Together Against Sizewell C

TOGETHER AGAINST SIZEWELL C (TASC) WRITTEN REPRESENTATION

SIZEWELL C PLANNING APPLICATION INQUIRY (IP no. 20026424)

NON-NUCLEAR MEANS OF GENERATING 3.2 GW OF 'RELIABLE ELECTRICITY' WHEN NEEDED

Neil Crumpton

TASC is indebted to Neil Crumpton for writing this paper which it endorses unreservedly as it shows that the electrical output from the proposed SZC development is capable of being generated from non-nuclear means. TASC's policy on energy is:

TASC believes that HMG should urgently pursue a policy of energy efficiency, decentralisation and conservation based on a 100% renewables electricity programme in order to drive down electricity demand rather than focus on the provision of nuclear generating capacity. However, by examining the government's own energy modelling, this report demonstrates that the 3.2Gw electricity projected to be generated by Sizewell C can be provided by alternatives in the event that the Sizewell C project were to be refused planning permission.

This paper considers the claimed 'need' for a Sizewell C project by assessing alternative ways to generate 3+ GW of low-carbon electricity when needed. Assessing alternative means of generation provides due diligence and transparency as regards the project's IROPI justification under Habitat's Directive and in terms of Value for Money (VfM) by way of a counter-factual economic comparison.

Summary

1. New nuclear power stations have been proposed by the UK Government to provide reliable low-carbon electricity to the future UK Grid in order to help achieve its wider policy of becoming a net carbon-zero country by 2050.
2. Yet the Government's own recent electricity sector modelling shows that there are viable non-nuclear ways to generate reliable low-carbon (or net carbon-negative) electricity. The modelling shows that a combination of renewable energy technologies and carbon capture and storage (CCS) technologies can provide such reliable power and in some scenarios at a lower cost than current nuclear technologies such as the Sizewell C (SZC) project proposal.
3. There is also every prospect that such non-nuclear energy technologies could be built, at least in part, and generating electricity before a SZC project would be commissioned.

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4. For these reasons there is neither an IROPI justification under the Habitat's Directive, or a consumer-affordability, or climate-emergency, rationale for the building of a SZC project.

Overview

5. Sizewell C project was one of about five 3 GW-scale projects proposed in energy policies from around 2010. The 3.2 GW Sizewell C project would generate about 25.5 TeraWatt-Hours per year * of essentially continuous or 'baseload 'electricity in its proposed normal operational mode (apart from periodic routine maintenance and refuelling downtimes).
6. Expressions of interest by the project developer in November 2020 of using some of the project's output for on-site Direct Air capture (DAC) of atmospheric carbon dioxide, and on-site hydrogen production via electrolysis, would not significantly reduce the proposed project's annual output to the Grid. Such technologies are not part of the SZC DCO
   - 3.24 GW x 8.76 x 90 %' baseload 'capacity factor = 25.5 TWh/y
7. In evidence to the BEIS Committee in Jan 2021, the BEIS Secretary of State Kwasi Kwarteng supported new nuclear power station capacity being built in the UK variously describing nuclear output as reliable, firm, baseload or dispatchable.
8. He stated, in answer to a question about a '100% renewables scenario', that around 15% of future annual electricity generation needed to be 'reliable' (or 'firm' or 'dispatchable') i.e. not PV generated electricity which is intermittent (day/night) or wind-generated which is highly variable (over hours, days and seasons) - see video 50 seconds from 11.48 45 secs : https://www.parliamentlive.tv/Event/Index/4fcb3791-2cf3-4e43-b766-30cb007fb58c
9. The Energy Secretary referred to the department's most recent 2050 electricity / energy sector modelling which is documented in the BEIS '*Modelling 2050 Electricity System Analysis*' report published alongside the December 2020 Energy White Paper (attached).
10. Also see the supporting document published by BEIS in 2020 '*Electricity Generation Cost*' report (attached).

