

Current reliability indicators for interconnectors do not take adequate account of the historical availability of imports during peak periods, nor do they fully anticipate the risks of policy and technological convergence across Europe in the future. Interconnectors currently export power during 14% of peak winter hours; higher use of renewables and carbon price convergence in Europe could dramatically reduce potential imports by 2030.

Extended periods of low wind are a major risk during the summer months. This occurred in July 2018 and is already leading to higher summer peak prices and a heavy dependence on gas for backup. If the UK has to rely on gas for backup in summer in 2030 this could have substantial impacts on decarbonisation and affordability for consumers.

Completing the nuclear new build programme in full would eliminate these risks and provide the UK with secure, low-carbon electricity at low marginal cost.

Existing nuclear generation is a major contributor to local economies and local tax bases, providing up to 28% of local Gross Value Added (GVA) and up to 45% of local business taxes in the communities where they are sited. GVA is the value generated by any unit engaged in the production of goods and services.

Productivity in the nuclear industry is very high – GVA per job in nuclear generation is six times higher than the national average. Productivity growth has been five times higher than the national average in nuclear generation and four times higher across the Nuclear Decommissioning Authority estate

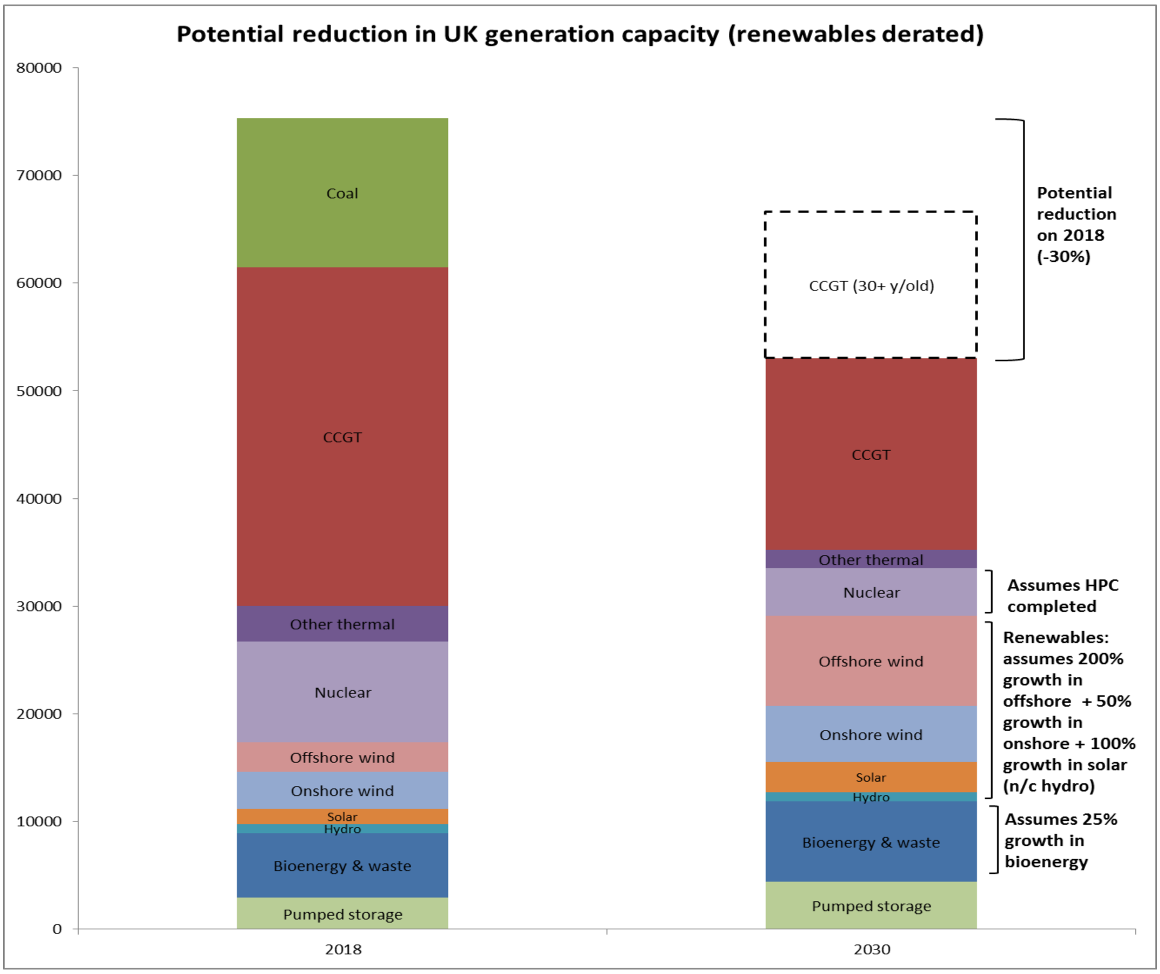
During the operational phase, the new build programme has the potential to generate around 34,000 high skilled jobs and up to £6 billion per year for UK plc. If government took a 50% stake in the whole programme, this would generate £1.35 in tax revenue gains for every £1 spent. It could also result in strike prices 13% lower than the average achieved by offshore wind in 2017 and 42% lower than the strike price agreed for Hinkley.

Nuclear's potential contribution to resolving the UK energy trilemma

Potential losses in generation capacity by 2030

The UK could see a 30% reduction in generation capacity by 2030 even with a strong growth in renewables and the completion of HPC because of:

- the planned closure of the UK's remaining coal plant
- the decommissioning of most of the UK's existing nuclear capacity, and
- the potential closure of a significant proportion of existing Combined Cycle Gas Turbines capacity – more than 40% of current CCGT capacity will be more than 30 years old in 2030, beyond the normal lifespan of this type of plant).[1]



This reduction in capacity will necessitate a heavy and growing reliance on imports to meet supply requirements and could lead to a serious supply shortfall during peak demand periods.

These changes in the composition of the UK's generation mix illustrate two key features of the UK energy transition each of which are historically unprecedented:

- a heavy reliance on non-despatchable generation and
- a growing reliance on non-domestic generation sources.

The inherent risks of each are greatly compounded by trying to do both simultaneously.

Why low wind and high demand could create serious system stress during the winter peak period by 2030

As a result of the changes in the capacity mix outlined above, the UK electricity system is likely to be exposed to significant new systemic risks by the end of the next decade. The two biggest risk factors are:

- The growing proportion of capacity that is comprised of variable renewables (potentially rising from 10% in 2018 to 35% by 2030).[2] This leaves available output increasingly vulnerable to changes in weather conditions. During winter peak periods (typically early evening), a lack of wind would leave renewables unable to contribute significantly to meeting demand. Aurora Energy Research (AER) calculated that there is a 60% probability of low wind availability during the very highest demand periods in the UK.[3]
- A growing reliance on imports to meet peak demand. There is a significant and growing risk of under- or non-delivery of power during a UK peak demand period, especially as the share of variable renewable capacity grows in neighbouring markets (see more below).

The following section models a variety of increasingly severe low-wind/high-demand scenarios and examines how the UK's electricity system might cope in 2030.

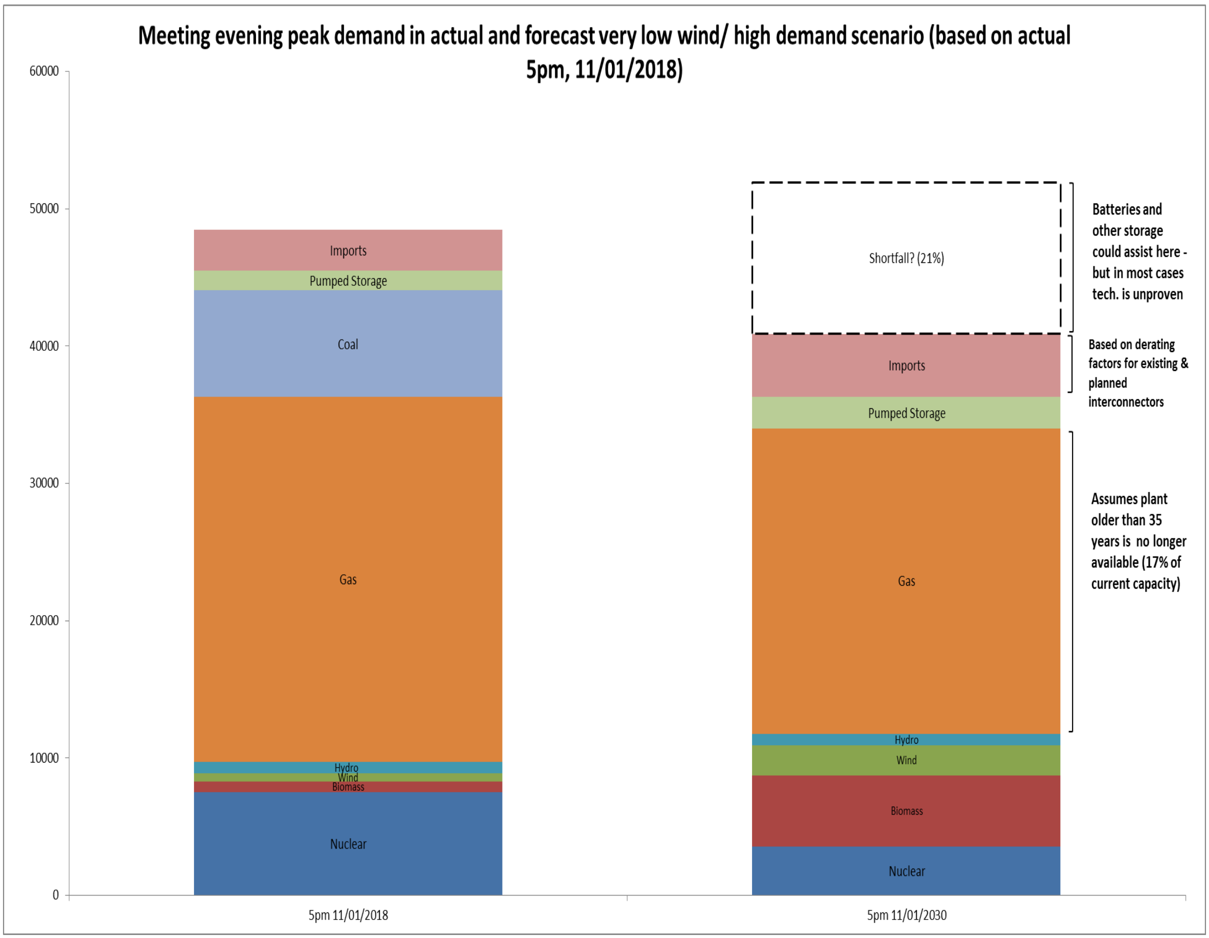
	Demand	Wind output	Historical frequency (peak periods)
Scenario 1	5%+ above normal	50%+ below average	6.5% (~3x per week)[4]
Scenario 2	5%+ above normal	75%+ below average	2.5% (~5x per month)
Scenario 3	10%+ above normal	50%+ below average	2% (~1x per week)
Scenario 4	10%+ above normal	75%+ below average	0.7% (~1x per fortnight)
Scenario 5 ('Jan 11 2018')	8% above normal	85% below average	0.4% (~1x per 5 weeks)

