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Civil Nuclear Energy Policy – An Alternative Perspective discussion paper

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Introduction

This discussion paper considers recent energy related events in the UK and abroad to re-examine the Government's rationale for nuclear new-build. The three stated 'pillars' or rationale of the nuclear programme are or were : timely ie by mid 2020s low-carbon electricity, energy security and consumer affordability. The paper also considers evidence presented at the recent Public Accounts Committee (PAC) on a possible unstated rationale for the planned new-build programme.

This paper focuses on cost to consumers and security issues and should be considered in conjunction with two recent Forum discussion papers (listed below) covering the other significant issues of concern about new nuclear energy programmes :

'Reasons for an NPS Review' Jan 2015 (a 19 page report and presentation summary - covering nearly every issue of concern about nuclear energy)
'Nuclear Energy Policy - NGO's Issues of Concern' July 2017 (a 20 page discussion document summarising the main issues of concern). Circulated with this Agenda.

Neither of these papers has had, to date, any substantive response or rebuttal from BEIS. This paper puts forward estimates for subsidy costs for Hinkley Point C (HPC) and other first-tranche nuclear projects compared to an offshore wind counterfactual based on recent CfD auction awards. Subsidies for HPC range around **£ 30 billion**, and a 16 GW five project programme range between **£ 50-85 billion.**

The cost estimates are set out in some detail in an Annex to this paper to show transparency and to encourage BEIS response or rebuttal of the costs, methodology, assumptions and or conclusions. A critique of the HPC 'Value for Money' (VfM) assessment is also included in the Annex.

The paper also considers in detail a possible hidden military rationale for a new civil programme, as suggested by academics at Sussex University, and concludes any such rationale is a mis-perception with very significant adverse and counter-productive consequences for National Defence.

Consumer Affordability

It is becoming increasingly obvious, month by month, to more media and UK public that the cost of nuclear energy is becoming significantly more expensive than a mix of intermittent renewable technologies even after higher estimates of additional system integration costs are added in. The Hinkley Point C (HPC) CfD deal has faced widespread public criticism including from the Public Accounts Committee (PAC).

The Sept 2017 offshore windfarm auction awarded 15 year contracts around £ 60 /MWh for 2022 delivery. Contracts for 2025-27 delivery could well fall further. Additional 'system 'costs, ie the extra needed for intermittent renewables [offshore wind], comprising gas-fired back-up, 'gas' balancing, electrolyzers and other costs, are likely to be in the range of **£ 7.5 /MWh** more than a new-build nuclear-inclusive system equivalent (see author's estimates and scenario calculations in Annex).
So a reasonable offshore wind+ system comparator or 'counterfactual' for mid to late 2020s delivery would be around £ 67.50 /MWh (in 2017 prices) for the first 15 years. Contract costs would likely fall further by

the time the 2020s turbines would need replacing in the late 2040s. In contrast, HPC CfD cost is £ 98 /MWh (in 2017 prices) falling to £ 95 /MWh if a Sizewell C is built.

A case can be made that the BEIS Sept 2016 Value for Money (VfM) assessment of HPC was so flawed in various assumptions and analyses that the next generations of British children will pay around **£ 30 billion more** as electricity consumers than they would have if HMG had followed a renewables pathway (see the author's HPC offshore wind system counterfactual calculations in Annex).

Yet Chancellor Hammond in his November 2017 budget spoke about 'not saddling our children with debts' one moment then announced that renewables funding to 2025 will be minimal the next. Notably, 2025 is when the Government is hoping that several nuclear new-builds will be coming online. So new nuclear schemes would from that time be drawing on the lion's share of low-carbon funds or other major subsidy mechanisms for 35 years (to around 2060) leaving renewables to fight for scraps.

That said, a 2017 National Grid report suggests that offshore wind may not need any subsidy by 2040 and the new BEIS climate change minister Claire Perry was enthusiastically saying on TV recently that some PV schemes are already subsidy-free.