BEIS non-nuclear 'RE+CCUS' scenario

11. BEIS's '*100% renewables scenarios*' modelling indicates that such scenarios would lead to higher costs and emissions than nuclear-inclusive scenarios (given the inputted assumptions and model parameters).
12. However, the same BEIS scenarios analysis shows that non-nuclear 2050 scenarios which include Carbon Capture Use and Storage (CCUS), i.e. 'renewables + CCUS' **would be of similar and in some scenarios, lower cost than nuclear-inclusive scenarios** (including 'nuclear + RE + CCUS'). The lower cost could be in the order of several hundred £ millions per year in 2050.
13. The BEIS 'Modelling 2050 Electricity System Analysis' report shows (Fig 1, page 11) that scenarios (WITH Hydrogen) comprising 'RE+CCUS' (Blue dots) tend to be of lower cost than scenarios comprising 'Nuclear+RE+CCUS' (Yellow dots).
14. The RE+CCUS scenarios have slightly higher annual emissions than nuclear-inclusive (by typically around 3.3mtCO2 per year in 2050 e.g. 660 TWh/y x 5 grammes/kWh). However, these emissions could be mitigated or directly reduced

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using some of the saved money (e.g. funding some BECCS or DACCS) and or potentially utilising curtailed electricity (e.g. in direct heating, hydrogen production or powering DACCS see Section 6 below).

15. For example, just 4 TWh/y generated from woody biomass could have negative emissions of about 3.6 mtCO_2 per year (4 x minus 0.8 mtCO_2 per TWh) or around 7 TWh/y generated from bio-methane (7 x minus 0.45 mtCO_2 per TWh generated)
16. Note that CCUS can include 'negative emission' BECCS (bio-energy with carbon capture and storage) and DACCS (Direct Air Carbon Capture and Storage) powered by low-carbon electricity and heat. CCS networks and pipelines to offshore sub-sea storage sites are currently being planned around UK industrial areas. So in effect CCUS will very likely feature in any real UK scenario from 2030.

17. **3 Reliable/dispatchable electricity generation**

18. Conventional nuclear power stations are promoted to produce baseload (continuous) but not very ‘dispatchable' (variable on request) electricity. The Sizewell C project could technically vary its output to a degree to aid Grid ‘balancing’ (matching supply to demand) but any significant 'dispatchability’ could well result in a reduction in annual generation and therefore lower profits (depending on financing policy e.g. CfD or RAB) and so would probably be avoided by the operator for commercial reasons.
19. EdF has expressed an interest of utilising steam from the steam generation circuit to energise a DAC scheme. A small demo DAC scheme operating by 2025 has been suggested by EdF for the Sizewell site. A commercial-scale scheme (eg capturing 1mt CO_2 per year for sub-sea storage) would still only reduce the reactors baseload output by a few percent. So the scheme’s output could hardly be then described as dispatchable on such grounds (compared to generating capacity, with low annual Capacity Factor, that is designed and operated to ramp-up quickly from zero output to follow changes and lulls in wind and PV output). There could also be safety and security issues with co-siting a commercial-scale DAC plant next or near a large nuclear complex (of 4.4 GW including Sizewell B) especially given the size constraints of the site.
20. Reliable (i.e. ‘dispatchable’ on request) <u>low-carbon</u> electricity generation can be achieved by using any or a mix of all of the following fuels and technologies to achieve Grid balancing with variable renewable sources (mostly wind / PV):

    i) Natural Gas in gas-fired power stations (e.g. CCGTs or CHP schemes) with CCS equipment fitted
    ii) ‘green’ hydrogen in gas-fired power stations (using stored hydrogen produced by electrolysis using renewable energy) so-called ‘power-to-gas’ P2G
    iii) ‘blue’ hydrogen in gas fired power stations (using stored hydrogen produced by converting Natural Gas in CCS-fitted steam reformers)
    iv) biomass in CCS-fitted power stations (BECCS)
    v) bio-methane in CCS-fitted gas-fired power stations (BECCS) the storable bio-methane being derived via the gasification of biomass

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21. A combination of the above reliable generating technologies could be used to provide whatever level of baseload or dispatchable capacity and annual output (e.g. 15% of demand / ~ 95 TWh/y) where deemed necessary to provide reliable electricity on the Grid to future consumers.
22. It is important to note that biomass use is currently not considered in the BEIS modeling

