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Serious implications for the viability of the Sizewell C project of the expansion of wind power proposed in Energy White Paper (CP337)

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1) Introduction

The UK government's recent Energy White Paper [1] proposes a major expansion in offshore wind power. The various scenarios that the Department for Business, Energy and Industrial Strategy (BEIS) have modelled for the electricity supply [2] all include a certain amount of new nuclear power, reaffirming the government's commitment to the constant, baseload power of Hinkley Point C and Sizewell C.

We have compared BEIS' modelling of the options for the 2050 electricity supply with the predictions of our simulation of a secure, all-renewable electricity supply using our *Get it from the Sun (GIFTS)* software [3]. The BEIS Dynamic Dispatch Model (DMM) "does not tell us the optimal mix of technologies to ensure security of supply" [2]. By contrast *GIFTS* calculates the *minimum* installed wind, PV, bioelectricity and storage power that would have ensured security of supply every hour of the year for the five years 2013-2017.

Because *GIFTS* minimises these installed values, we can determine how soon an all-renewable power supply could be achieved if wind, PV and bioelectricity generators continue to expand at rates already achieved [4]. This approach enables this report to address, quantitatively, a crucial question on the viability of the Sizewell C project, ignored in the Energy White Paper and in the BEIS modelling:

If offshore wind power re-expands as proposed in the White Paper, how soon might the conditions of summer 2020 recur, whereby the reduction in demand in the pandemic resulted in a generator at Sizewell B being turned off to avoid periods of excess wind power over demand?

2) The *Get it from the Sun (GIFTS)* software

The *Get it from the Sun (GIFTS)* software simulates an all-renewable electricity supply that would have maintained the security of the electrical power supply of the mainland UK national grid every hour of the five years 2013 - 2017 [3].

GIFTS simulates the actions of the grid operators in matching supply and demand, by assuming values of installed wind and photovoltaic (PV) power that would achieve an all renewable supply. The software then scales up the actual wind and PV power generated in each hour in a year by these assumed capacities. Exact hour-by-hour equality of renewable supply and the actual electricity demand in the same hour is ensured by hydro-storage of any excess power. Any deficit is supplied from this storage, or by flexible bioelectricity generation.

The *GIFTS* methodology closely follows that of the first Kombikraftwerk project in Germany in 2006 [5,6]. The success of Kombikraftwerk in matching the real-time output of actual wind and PV generators to real-time demand with bioelectricity generation or hydro-storage was important in the German government's decision not to replace nuclear [6].

We have used *GIFTS* to minimise the values of installed wind, PV, bioelectricity and hydro-storage necessary to ensure supply equals demand every hour of the year for the five years 2013-2107. Our average installed wind plus PV capacity is 77.6%, in excellent agreement with the German Kombikraftwerk I project (78%) which used similar methodology while running in real time.

GIFTS clearly demonstrates that the inflexible, baseload power supplied by nuclear power will be redundant in an all-renewable electricity supply. The back-up has to be flexible over periods of an hour or so. The longest period for which a constant back-up was required in the 5 years studied was 55 hours. That was in the longest and deepest wind minimum of the 5 years [3].

3) The increase in offshore wind proposed in the recent White Paper is incompatible with the presence of constant baseload nuclear power

The inflexibility of nuclear power was responsible for the enforced shutdown of one of the Sizewell B generators in summer 2020 [7]. The Covid-19 pandemic had resulted in a fall in electricity demand. Electricity demand is lower in the summer than the winter. Grid operators faced the prospect of there being times at which the wind-power supply would exceed demand. They would have to pay wind generators to turn off at such times, or turn off one of the two generators at Sizewell B for the summer and compensate the nuclear operator. They chose the latter [7].

Fig. 1 suggests that those who produced the DECC [8] and BEIS [9,10] scenarios for previous administrations were aware this problem might arise if wind-power was allowed to continue to expand at the rate it had achieved prior to 2015.

Very impressively, renewable power in the UK increased 7-fold in the decade prior to 2015. However, it has been the intention of successive administrations since 2015, that renewable power should increase less than 2 times in this decade. The most likely explanation is that the analysts were aware that a large amount of wind power is incompatible with the significant contribution of inflexible nuclear power.

It is not clear why this problem was not communicated to those who used the Dynamic Dispatch Model (DMM) [2] to model the 2050 scenarios for the recent Energy White paper. What is clear is that a model like the DMM which does not consider the security of supply, as GIFTS does on an hourly basis, will not reveal the problem.