It would be helpful in terms of public accountability, transparency and due diligence that BEIS respond to or provide a rebuttal of the conclusions, methodology, assumptions and estimates copied in this paper's Annex. The Annex gives a detail description and calculations which indicate that additional system costs of offshore wind are **about £ 7.50 /MWh** more than that of new nuclear build (assessed as part of a scale-up to a 100% Renewables Grid by 2050). It then uses a £ 5 and 10 /MWh additional system costs to provide an offshore wind scenario or 'counterfactual' to a 16-18 GW nuclear programme.

From a range of possible cost scenarios it can be shown that even IF subsequent nuclear CfD prices fell to between £ 70 /MWh and £ 82.50 /MWh then each remaining 3 GW scale project would still cost probably between **£ 5-16 billion pounds more than an offshore wind system counterfactual** which includes a highly reliable and resilient gas-fired back-up (including full replacement after 30 years). A five project 16 GW (125 TWh/y) nuclear deployment between 2025-2030 would **likely cost consumers £ 50-85 billion more than a renewable energy / offshore wind deployment** by 2030, assessed over 65 years between 2025 and 2090.

Given the criticisms of the HPC CfD deal HMG seems now to be looking to other funding mechanisms, such as equity finance, to procure any or all of the subsequent projects that comprise the five-six project 16-18 GW first-tranche new-build nuclear programme. Minister Harrington stated at a recent nuclear conference in London that '*nuclear will be cost competitive*' with other forms of electricity generation.

Clearly, IF the cost of borrowing £ billions for years is minimised by HMG backing for nuclear energy but NOT for large-scale renewables, particularly offshore wind, PV and PV-Thermal sources, then presumably nuclear could be made to look competitive to the lay-person even though it would be an anti-competitive action, and very probably outside public consent.

Offshore wind will likely be a major part of any renewable Grid, or indeed any Grid mix considering the 1,000+ TWh/y UK Continental Shelf (UKCS) resources. Yet the Government's vision of a 10 GW deployment in the 2020s represents a deceleration of the 10 GW built by 2020 from a standing start in about 2009. The Government could be aiming to build 35-40 GW or more of offshore windfarms from 2018 to 2030 which would generate the same annual electricity as a 16-18 GW nuclear programme.

Papers putting forward detailed system integrated renewable energy scenarios, and comparisons with nuclear-inclusive scenarios, have been presented to this Forum over the last five years and more :

* 'A Non-nuclear UK electricity system to 2030 and beyond' Feb 2013 (a 21 page report and presentation summary)
* 'Nuclear Pathways' paper/presentation June 2014 (a critique of HMG scoping reports of up to 75 GW nuclear by mid Century)

However, non of these reports have had any formal written response let alone convincing rebuttal by any CSA or DECC / BEIS staff with one minor exception. The exception was that a member of the DECC 2050 team (Simon Counsell) rebutted the 2013 report on the grounds that it would cost consumers about £ 40 billion more by 2050 than DECCs nuclear-focussed policy. However, in 2013 nuclear price forecasts were optimistic, early offshore windfarm contracts were high, the nuclear programme had not slipped by up to 10 years. Considering the sums of public money involved, £ 70 billion is a double-Brexit, BEIS would show significantly more public accountability if it responded in writing to Forum scrutiny.

The three pillared rationale for nuclear new-build

The three officially stated reasons for the 16-18 GW first-tranche nuclear programme are that it would provide : (timely) low-carbon electricity, energy security and affordable to consumers.

These three stated pillars are all now in ruins :

i. climate : renewables were always low-carbon, and bio-energy can be carbon-negative if coupled with CCS technology. The Government has shown zero concern that the significant slippages in the 2018-2025 nuclear programme will mean that 200 MtCO2 of emissions will not now be avoided by new-build nuclear as planned by 2025. In 2015 it also scaled back low-cost renewables and imported more Russian gas. So, a genuine commitment by Government to its professed 'climate' rationale is highly questionable.