The modelling exercise takes each of these demand/wind scenarios, factors in the potential changes in capacity outlined earlier and makes some assumptions about the availability of imported electricity.

Essentially, this exercise assumes high renewables growth in France and increased carbon price convergence between the UK and key interconnected markets by 2030. These factors are discussed in more detail below.

Please note that these models are not intended to cover the full range of possible system outcomes and are somewhat simplistic given the tools and data we have available. They are simply designed to show one plausible negative outcome in order to highlight the significant risks we face.

The chart below attempts to model the most severe of these scenarios (scenario 5). This mirrors weather and demand conditions during an actual historical peak period, 11 January 2018 and shows how the system might cope if these conditions were repeated in winter 2030.[5]



As the chart shows, given the potential changes in the makeup of the UK's energy mix outlined earlier, a low wind/high demand event in January 2030 could result in a 21% shortfall in supply.

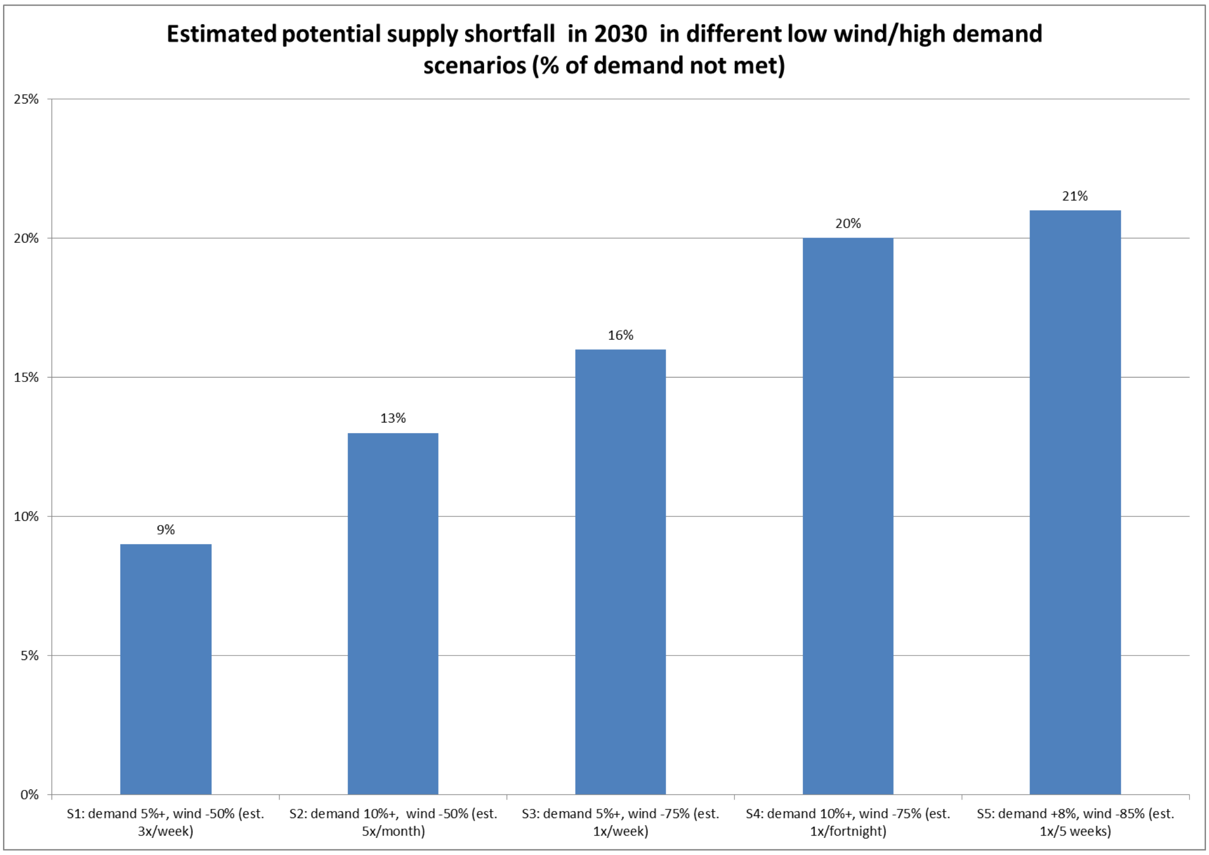
A proportion of this could potentially be met by batteries, other forms of storage or other demand side response (DSR). But much of this technology is at present theoretical and/or unproven at scale and its ultimate viability may not be clear for several years.

Given that a shortfall of this scale would have catastrophic consequences for security of supply, it would be extremely risky to rely on future technological solutions to avoid such an outcome.

The conditions modelled above represent a relatively rare situation – wind levels 85% below average and very high demand.

These conditions occurred during 0.4% of peak hours in the last three winters, which is still roughly once every five weeks.

However, less extreme low wind/high demand scenarios occurred much more frequently and if mirrored in 2030 could still result in shortfalls of between 9% and 20%.[6]



These scenarios outline relatively extreme, although still frequent, system stress events caused by a combination of low wind and high demand.

They suggest that the UK's electricity system in 2030 could become catastrophically vulnerable to sudden shifts in either of these factors if action is not taken.

In fact, analysis of historical grid data suggests that even if wind levels were normal, a surge in demand of 10% or more could produce shortfalls of at least 3%. Surges in demand of this magnitude have occurred during roughly 10% of peak weekday settlement periods over the past three winters, which equates to roughly five times a week.

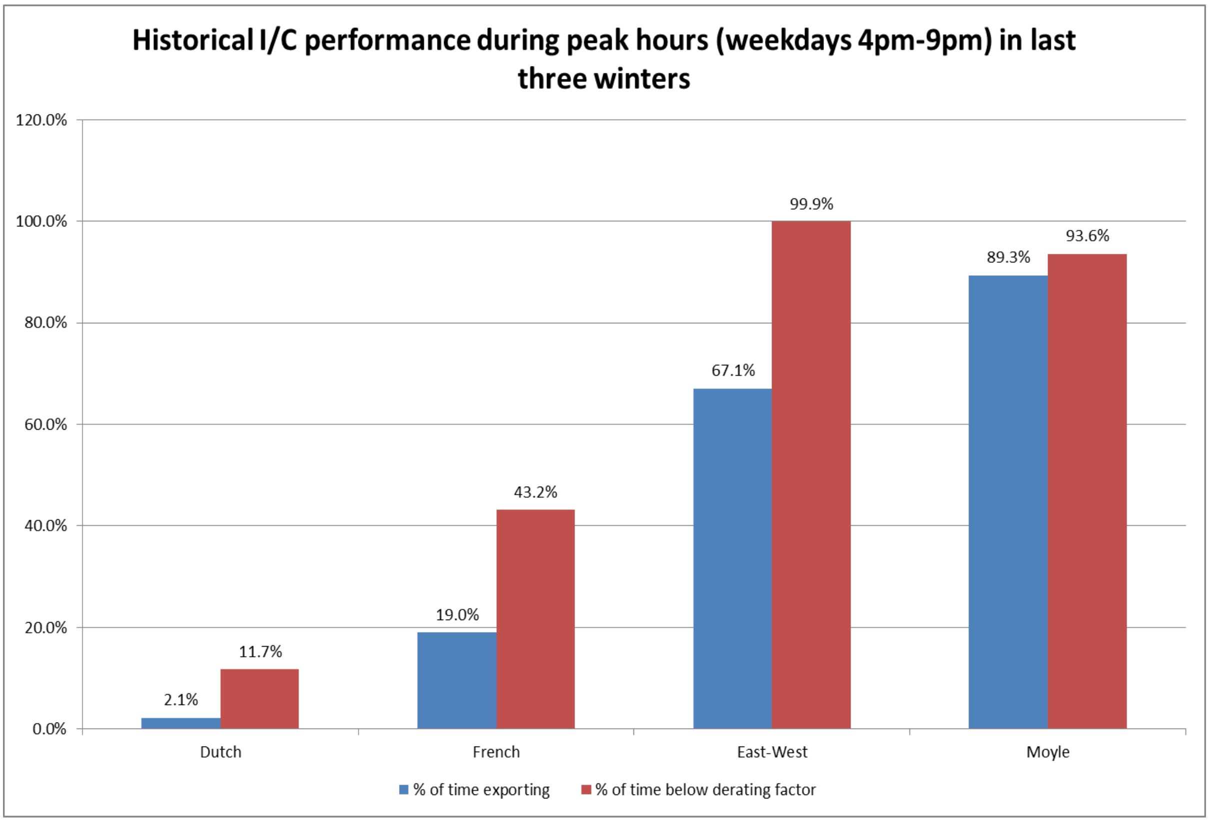
But the potential vulnerability of the future electricity system is not restricted to wind and demand factors and the projections above also attempt to account for the future unreliability of interconnectors.