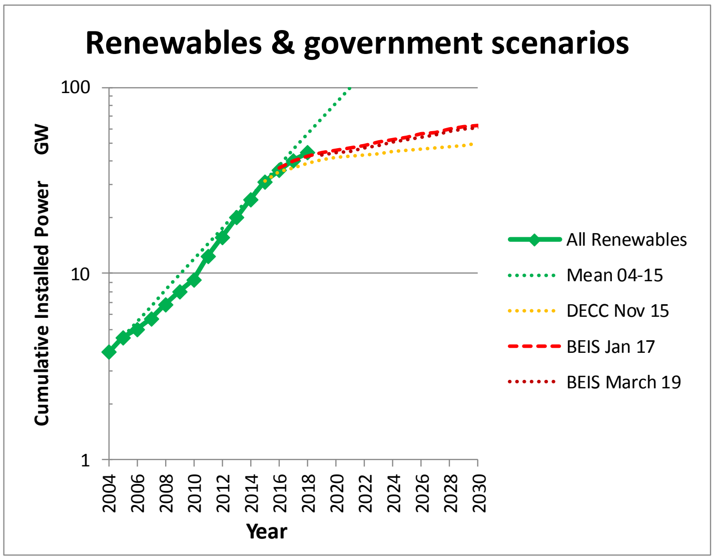

Fig. 1. Cumulative total of all UK renewable electricity installations at end of year shown. Green dotted line represents the mean of the yearly fractional increases 2004 to 2015. The three government projections are the DECC and BEIS "reference" scenarios [8,9,10].

The *GIFTS* methodology has been used to estimate when the proposed expansion of offshore wind power will result in hourly periods when wind power supply exceeds demand and result in the shutdown of a nuclear generator.

Fig. 2 shows the two assumptions for the future expansion of offshore wind. The realistic expansion is the dotted grey line. It assumes expansion from end 2021 at the average fractional rate achieved between 2009-2019 (dotted blue line). The dashed grey line is the pessimistic assumption, expanding from end 2021 at the average fractional increase achieved 2015-2019 (dashed blue line).

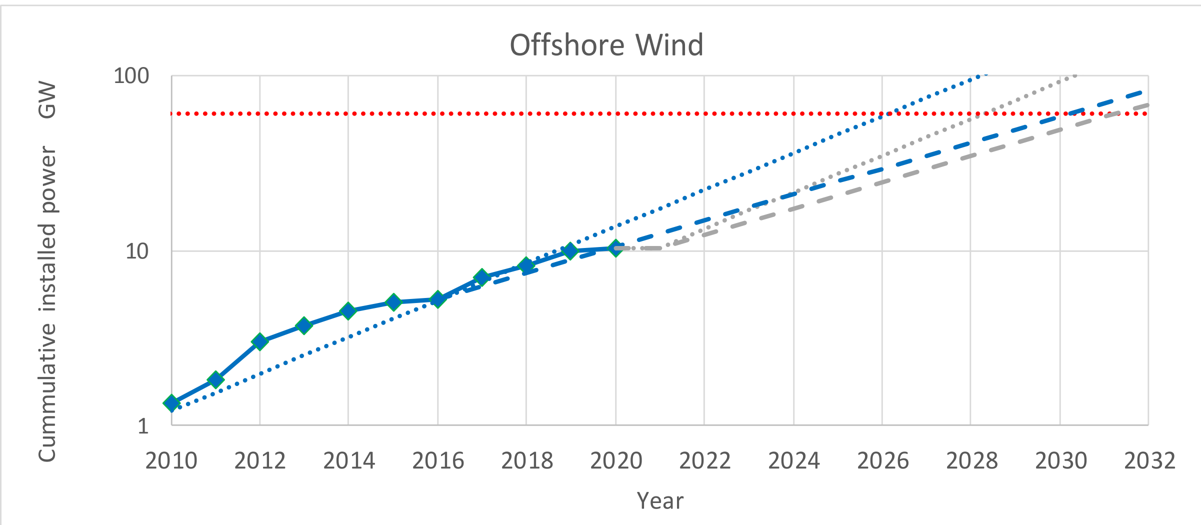

Fig. 2. Blue diamonds: cumulative installed offshore wind capacity at end of years shown. Blue dots extrapolate average fractional increase 2009-2019. Blue dashes extrapolate average fractional increase 2015-2019. Grey lines assume expansions from end 2021 discussed in text. Red dots are at half all-renewable wind target [3].

Two possible future expansions of onshore wind are shown in Fig. 3. The dashed grey line is the realistic expansion. It assumes expansion from end 2021 at the average fractional rate achieved between 2015-2019. The dot-dash grey line is the pessimistic assumption that there will be no future expansion of onshore wind power.