Hydrogen use modelling

23. ‘Excess' renewable supply (i.e. when wind and PV supplies more electricity than instantaneous consumer demand on the Grid net of other inputs) can be used in electrolysers to produce 'low-carbon' electrolytic hydrogen (so-called ‘green’ hydrogen). 'Low-carbon' hydrogen could also be produced from Natural Gas in CCS-fitted steam reformers (so-called ‘blue’ hydrogen). Low-carbon hydrogen (blue and or green) could be stored and could supply various specific sector needs depending on future technological development and policy pathways, particularly:

    i) industrial needs (e.g. production of plastics, fertilizers, ammonia, synthetic hydro-carbon fuels)
    ii) subsequent dispatchable electricity generation i.e. P2G (e.g. in CHP schemes)
    iii) building heat i.e. via hydrogen-convertible Central Heating boilers supplied with hydrogen via converted but largely existing gas pipeline distribution networks
    iv) other - transport sector (possibly HGV, large vehicles, rail, shipping)

24. These various potential future UK hydrogen demands could accumulate to require over 300 TWh/y <u>thermal</u> of hydrogen (be it a mix of green or blue hydrogen production and carbon-negative hydrogen from CCS-fitted biomass gasifiers).
25. It is not clear what level of hydrogen demand across all sectors is deemed to be needed in the models ‘with hydrogen’ and ‘without hydrogen’ scenarios in the ‘Narratives’ in Table 1 page (e.g. for industrial applications, transport and heat sectors).
26. In the BEIS Modelling report dispatchable low-carbon electricity generation is set at a maximum of 20 TWh/y (blue hydrogen) see page 6 including Note 6. The emissions from 20 TWh/y generation from Blue hydrogen would emit around 1 mtCO2/y (for comparison 3.1 mtCO2 per year is the difference between sector specific emissions of 10g/kWh and 5 g/kWh).
27. Blue hydrogen is generally assumed to be cheaper than green hydrogen but only to around 2030-2040 according to various estimates and stakeholders. Large quantities of renewable electricity is curtailed in the RE+CCUS scenarios (e.g. 78 to over 200 TWh/y) which could be utilised e.g. in green hydrogen production, powering DACCS schemes and direct heating such as District Heat stores.
28. Generating 20-30 TWh/y of dispatchable electricity using green hydrogen would require around 55-80 TWh/y of excess electricity (assuming electrolyser efficiency of 75% and generation efficiency of around 50%).
29. The BEIS report itself then states (page 16) that: ‘..*longer term storage, including using excess renewable* [green] *generation to produce hydrogen, which is stored and*

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then used to generate electricity, ***will further reduce systems costs by using excess renewable generation*** *in one period to help meet demand in another.*'

30. Indeed, depending on how much further offshore wind and PV costs fall (see below), it may be viable and optimal to 'spill' (an excess) of up to well over 100 TWh/y of such variable electricity in 2050. The larger renewables 'fleet' would supply more electricity even at times of low winter wind when consumer demand is very high. This would both reduce the annual need for using relatively expensive dispatchable electricity to fill supply-demand shortfalls, while providing more excess electricity for producing green hydrogen for dispatchable generation to fill the supply shortfalls and other carbon-reducing uses e.g. DACCS and DACCU e.g. producing synthetic hydrocarbon fuels (see Annex 1).

31. In the Energy White Paper (page 62) the Government has committed to making its energy sector modelling more transparent and accessible to stakeholders.