This unreliability arises because of potential shortcomings in the way interconnector derating factors are currently calculated.

These derating factors, which estimate the proportion of theoretical maximum capacity that will actually be available on average, are developed using a methodology that does not adequately take account of the potential for under- or non-delivery of capacity, especially in peak demand periods.

Firstly, current derating factors downplay the historical availability of existing interconnectors. In particular, they ignore or downplay the extent to which some interconnectors frequently export power at peak times.

The chart below shows the performance of existing interconnectors during weekday peak periods over the past three winters.



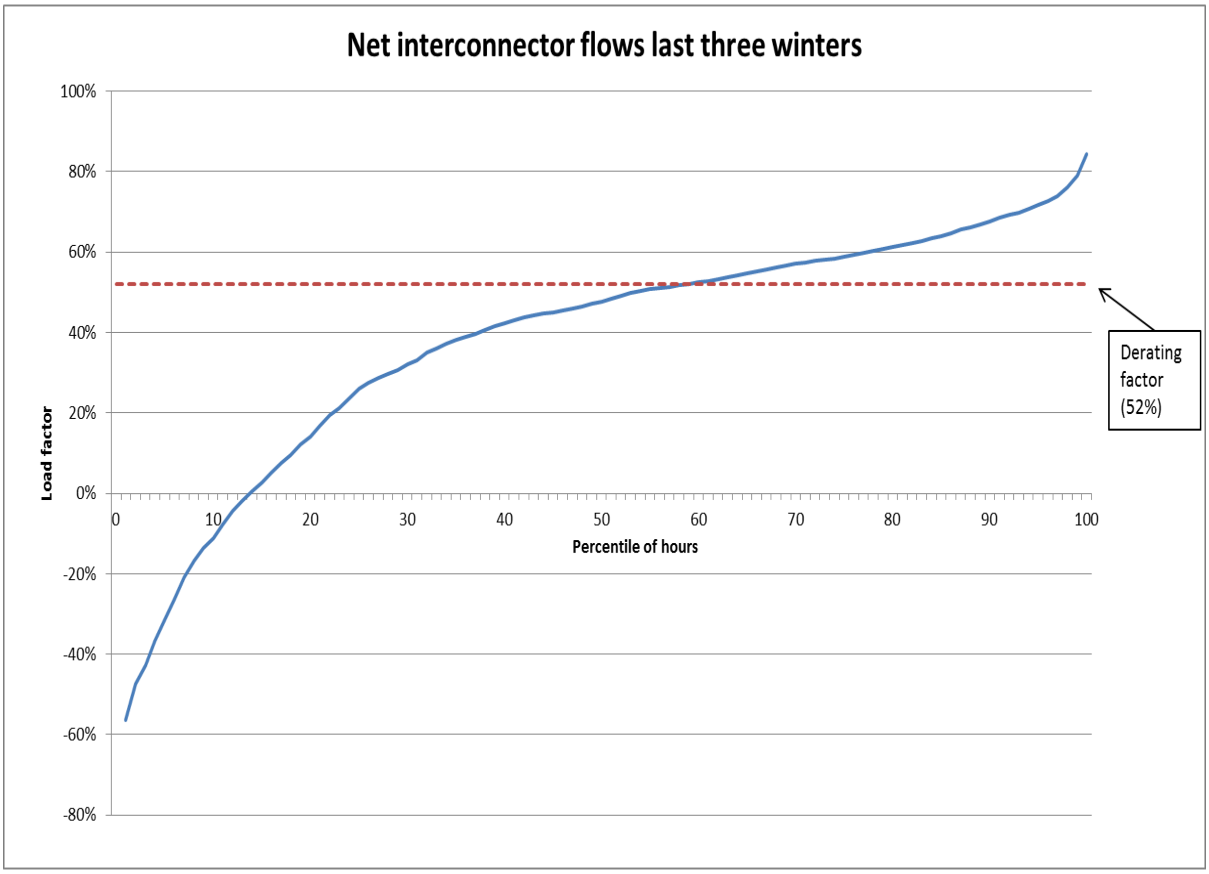
It compares the actual performance of interconnectors with the derating factors announced in July 2018 that would be used in the next capacity market auction. It shows the proportion of time they were below those derating factors (red bars) and the proportion of time they were actually exporting power (blue bars).

The two Irish interconnectors (East-West and Moyle, 500MW each) very rarely make any positive contribution to UK security of supply and usually act to increase demand at peak times.

While the French interconnector (2GW) is more reliable, it is still exporting power during roughly 20% of peak hours and is frequently below its derating factor.

The compound effect is even more concerning (chart below). Net interconnector flows have been negative in just under 14% of peak hours over the past three winters, ie exports have outweighed imports, which has added significantly to UK demand (1GW on average).

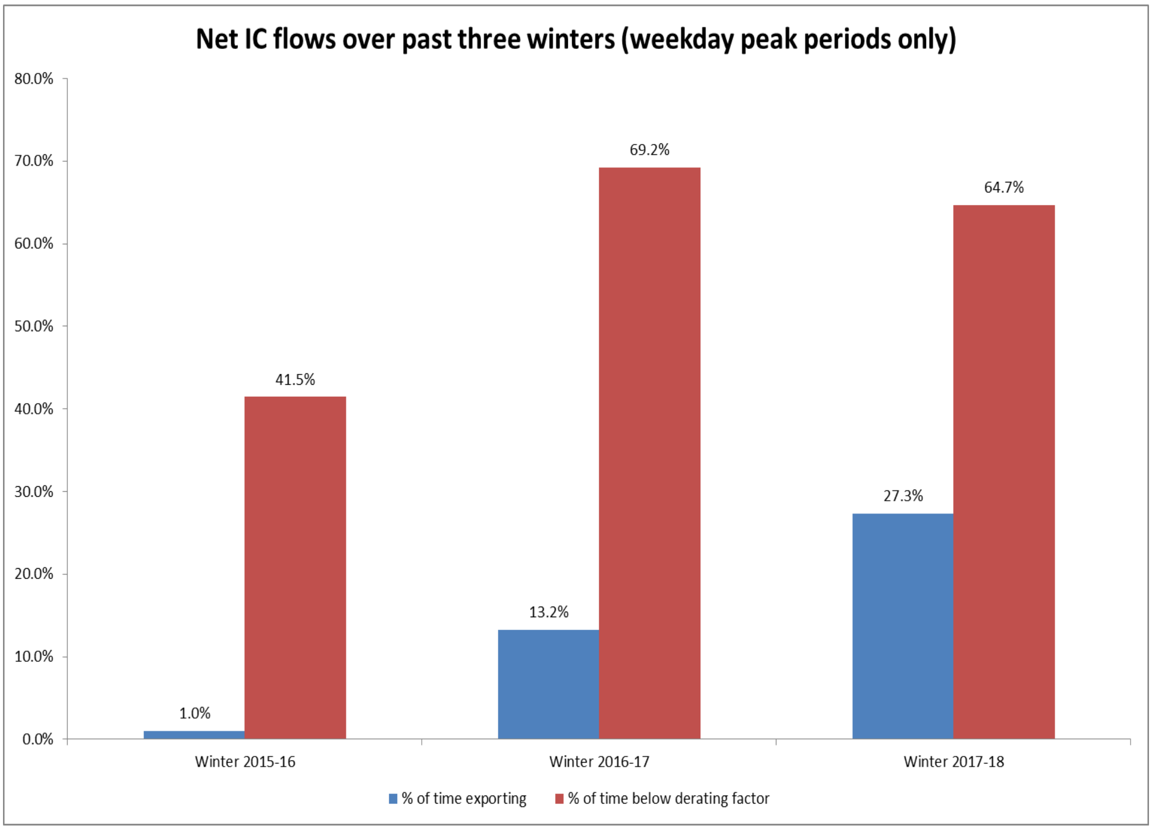
As the chart below demonstrates, this problem is getting worse. In winter 2015-16, net interconnector flows were negative in only 1% of peak settlement periods; this grew to more than 27% of peak settlement periods in the most recent winter period.



Similarly, in the most recent winter, net interconnector flows were below derating factors almost 65% of the time, compared with just over 40% of the time in winter 2015-16 (although this metric slightly improved in winter 2017-18).

The amount of power being exported when interconnector flows are negative has also grown. Average net exports were around 870MW in winter 2015-16, but rose to 1.2GW in 2017-18.

In short, interconnectors have exported more power more often during peak periods over the last three winters. Current derating factors do not make a proper allowance for this.