i. security : cost-effective and practical UK Continental Shelf renewable energy resources are very large-scale, indigenous, geographically-dispersed, ever-replenishing and unstoppable, which can be harnessed by thousands of large and millions of small energy schemes and devices. Combined with widely dispersed 'gas'-fired and other back-up and storage, such resources would provide very high energy security, a highly reliable Grid supply, and a highly resilient Grid system, to match constantly changing consumer demand to changing supply. Centralised nuclear power infrastructure is a tempting terrorist target which could have devastating long-term radio-toxic consequences.

i. consumer affordability : renewables costs inclusive of their additional system costs are clearly becoming significantly cheaper than the nuclear projects - how low-cost do renewables have to be in the DDM modelling and VfM assessment to be preferred ?

Baseload and Intermittency

Minister after minister, since PM Blair's 'nuclear back with a vengeance' speech in 2006, have claimed that **nuclear energy is 'key', 'crucial' or of 'absolute' need**. Minister after minister claim that nuclear energy provides **'baseload'** and that renewable sources are intermittent and hence unreliable. This is a kindergarten level of understanding of an electricity system. How can a variable supply (from renewables) and a variable demand (by consumers) be balanced by the fixed output from a baseload (nuclear) supply ?

Yet, the constant repetition of this baseload versus intermittency argument, continues and new energy ministers (averaging one a year) do seem to get taken in by it. It seriously mis-represents the actual technical situation and engineering options that are available and likely to be built at scale in ANY likely future UK electricity-energy system, particularly 'gas'-fired back-up and electrolizers and energy storage.

It needs pointing out that the amount of 'gas' burnt and its annual carbon content ('gas' = Natural Gas, bio-methane, bio-SNG and electrolytic hydrogen) is likely to be about the same to balance the system in any likely 2050 energy scenarios nuclear-inclusive or not. That said, SoS Amber Rudd's 2015 energy policy to

significantly reduce renewables deployment, particularly onshore wind and PV. That same year Centrica signed up for increased gas imports from Putin's Russia.

So, it is clear that HMG would rather import gas from a nation implicated in proxy wars and the shooting down of civilian airliner than build PV and onshore windfarms which the majority of the British public continue to support in probably every poll ever carried out. Avoiding dependence on Natural Gas from Russia was a primary rationale for new-build nuclear during the energy reviews between 2005-2007 in the first place.

Security Issues

In terms of National Defence and energy security it would be difficult to significantly disrupt a decentralised renewable energy system, described above, even by concerted malicious or military actions or after major natural events. In stark contrast, large coastal radio-toxic critical infrastructure provide a relatively highly vulnerable, potentially devastating (and hence tempting) targets for terrorists or rogue states for at least 100 years to 2130.

The author's estimate (in previous papers) of nearly 40 mTBq of mainly Spent Fuel radioactivity (nearly half of all the UK's 87 mTBq legacy arisings) would have accumulated after 60 years at EACH of the five or six planned new nuclear sites has not been rebutted or confirmed by DECC or BEIS. Does BEIS actually know the amount for security analysis ?

A mix of renewable energy sources would provide significantly more UK energy security and energy system security than a nuclear-inclusive energy mix, let alone a nuclear-predominant Grid which is the Government's preferred vision and likely policy IF SMR's by 2030 can be made to look low-cost. Yet, despite the strength of these arguments, including that of falling renewables costs by 2016, the Government still pushed ahead with HPC.

This has led many observers to consider that some significant but hidden factor is playing on ministers' decisions that is not part of the three pillar rationale for a new nuclear programme.

A hidden military rationale for a civil nuclear programme ?

Note : for readability and clarity this section has been reworded in various places without changing the views expressed by the authors in the original text

Ministers, from 2007 to 2017 have routinely stated that a new-build civil nuclear programme is 'crucial', 'key' or of 'absolute need'. The Government's continued strength of commitment to its new-build nuclear policy, in the face of numerous and increasingly adverse challenges, is now baffling more and more observers. Some form of covert national security rationale has been proposed by some. A covert military rationale, or other disproportionate influence, would explain so much that such possibilities need to be considered.