Future costs reductions of offshore wind and PV technologies and nuclear financing schemes

32. Offshore wind and PV generation costs have fallen significantly in recent years as the technology begins to mature. Further potentially significant cost reductions below 2020 costs have been identified regarding offshore wind in particular, see report in Nature April 2021 (attached).
33. The most relevant cost reductions in the UK 2050 context is that of floating offshore wind technologies given that new onshore wind sites are becoming constrained and fixed platform offshore wind sites are relatively more limited. Any such potential for further significant cost reductions in offshore wind schemes would be precluded if a Sizewell C project were built. That is, saving in generating 25.5 TWh/y for 35 years (assuming a 35 year CfD type subsidy) from around 2035 using offshore wind schemes built between 2030-2035 and replacement schemes built with further cost reductions between 2055-2060 (assuming a 25 year life-expectancy).
34. In comparison, projected or expected cost reductions in Generation III+ nuclear projects look uncertain. The Hinkley Point C scheme construction costs have increased since its Final Investment Decision in 2016.

Negative Emissions needed to achieve net-zero by 2050

35. The Climate Change Commission (CCC) has estimated that up to 75 mtCO2 per year of negative emissions could be needed by the UK by 2050 to achieve net zero emissions (see EWP page 54). Such levels of negative emissions would likely require significant use of greenhouse gas reduction (GGR) technologies (BECCS and DACCS).
36. Significant levels of 'negative (carbon) emissions' can be achieved using biomass as a fuel source (i.e. BECCS). Biomass could be either burned directly, as in the Drax power station currently, or gasified to bio-methane or hydrogen and stored for use by gas-fired generating capacity on demand. DACCS technologies are currently forecast to be more expensive than BECCS but could utilise otherwise curtailed (excess) renewable electricity (e.g. during wind peaks) and high temperature reject heat from power generation. Note that baseload power (from nuclear power stations) would add to excess supply at times of high winds and strong sunshine. So fully dispatchable

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generation is better than moderately variable baseload generation in managing RE supply peaks.

37. BECCS would likely be needed at scale (tens of TWh/y) in any net-zero 2050 UK emissions scenario and would likely be the major 'carbon-negative' contributor (in comparison to DACCS, tree-planting, other). BECCS on biomass could result in up to about 8 mtCO2 of negative emissions per 10 TWh of electricity generated (i.e. 0.8 mtCO2 stored per TWh generated at around 90% capture rate).
38. So it is likely that reliable/dispatchable BECCS-based electricity generation will be needed at scale. This suggests that most biomass, outside essential industrial needs, should be directed for use in BECCS to achieve net-zero providing **essential reliable** (dispatchable) electricity supplies rather than the production of, for example, bio-aviation fuel which would reduce the cost of **non-essential** air travel.
39. The Government is currently carrying out a sustainable biomass review to inform a strategic policy for future use. The Government will establish a role for biomass by 2022 (see EWP page 54). Given the large impact of biomass on UK emissions scenarios it is pre-mature for the BEIS model to indicate that RE+CCUS scenarios cannot have significantly carbon-negative sector specific emissions rather than struggling to achieve 5g/kWh.

Construction Timescale

40. The Sizewell C scheme has a forecast 12+ year construction period after FID before first generation e.g. circa 2035 assuming a FID by 202~~5~~4. There are site-specific construction issues (as there are at the Hinkley C site) and a major issue for transportation of materials to the site on rural transport network that could slow the Sizewell C project completion. Hinkley Point C is also currently around 8.5 years late in its promised claim of roasting the 2017 Xmas turkey. Early carbon-reductions were a major rationale for the nuclear policy EN6 published in June 2011.
41. Construction time-scales for offshore wind and PV schemes are likely to be quicker and more certain, and some elements of a full 25 TWh/y equivalent scheme could be commissioned and operational before full scheme completion.

Summary

42. There are various non-nuclear fuels and technologies which can generate reliable, preferably dispatchable, low-carbon or carbon-negative electricity at scale. New-build nuclear projects, like a Sizewell C, are not needed, let alone ‘essential’, to providing reliable low-carbon generation. Consequently, the Sizewell C project is highly questionable in terms of an ‘IROPI’ rationale given the numerous Habitat’s Directive concerns expressed by various stakeholders.
43. The Government’s own 2050 electricity sector modelling indicates that non-nuclear scenarios comprising a mix of renewables (mostly offshore wind and PV) plus CCUS (which is happening anyway) would likely be cheaper than nuclear-inclusive system scenarios (plus CCUS). Consequently, there is no clear economic case, let alone imperative, for progressing the Sizewell C project on ‘affordable consumer electricity’ grounds either.