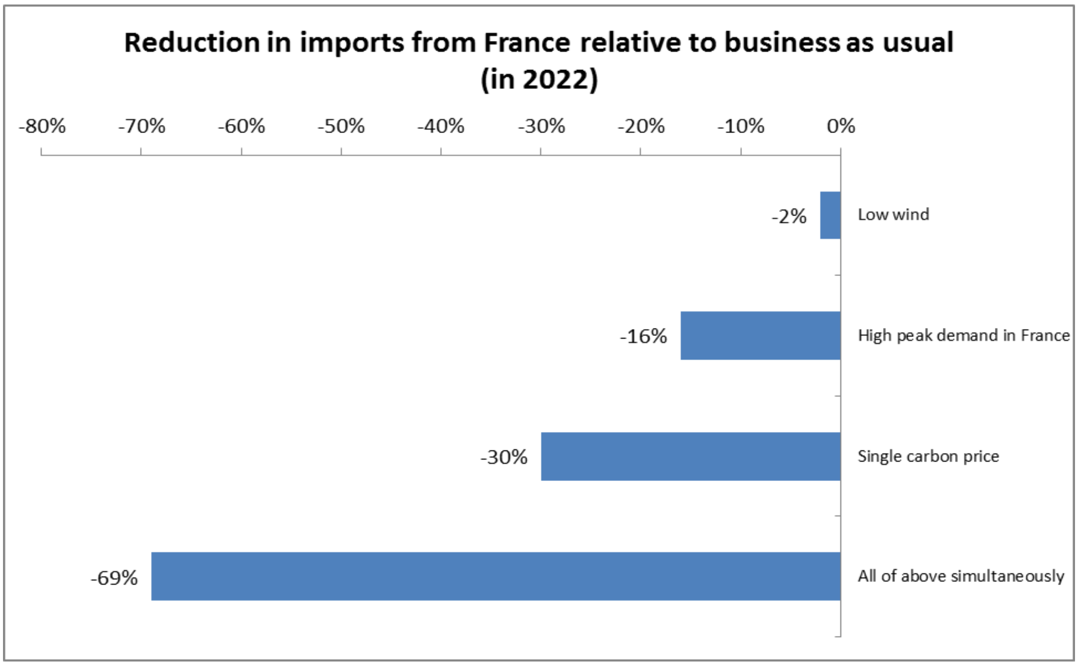


As well as ignoring the historical record on interconnector performance, current derating factors also downplay the long-term trends towards technological and policy convergence as European states decarbonise.

Greater harmonisation of carbon pricing across Europe, for example, could by itself have a dramatic impact on interconnector availability.

Aurora Energy Research estimates that greater carbon price harmonisation by 2022 could cut average imports from France by 30%.

Coupled with low wind and higher than usual demand in France, this could rise to almost a 70% reduction because of the mutually reinforcing impact of some of these individual factors.[7]



Current derating factors also place too little weight on relatively rare, but potentially very serious, system stress events.

France usually exports power in the winter. But prolonged cold weather in Europe in the winter of 2016-17 (and hence higher demand) and a shutdown of around 30% of France's nuclear reactors for emergency inspections led to France becoming a net importer.

If that scenario was repeated in 2030, AER estimates that UK power prices could spike to close to £3,000/MWh and this still wouldn't prevent interconnectors exporting to France.[8]

Some attempt to adjust interconnector output to account for these risks has been made in the modelling exercise above.

It is assumed that France (a key source of power imports) has invested heavily in renewables by 2030, in line with current French aspirations, and that this has greatly reduced the availability of French imports.

AER has estimated that a high level of renewables deployment in France could reduce French interconnector load factors by 67%.[9] The modelling above adjusts imports from France in line with this.

As mentioned, carbon price convergence is another key risk for interconnector availability.

At present, the UK's carbon price floor mechanism, which 'tops up' the EU carbon price, helps to elevate prices relative to European neighbours (thus incentivising imports of power).

But the government has frozen the UK's carbon price support mechanism and the Department for Business, Energy and Industrial Strategy currently anticipates that the gap between UK and EU carbon prices will virtually disappear by 2030.[10]

AER estimates that carbon price convergence could cause significant reductions in interconnector availability (by eroding the price differentials that interconnectors rely on to make money). The modelling above attempts to make some allowance for this. [11]

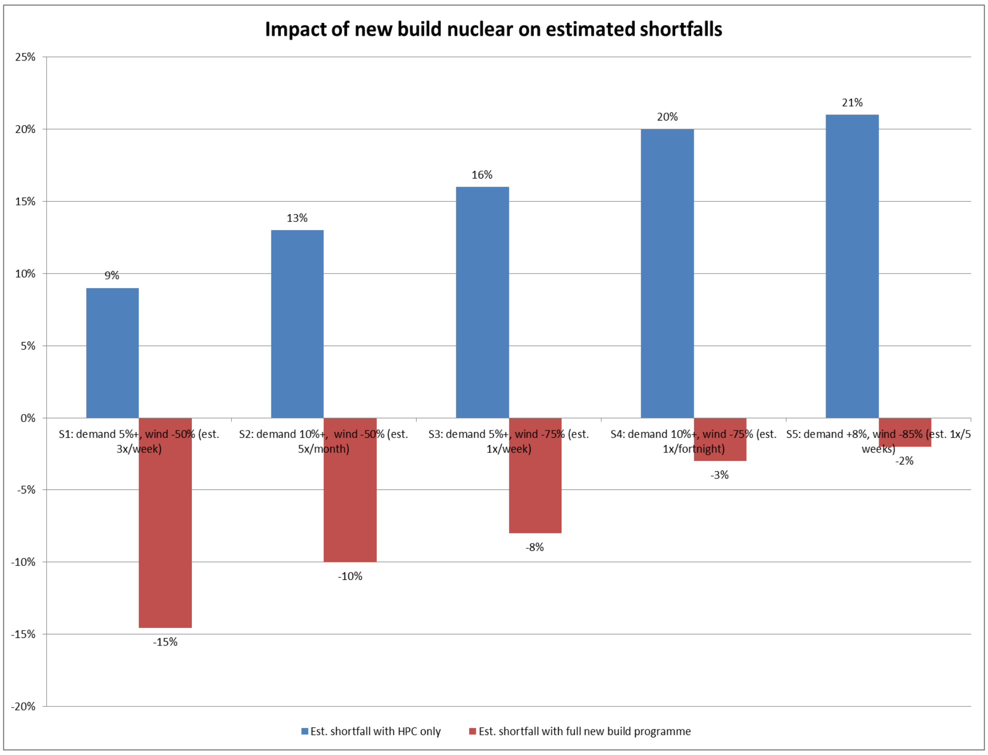
How new nuclear could close or reduce the gap in winter

If the kind of supply shortfalls outlined above were to materialise, it would probably represent the biggest energy policy failure in modern UK history.

In reality, it is likely that steps will be taken to mitigate the risk of such a disastrous outcome. However, the closer we get to 2030, the more likely it is that the only realistic way of ensuring security of supply will be by building more CCGT gas plant. This would result in a significant stalling of decarbonisation and probably higher costs for consumers too.

But if the new build nuclear programme was completed as originally planned, the potential for large supply shortfalls would be eliminated and transformed into significant surpluses that could supplant fossil gas or imports[12] (see chart below).

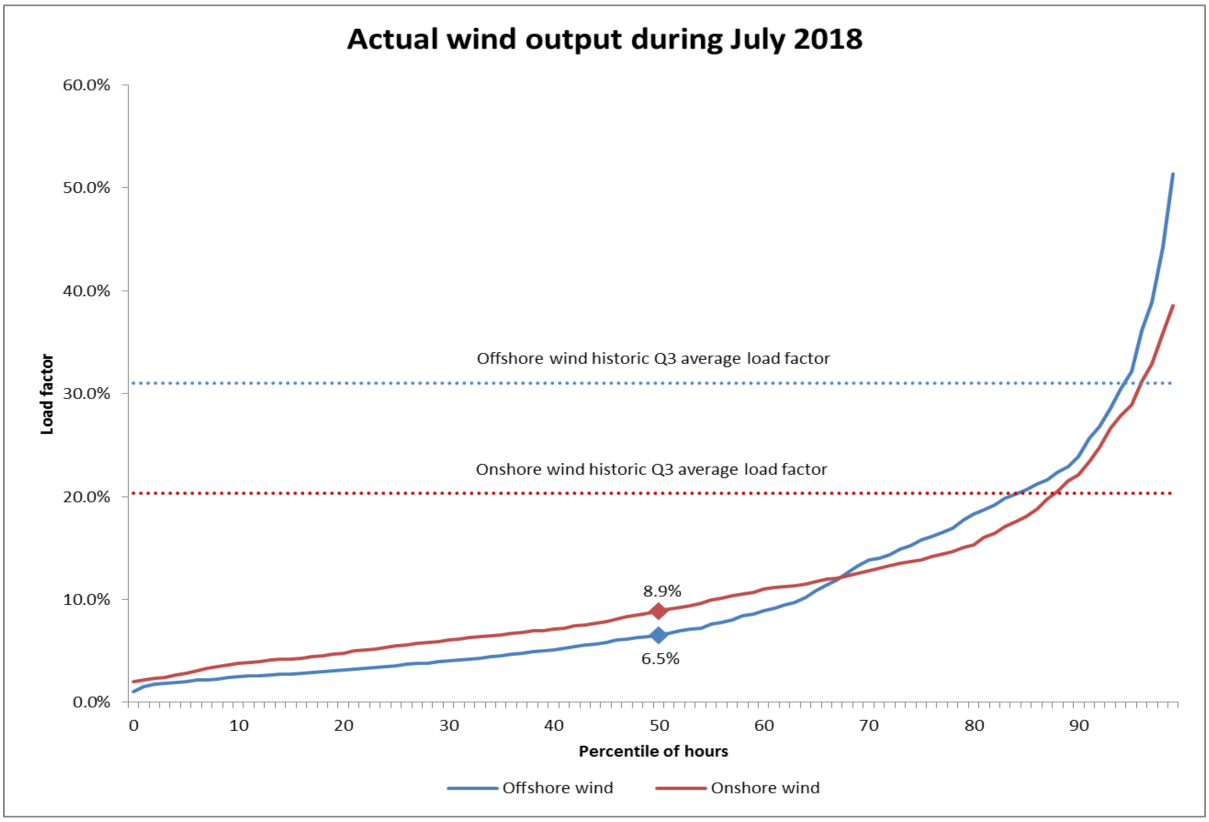
This could be achieved without increasing carbon emissions while also creating tens of thousands of skilled jobs and delivering significant economic benefits for local communities.