The Science Policy Research Unit (SPRU) at Sussex University has presented evidence that a covert military rationale is influencing policy. The SPRU presented evidence to the recent PAC inquiry stating that (Summary 1.1) : '*...is partly due to a perceived need to subsidise the costs of operating and renewing the UK nuclear-propelled submarine fleet*'.

It is reasonable for Government to say that a new-build programme would have (overt) cross-benefits with military needs by creating similar or over-lapping skills and supply-chains, all other energy scenarios being equal (including the civil skills and supply-train benefits of building any technology). However, a covert Government cross-subsidy rationale, with a deliberate intention to subsidise future nuclear skills and supply chains for submarine construction and operation, is another matter as other energy scenarios may be much more than equal, and covert policies are hardy conducive to an informed democracy.

Indeed, it can be argued that any such covert rationale or influence on policy has spectacularly back-fired on the signing of the Hinkley Point C deal in September 2016. Given the possible £ 30+ billion subsidy costs of HPC alone it would have been much cheaper for the Government to simply directly fund any crucial military nuclear skills and submarine supply-chain services via taxation. Then, instead of around £ 900 million per year leaving UK consumers pockets to boost EdF's hollow bank account for 35 years, a much smaller amount each year could have been taken in tax to overtly fully fund the military submarine programmes that the UK electorate votes for.

During the 2006/7 nuclear energy policy debates the retention of nuclear skills and supply-chains for submarine construction may well have persuaded PM Blair in the post-Iraq War period to promote a civil new-build programme (https://www.rand.org/content/dam/rand/pubs/monographs/2005/RAND_MG326.1.pdf). It was a time before the seven Astute-class SSNs and four Dreadnought-class SSBNs were ordered, and UK naval reactor manufacturers were relying on help from their US Navy counterparts.

However by September 2016 these were hardly pressing concerns. The Astute class construction was underway and the Dreadnought submarines had been voted by Parliament and soon to begin construction for late 2020s delivery (https://www.baesystems.com/en/product/astute-class-submarines). These submarines will not stop being built by a large workforce at BAE Barrow shipyards just because HPC is late or never works or the other new-build projects do not get consented.

So any such skills and supply-chain considerations would or should by 2016 predominantly have related to post 2030 fleet type nuclear submarine design/manufacturing capabilities and a post-2060 deterrent class of submarines. Presumably, with voter consent, the Royal Navy would be looking to a 'PWR4' 20 MW-scale reactor design by 2030 for future fleet submarines (unless hybrid / battery electric submarines supersede nuclear steam propulsion), and a 'PWR5' reactor by 2050 for a Dreadnought-class successor commissioning by 2060 should a CASD (Continuous At Sea Deterrence) policy still be operative at that time.

Indeed, the UK electorate may want any future British naval reactor designs to NOT require fuelling with weapons-grade highly-enriched uranium (HEU) as this would be a very useful precautionary step in terms of UK security and global WMD non-proliferation. Only the Royal Navy and the US Navy currently operate HEU-fuelled nuclear submarines. Its unlikely that the UK electorate would want other countries to follow the Royal Navy's current HEU reactor fuel practice or want a UK nuclear deterrent to rely on the US Navy and it future reactor designs.

Compared to a HPC subsidy of possibly £ 30+ billion, directly funding the required military skills, supply-chain, and complex nuclear submarine design and construction capabilities, would be relatively small. Direct funding assessments should have been carried out (or perhaps were).

For example, retaining or creating one thousand CAD-experienced naval architects, reactor designers, and supporting staff and one thousand more in nuclear submarine propulsion related industries (eg at Sheffield Forgemasters) would cost possibly £ 150 million per year (assuming £ 60k pa average salaries plus £ 30 million other costs). £ 150 million per year is less than 0.4 % of the £ 40 billion per year UK defence budget (and would count towards the '2 % of GDP' defence policy). Its also just one fifth of the probable HPC subsidy between 2025 and 2060 (compared to an offshore wind counterfactual) or about £ 6 billion over 40 years to 2060.