Neil Crumpton for TASC May 2021

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44. **Biography :** Neil Crumpton

45. Degree in electrical engineering at Liverpool University in 1977, Friends of the Earth Cymru energy campaigner from 1994 to 2010 including (anti) nuclear spokesperson 2007-2010. Member of BERR ACCATS (Advisory Committee on Carbon Abatement Technologies) 2008-2010. Bellona Foundation UK representative (specialising in carbon-negative technologies) 2010-2011. Energy consultant 2011 to date. Member of BEIS-NGO nuclear Forum 2013-to date (Deputy NGO co-Chair from 2019).

Glossary

BECCS - Bio-Energy with Carbon Capture and Storage
CCC - Climate Change Committee
CCGT - Combined Cycle Gas Turbine
CCS - Carbon Capture and Storage
CCUS - Carbon Capture, Use and or Storage
CfD - Contract for Differences
CHP - Combined Heat and Power
DACCS - Direct Air Capture of Carbon and Storage
FID - Final Investment Decision
GGR - Greenhouse Gas Reduction
HGV - Heavy Goods Vehicle
IROPI - Imperative Reasons of Overriding Public Importance
PV - Photo-Voltaic
P2G - Power-to-Gas
RAB - Regulated Asset Base
RE - Renewable Energy
TWH/y - TeraWattHours per Year
VfM - Value for Money

Annex 1

One British company Fuel From Air (FFA) Ltd* based near Loughborough has built a small-scale fuel synthesis plant which uses renewable electricity to produce ‘low-carbon' liquid hydrocarbon fuel eg, petrol, aviation fuel. The process extracts carbon dioxide from air and combines the carbon with renewably produced electrolytic hydrogen. So, this is a DACCU process (i.e. Direct Air Captured CO_2 + green H_2 = H/C fuel + H_2O).

The company has claimed it requires as little as 2.2 TWh of electricity to synthesise 1 TWh (thermal energy) of liquid hydrocarbon fuel. Even if it requires a conservative 3 TWh electricity then such a DACCU technology could play a significant role in carbon reduction by providing an easily storable liquid fuel ideal for dispatchable 'low-carbon' power generation or aviation fuel (otherwise requiring biomass-based production). 1 TWh of (fossil-sourced) jet fuel emits 260,000 tonnes of CO_2 when consumed. So around 4 TWh/y (thermal) of synthetic fuel, requiring 12 TWh/y of renewable electricity, could save 1 mtCO_2 per year (12/3 x 260k).

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A synthetic fuel process could prioritise the use ‘excess' (otherwise curtailed) RE electricity to minimise the fuel production cost. The production of about 13 TWh/y of synthetic liquid fuel would require the capture of around 3.3 mt of atmospheric carbon dioxide per year (3.3 m / 260 k). This is equivalent to a reduction on electricity sector specific emissions of 5 g/kWh (625 TWh/y x 5 g/kWh = 3.3 mt CO2/y). 13 TWh/y of fuel would require about 40 TWh/y of renewable electricity (13 x 3) or possibly less. The BEIS 'Modelling 2050 report shows curtailment levels across a range of ‘RE+CCUS’ scenarios (page 23, Fig 10). The Figure's 5 GW nuclear rows show considerable levels of curtailed electricity, from 60 to over 200 TWh/y.

It would be useful if the BEIS modelling included the utilisation of otherwise curtailed electricity for such synthetic low-carbon fuel production (DACCU) to achieve potentially significant reductions in sector specific emissions (eg at least 5 g/kWh to possibly over 20 g/kWh in the higher curtailment scenarios). DACCU would transform the BEIS analysis, as would the inclusion of some biomass-based generation (BECCS) in the forthcoming Biomass Strategy.

* http://www.westbeaconfarm.co.uk/fuelsfromairltd/index.html#:~:text=FUELS%20FROM%20AIR%20LTD%2C%20is,creates%20carbon%20neutral%20fuel%20loops.

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