System risks during the summer months – coping with sustained wind lulls

Wind output is typically lower during the summer months than during the rest of the year. But in July 2018, wind levels were especially low for almost the entire month.

Median load factors for onshore wind of 8.9% and offshore wind of 6.5% were well below historical Q3 average load factors (see chart).[13]



As the UK electricity system comes to rely more heavily on variable renewables, extended periods of unfavourable weather conditions, such as low wind, pose significant challenges.

At present, demand in summer peak periods is significantly lower than in the winter. So even with forecast reductions in despatchable generation by 2030, there would theoretically still be capacity available to compensate if weather patterns like those in July 2018 were repeated.

But the major caveat is whether the economics of gas generation in 2030 would stack up sufficiently to allow the UK to maintain enough backup gas capacity.

High renewables penetration has already severely eroded profit margins in conventional generation and many plants would have already closed without mechanisms like the capacity market.

Anticipated higher carbon prices in 2030 would likely exacerbate this. Without new nuclear, market intervention via a mechanism akin to a ‘summer capacity market’ may have to be developed to preserve enough gas capacity to cope during wind lulls.

Energy prices and decarbonisation may be jeopardised if we are forced to rely on large amounts of gas generation to maintain supply in the summer peak periods, as we did in summer 2018.

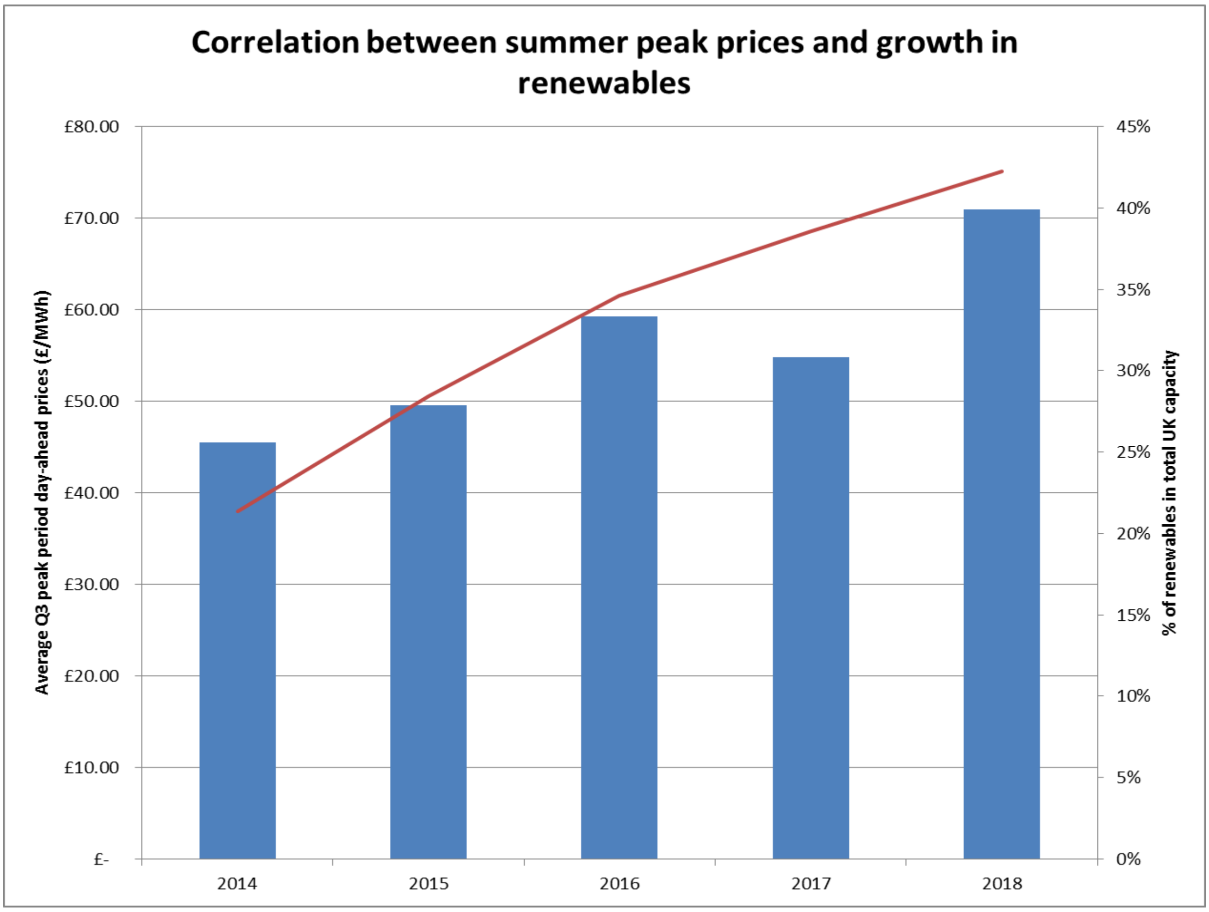
During July 2018, gas generation typically provided more than half of our electricity in order to compensate for the sustained low wind levels.

The Committee on Climate Change calculates that we need to limit fossil gas generation to no more than 25% of total output by 2030 in order to comply with the fifth carbon budget.

The increasing reliance on variable renewables and a corresponding heavy reliance on gas to compensate, has an impact on prices.

Average day-ahead peak period electricity prices were 43% and 47% higher in July and August 2018 respectively than the average in the previous five years.

Peak summer energy prices have risen steadily since 2013 as the proportion of renewable capacity has grown (see chart below).[14]



Completing the new build programme would largely alleviate these problems. The low marginal cost of nuclear power would allow it to provide a large amount of reliable backup power without elevating carbon emissions during extended periods of unfavourable weather.

While a range of new storage technologies could be available by 2030, there is currently no proven way to store large amounts of power affordably for weeks at a time.

Forgoing the certainty of low-carbon nuclear for the possibility of a future alternative technological solution would be extremely risky and could have profound consequences for UK energy security if no such solution emerges.

The economic case for new nuclear

Current impact of nuclear generation

In addition to the important role that nuclear new build could play in resolving the UK's energy trilemma, nuclear power already makes a significant contribution to the UK economy as a whole – and could do so to an even greater extent if the new build programme was completed.

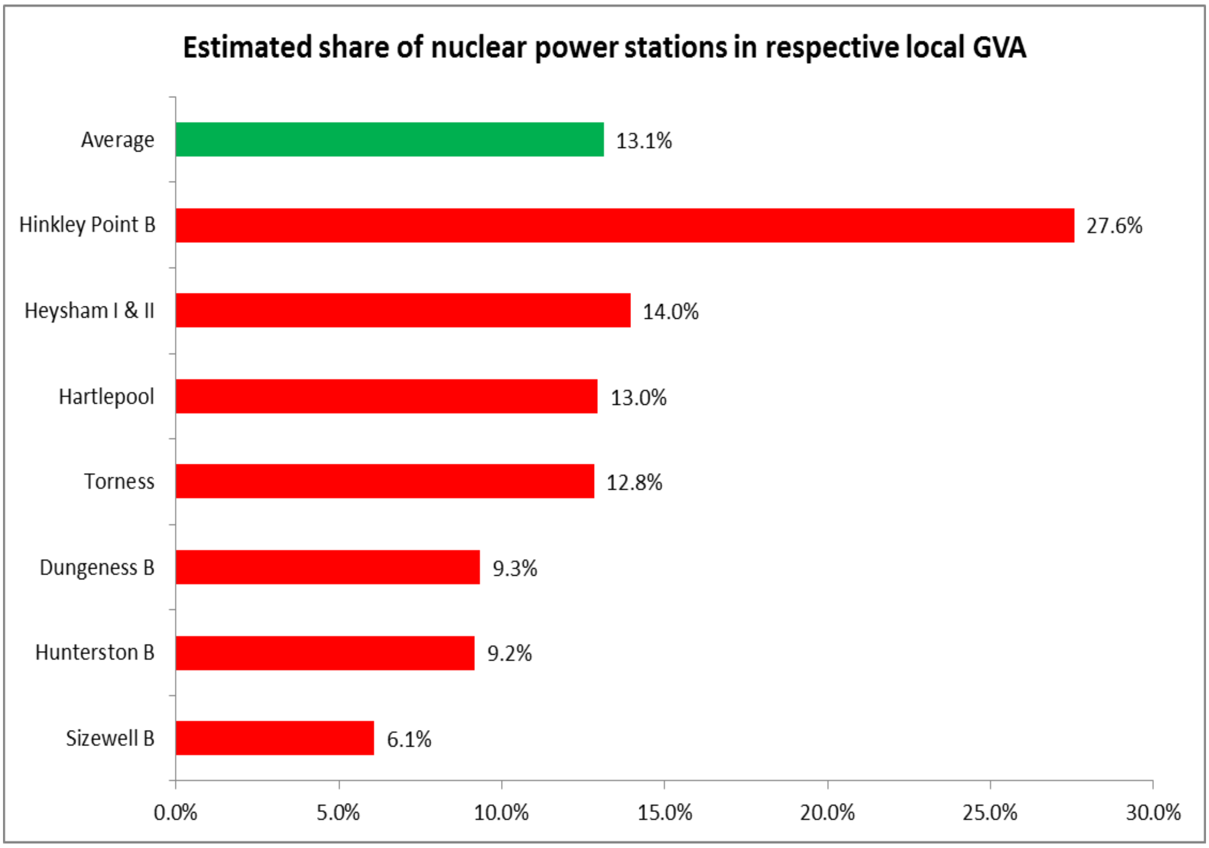
The economic benefits of nuclear are especially concentrated in the economically marginal communities where nuclear plants are typically located.