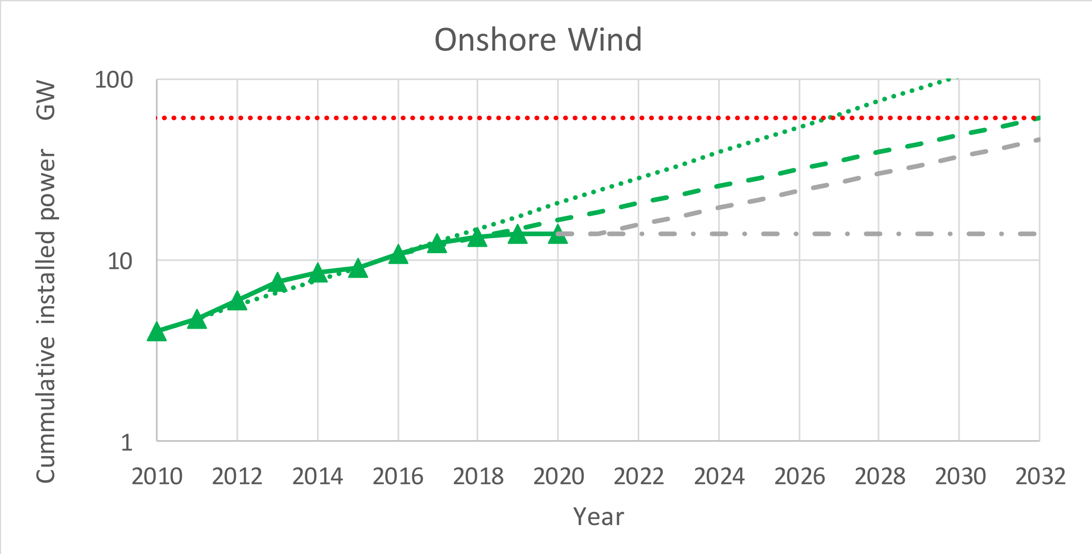

Fig. 3 Green triangles: cumulative installed onshore wind capacity at end of years shown. Green dots extrapolate average fractional increase 2009-2017. Green dashes extrapolate average fractional increase 2015-2019. Grey dashes assume expansion from end 2021 at rate achieved 2015-2019. Grey dot-dash line assumes no expansion from 2020. Red dots: half all-renewable wind target [3].

Our assumption for the future of nuclear power is that it will continue at the average output power rate it achieved in 2018 and 2019 until 2022. Thereafter, we first assume a recent BEIS "reference" scenario for nuclear power [10].

The government's nuclear power projections are unrealistic. They assume that the first reactor at Hinkley Point C will turn on at full power all year in 2025 and the second reactor at full power a year later. Our realistic assumptions for this new generation of reactor, the prototype of which is yet to generate, is that they are each one year late, and in the first year generate average power of 0.4 GW. In successive years this average power generation is assumed to increase by 0.4 GW each year until full power is achieved.

We apply the *GIFTS* scaling methodology to the actual wind power generated in every hour of 2013, not up to assumed installation levels an all-renewable supply as in Ref. 3, but up to the projected levels in Figs. 2 and 3. We chose 2013 as our reference year. This is because, of the five years studied in Ref. 3, 2013 was the one with the median value of the fraction of hours all-renewable wind power plus photovoltaic power were above demand.

Fig. 4 shows the percentage of hours in summer (gold points) and winter (black points) when the scaled wind power scaled exceeded the actual demand in 2013 for the various assumptions.