As the chart below shows, on average EDF's existing fleet of nuclear power stations are each contributing around 13% of local gross value added (GVA). Plants in particularly economically marginal areas, such as Hinkley Point B, contribute close to 30% of local GVA.[15]

This means that on average, nuclear power plants generate £1 out of every £8 of economic value in their local economies.

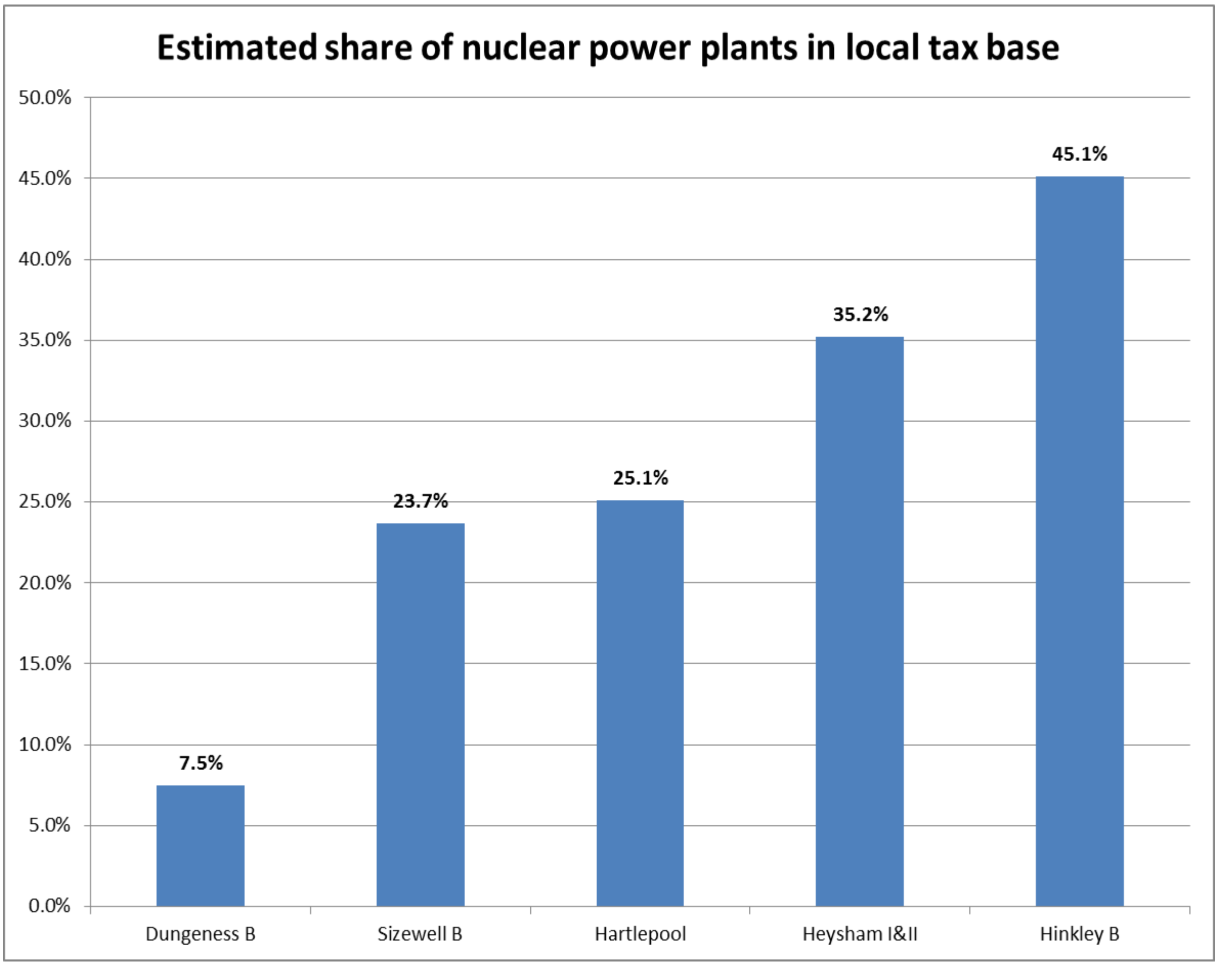
Although the figures shown are significant, they understate the true impact of these plants because they don't take account of 'induced' economic effects (ie the impact on the local economy of plant employees spending their wages) or any 'indirect' effects (ie local supply chain activities).[16]

In combination, the full impact of nuclear generating plant, especially in the most marginal economic environments like West Somerset, is likely to be critical to the local economy.



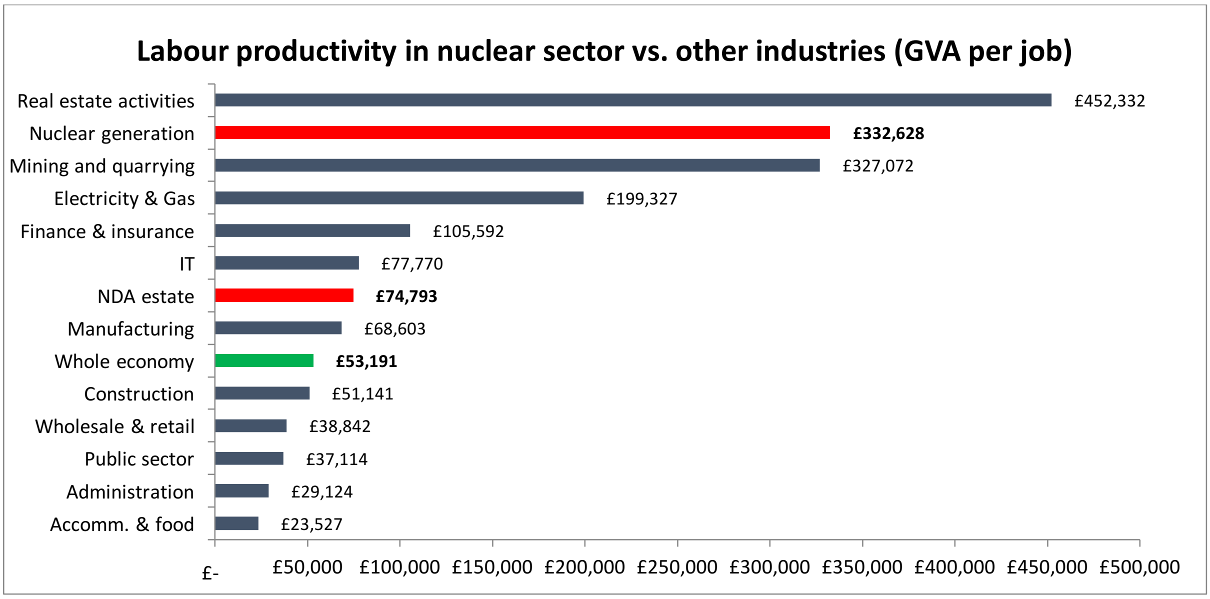
As well as the broader positive economic benefit of nuclear in the local economy, they are also a critical part of local authority business tax bases.

The six plants in England contribute between 7.5% and 45% of business taxes (see chart below), and provide a significant proportion of council revenues. This is particularly important in a time of sustained austerity and cuts to central government grants.[17]



Productivity benefits of the nuclear industry

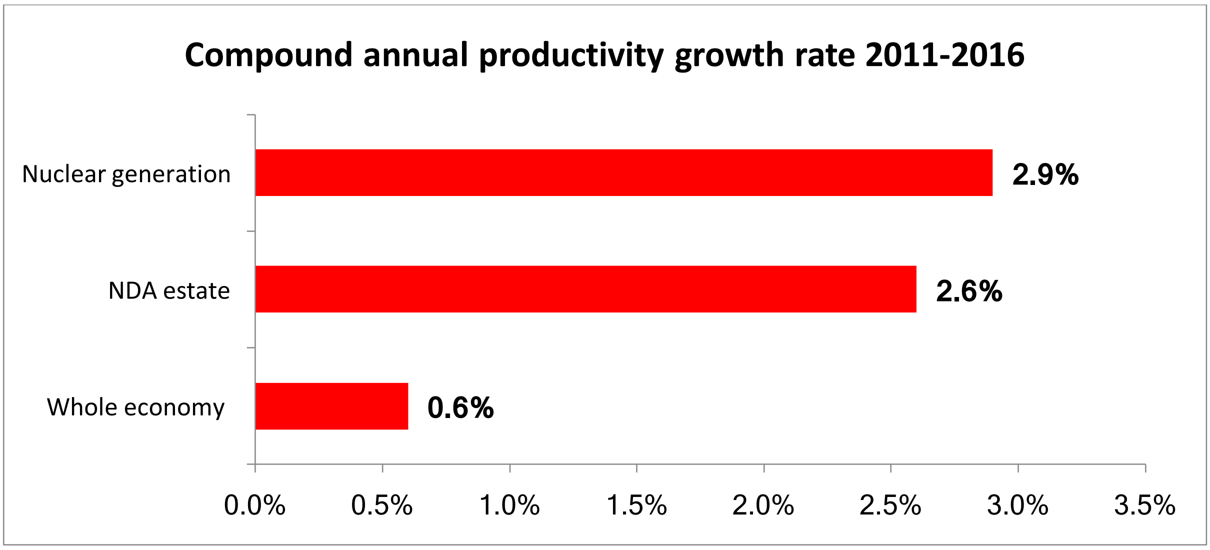
The UK nuclear industry is highly productive. GVA per job in nuclear generation is more than six times higher than the whole economy average. Productivity across the Nuclear Decommissioning Authority estate is around 40% higher than the average.[18]



Productivity growth has also remained strong in the nuclear sector, especially compared to the UK economy as a whole which has been plagued with low productivity since the financial crisis (see chart below).

Average annual growth in productivity in nuclear generation was almost five times higher than the national average between 2011 and 2016. In decommissioning, (the NDA estate), productivity growth was more than four times higher.

A shift towards greater employment in high productivity sectors like nuclear will be central to solving the UK's productivity puzzle. Delivering the new build programme, and the jobs that go with it, could make an important contribution to this effort.



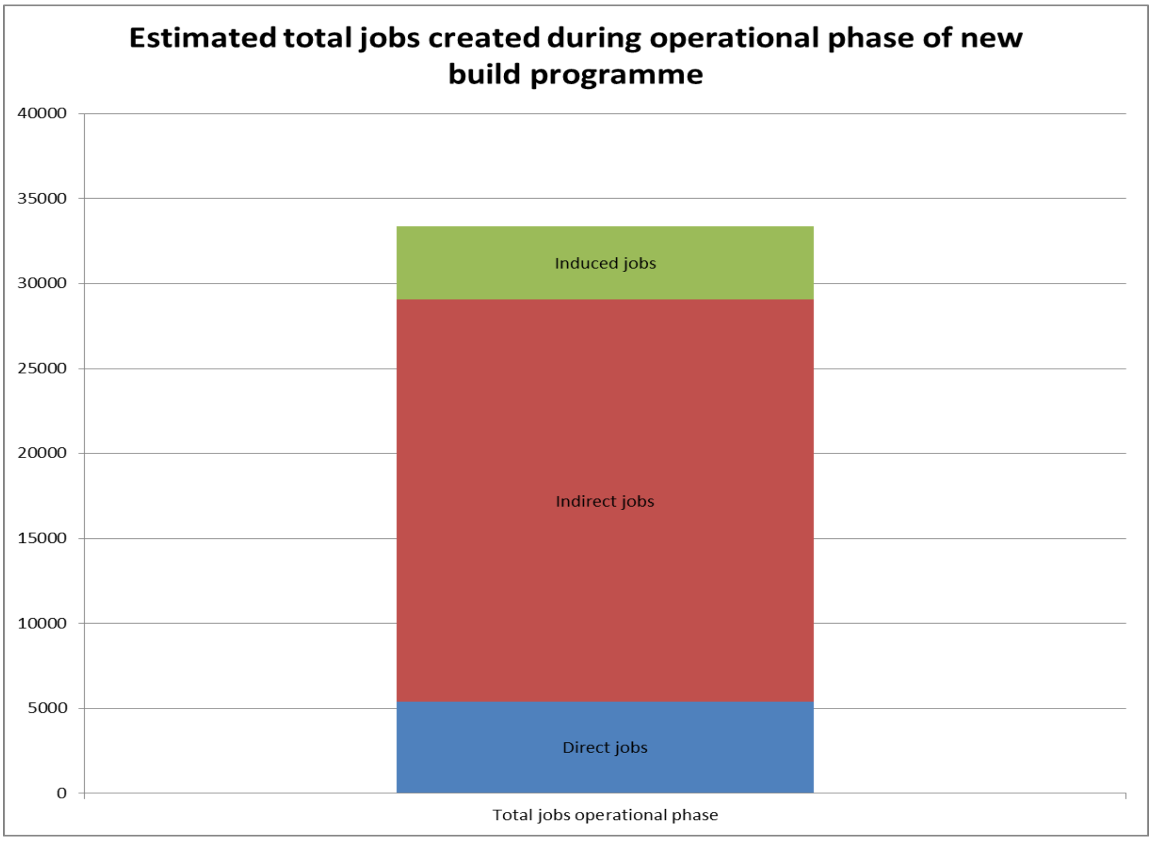
Estimates of jobs created and GVA for new build programme during operational phase

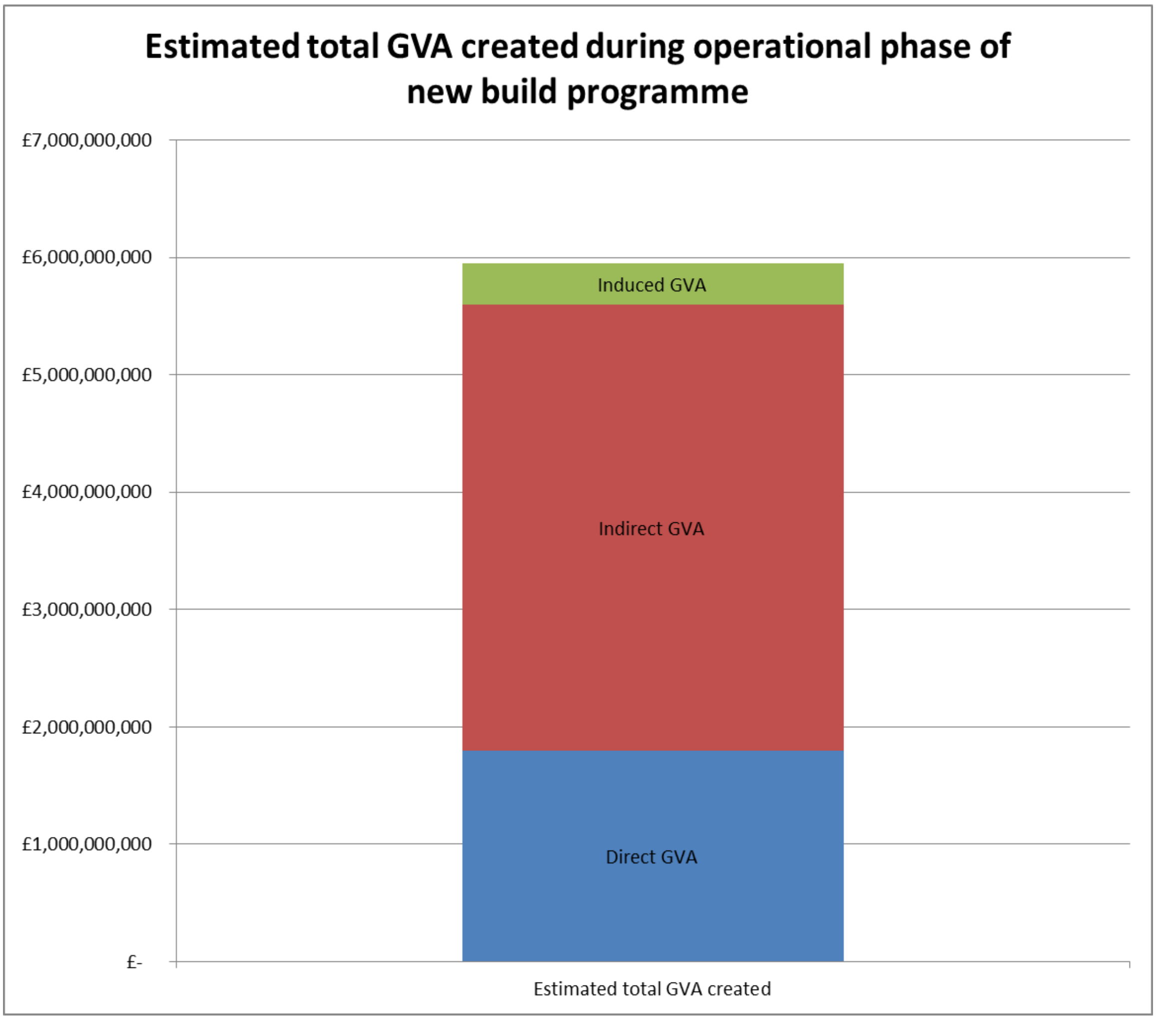
As the existing nuclear fleet demonstrates, nuclear generation makes a crucial contribution to the UK economy.

During the construction phase, the new build programme will create tens of thousands of jobs and billions of pounds in economic value. The precise numbers are difficult to quantify partly because of uncertainties about the construction process.

But economic and employment benefits during the operational phase are easier to assess. If completed in full, the new build programme could create more than 33,000 jobs and generate around £6bn a year for UK plc (see charts below).

These figures include the direct impacts of the plants themselves, the impact on the supply chain and wider 'induced' effects in the broader economy (from workers spending their wages etc).[19]


Estimated total jobs created during operational phase of new build programme
40000
35000
30000
25000
20000
15000
10000
5000
0
Induced jobs
Indirect jobs
Direct jobs
Total jobs operational phase


Estimated total GVA created during operational phase of new build programme
£7,000,000,000
£6,000,000,000
£5,000,000,000
£4,000,000,000
£3,000,000,000
£2,000,000,000
£1,000,000,000
£-
Induced GVA
Indirect GVA
Direct GVA
Estimated total GVA created

Estimating returns on a public investment in nuclear

The biggest single obstacle to the realisation of the new build programme is cost. The chosen formula for funding Hinkley Point C, driven by political imperatives, was the most expensive option available.[20]