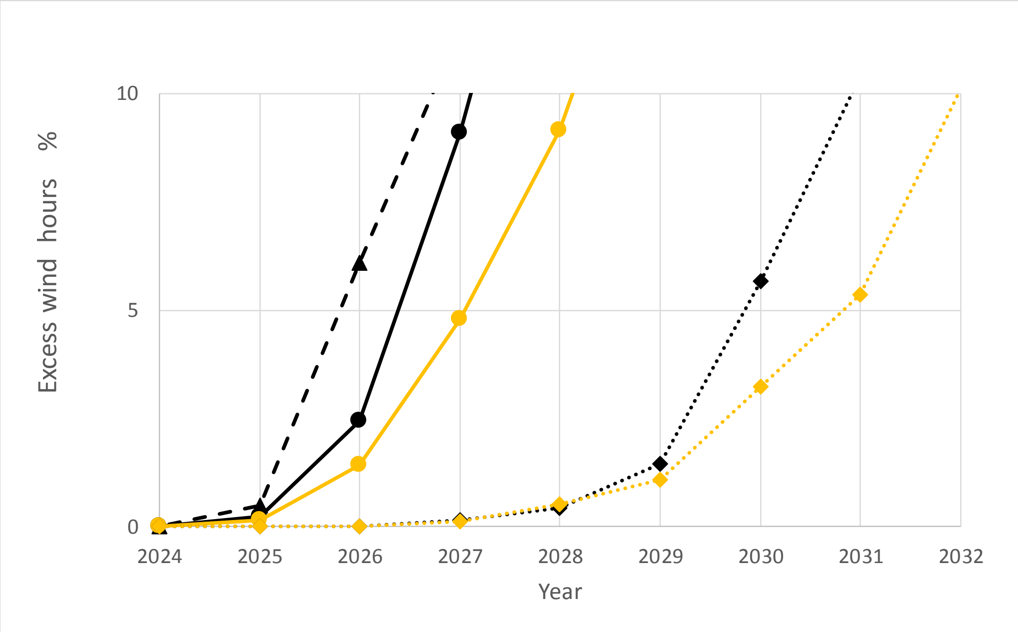

Fig. 4. Percentage of the hours in summer (gold) or winter (black) that projected wind power supply exceeds demand. Black triangles: assuming realistic wind and BEIS nuclear. Circles: assuming realistic wind and nuclear. Diamonds: assuming pessimistic wind and realistic nuclear.

At very low percentages there are more excess hours in summer than winter, as was the case in the pandemic. However, as installed wind power rises, the number of excess hours in winter exceeds those in summer on both realistic and pessimistic scenarios. This reflects the observation that the monthly average wind resource in the UK is a reasonable match to the UK electricity demand [11].

On all five assumptions for wind and nuclear power expansion, when BEIS expects Sizewell C to start generation in 2032, there will be excess wind power for at least 10% of hours summer or winter. All baseload nuclear power will have to be shut down all-year.

4) Conclusions and recommendations

The evidence from Fig.4, supported by previous government projections for renewable energy in Fig. 1, is that the White Paper's decision to resume the expansion of offshore wind has made Sizewell C redundant. Ref. 3 demonstrates that the national grid does not need any constant baseload power but does need more hydro-electric storage. Two recommendations from the Conclusions of Ref. 3 are relevant to Sizewell C:

1. All new-build nuclear activities should be terminated.

2. EDF should initiate a study to replace Sizewell B at the end of life by an elevated, hydro-electric storage tank to store excess wind energy from the nearby offshore wind generators. The elevated tank could be formed from the inverted pressure vessel of Sizewell B and mounted on a structure built on the concrete "core-catcher" foundations.

References

1) HM Government, "Energy White Paper: Powering our Net Zero Future", December 2020, CP 337
2) Department for Business, Energy and Industrial Strategy, "Modelling 2050: Electricity System Analysis" December 2020
3) Keith Barnham, Orrin Lancaster, Jamie Taylor "A secure, all-renewable electricity supply: implications for UK government energy policy", submitted to *Energy Policy* (May 2021)
4) Keith Barnham, Kaspar Knorr, Massimo Mazzer, "Recent progress towards all-renewable electricity supplies", *Nature Materials*, **15**, 115-116, (2016), http://go.nature.com/2cKxuBK
5) Kombikraftwerk 1 "Technical Summary of the Combined Power Plant", 2007, https://www.researchgate.net/publication/343788271_Technical_summary_of_the_Combined_Power_Plant_Kombikraftwerk1
6) Keith Barnham, *The Burning Answer: a User's Guide to the Solar Revolution*, Weidenfeld & Nicolson, (2015), *The Burning Answer: a User's Guide to the Solar Revolution*
7) The Energyst, "National Grid extends EDF contract to turn down Sizewell B", 12th June 2020, https://theenergyst.com/national-grid-extends-edf-contract-to-turn-down-sizewell-b/
8) Department of Energy and Climate Change, "DECC Updated Energy & Emissions Projections", Annex L Total Electricity Generating Capacity, 18-11-15 https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2015
9) Department for Business, Energy and Industrial Strategy, "BEIS 2016 updated energy and emissions projections", Annex I, Major power producers' total electricity generating capacity, 26-1-2017, https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2016
10) Department for Business, Energy and Industrial Strategy, "Updated energy and emissions projections: 2018", Annex I, Major power producers total electricity generating capacity, 29-3-2019, https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2018
11) Keith Barnham, Kaspar Knorr, Massimo Mazzer, "Benefits of photovoltaic power in supplying national electricity demand", *Energy Policy*, **54**, 385–390, (2013) https://doi-org.iclibezp1.cc.ic.ac.uk/10.1016/j.enpol.2012.10.077