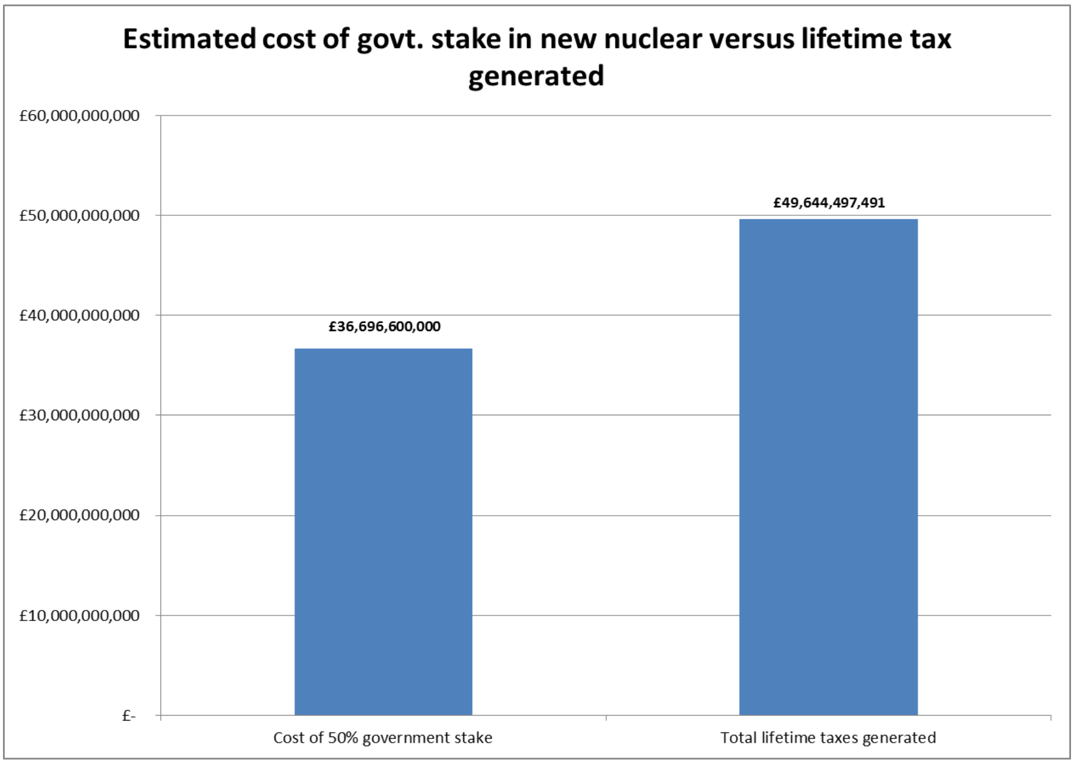
However, this needn't be the case and there are opportunities to substantially reduce costs and deliver cheaper outcomes for taxpayers and consumers.

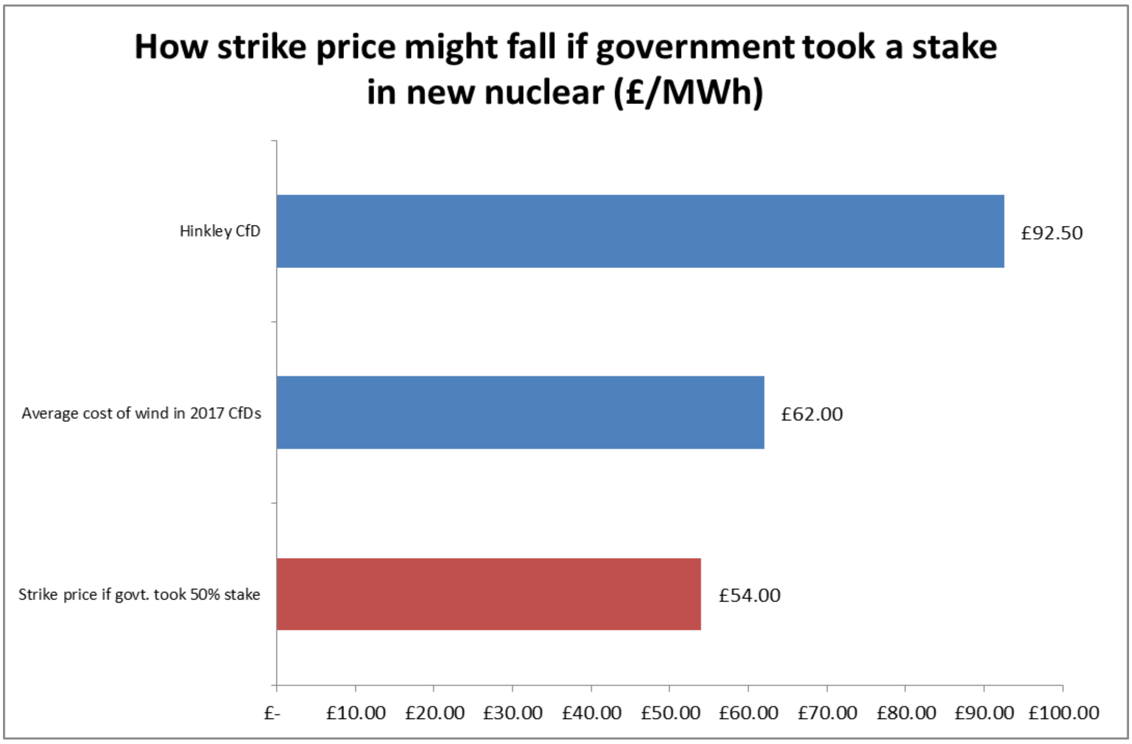
A recent MIT study demonstrated that overnight construction costs[21] for nuclear projects could be reduced by 25% – primarily by using advanced modular construction techniques and overhauling project management methods.[22]

The National Audit Office has calculated that strike prices would fall substantially if the government took a stake in new nuclear projects.

Every £1 of public investment could generate £1.35 in tax revenues for the public purse over the lifespan of the plants if the MIT recommendations were implemented and if government chose to take a 50% stake in the new build programme.

At the same time, the strike prices for the electricity generated from these plants could be 13% lower than those achieved by offshore wind in the 2017 contract for difference (CfD) auction and 42% lower than the strike price agreed in the Hinkley CfD.[23]





Significant public investment in nuclear new build could generate tens of thousands of high-value, high-productivity jobs and billions of pounds of economic value for UK plc. This in turn would generate substantial tax revenues for the public purse.

At the same time, the secure, low-carbon electricity these plants would produce would allow the UK to meet its carbon targets and avoid dependency on intermittent and unreliable energy sources.

References

1 This forecast is sensitive to pace of new renewables investment, the successful completion of the HPC project and decisions about ageing CCGT plant. If renewables investment is lower than forecast and HPC is delayed, the capacity reduction could be much greater. Note that renewables capacity in the accompanying chart is shown after derating – ie after theoretical maximum capacity has been adjusted for actual average output.

2 This calculation, as with the capacity chart above, accounts for renewables after derating factors have been applied.

3 AER, 'Energy Security in an Interconnected Europe', May 2018

http://bit.ly/aer-interconnected-europe

4 Frequency is based on the number of settlement periods in which demand is not met in each scenario. Settlement periods are the thirty minute segments into which each day is split for electricity trading and balancing purposes. The following projections are based on analysis of peak periods only (weekdays, 4pm-9pm), during which there are eight settlement periods. A 2% frequency, for example, means there is roughly one week day peak settlement period per week when demand is potentially not met.

5 Data is drawn from Elexon/National Grid, and supplemented with modelling assumptions about future capacity availability. As with the capacity chart above, model assumes 30GW of offshore wind, 100% growth in solar, 50% growth in both onshore wind and biomass plus completion of both HPC and the Coire Glas 1500MW pumped storage project.

6 Chart models various low wind/high demand scenarios using historical generation and demand data and forecasts of available capacity in 2030 as described earlier. It also calculates the % of demand not met after net interconnector flows have been accounted for.

7 AER, 'Interconnected Europe', May 2018: p31

8 AER, 'Interconnected Europe', May 2018: p34-5

9 AER, 'Interconnected Europe', May 2018: p28

10 See BEIS, 'Updated energy and emissions projections 2017' Annex M

http://bit.ly/beis-projections

11 This is based on AER's estimates of the impact of carbon price convergence in France, Ireland and the Benelux countries by 2022 (-30% for France, -193% for Ireland, -42% for Benelux). This may change further by 2030 but no reliable forecasts are available.

12 The full new build programme is taken to be HPC, Moorside, Wylfa, Oldbury, Sizewell C, and Bradwell B, with a collective nameplate capacity of 17.4GW.

13 Data is calculated from Elexon output data, and BEIS load factor figures. 'Historical average' is 2015-2017 Q3 average

14 Figures are calculated from NordPool historic price data and for 2018 only include the period between 1 July and 5 September.

15 These figures give the estimated share of each plant in total company GVA (calculated based on the proportion of the total workforce at each plant) expressed as a proportion of the relevant local authority GVA (taken from ONS estimates of GVA per local authority).

16 Induced effects are difficult to determine precisely without better data on where employees actually live – some may live (and spend their wages) outside of the local area where the plant is located. Similarly, supply chain effects are difficult to quantify in the absence of data on the geographical spread of supply chain spending.

17 The figures in the chart are calculated from publicly available data on business rate accounts in the relevant local authorities. No data was available for the Scottish plants (Hunterston B and Torness).

18 The figures in these two charts compare ONS figures for GVA per job with my calculations of GVA per job at EDF nuclear and the companies in the NDA estate.

19 These figures have been calculated using ONS and Scottish Government 'multiplier effects' for employment and GVA for the electricity industry. Direct GVA has been calculated based on current GVA per worker in nuclear generation and workforce estimates during the operational phase of the new build programme. As mentioned above, the full new build programme is assumed to be Hinkley B, Moorside, Wylfa, Oldbury, Sizewell C, and Bradwell B.

20 See NAO report on HPC http://bit.ly/nao-hinkley

21 Overnight construction costs calculate total cost of constructing a plant without factoring in the cost of capital (ie as if the plant were built overnight)

22 MIT, The Future of Nuclear in a Carbon Constrained World, 2018: p55

http://bit.ly/mit-carbon-constrained

23 Cost of government stake is based on half the cost of building a 17.4GW new build programme at a cost of £4,218 /kW (this is after factoring in MIT recommendations for cost reductions). Total taxes are calculated as a percentage of GVA generated per year over 60-year life of plants, based on ONS figures for effective tax rates across economy as a whole. Strike price is midpoint of NAO estimate range if government had taken a 50% equity stake in HPC.

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Making the case for New Nuclear

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