The subsidy required to deliver the whole planned 16 GW new-build programme could amount to over £ 70 billion compared to a predominantly offshore wind counterfactual. For comparison, two additional squadrons of nuclear-powered submarines (14 SSNs at £1.4 b) would cost less than a third of that ie £ 20 billion. That scale of construction would keep the Barrow shipyards and associated industries in skill-sustaining employment (eg one SSN order every two years) from 2027 to 2055. The seven Astute class submarines are scheduled for construction over 14 years, so a similar drum-beat of one SSN order every two years.

Now, following the HPC deal, to maintain the required nuclear submarines skills and construction capability it would still be much cheaper to not consent any further nuclear power projects, cancel HPC (costing £ 2 billion ?) and directly fund via taxation the retention or creation of the required capabilities and also possibly build a few more nuclear-powered submarines. Even building some non-nuclear powered submarines would retain valuable skilled jobs at BAE Barrow.

Indeed, battery-AIP (Air Independent Propulsion) electric submarines, at less than half the price, half the crew, better stealth, simpler design, and far fewer operational headaches than nuclear powered submarines may soon become the submarine type of choice. Nuclear-powered submarines are definitely very fast over long distances but they cannot be in two or three locations at once. Nor can they be maintained at most, or even visit some, foreign ports which may impede the service's global reach.

In any event, it seems likely that more submarines, rather than surface ships, of whatever propulsion system may well be needed and various types of skilled jobs at Barrow are safe anyway. Hypersonic weapons (missiles and rail-gun projectiles travelling at 5,000+ mph) may well soon dominate the future surface naval environment making the undersea battle-space relatively more survivable despite increasing detectability. The Russian Zircon missile is now entering service : http://nationalinterest.org/blog/the-buzz/imagine-almost-every-russian-warship-hypersonic-missiles-22675. The potential for submarine-launched ICBMs (eg Trident) to become easy pray for hypersonic missiles by the mid 2020s let alone 2060 also needs to be considered.

Note also that a civil new-build nuclear programme is not necessary for maintaining nuclear weapons ie the UK weapons-grade plutonium stock is in excess of defence policy requirements and tritium for warhead 'refreshment' can be produced using particle-accelerators. Indeed, HMG's global promotion of civil nuclear energy only provides non-nuclear countries an excuse to develop dual-capability nuclear sectors eg Iran, Saudi Arabia (both countries with massive solar resources).

In contrast, strategic-scale deployments of offshore windfarms would be a major defence benefit in themselves. Thousands of turbines could support detection systems, plug-in points for electric submarine recharging and, if necessary, weapons systems. The structures could ensure safer airspace and sub-surface areas for allied submarines and for intercepting hypersonic missiles and unmanned undersea drones targeted at coastal UK critical infrastructure.

In summary, politicians have and continue to draw attention to the benefits of the planned new-build programme in retaining skills and supply-chains across UK civil and military nuclear industries. However, if such overtly stated benefits were a significant factor in the HPC deal then that influence was hugely disproportionate considering the likely massive subsidy which will be paid by electricity consumers. There would also have been skills and supply-chain benefits in offshore wind and other counterfactuals to include for comparison in the VfM assessment.

Due diligence was sorely lacking in the HPC VfM as the value of nuclear skills and supply-chain benefit was assumed rather than quantified and assessed. Possibly, no-one was asking critical questions not least because all the main political parties were in favour of the planned new-build programme and the political momentum for getting the new-build programme started was considerable. However, that still begs the question why the momentum.

If there was a covert and possibly 'crucial' military rationale (possibly conveyed orally so not necessarily written into any policy document) which drove the HPC deal, as part of the planned new-build programme, then it has spectacularly back-fired. It would have been much cheaper, eg £ 6 billion over 40 years, to set out the case to the electorate and put up taxes to directly fund the required crucial submarine-related capabilities. Consumers would then still have around £ 25 billion left in their bank accounts, not EdFs, if an offshore wind counterfactual was deployed.

It would be in the national interest for Government to facilitate informed public debate with the MOD and Royal Navy about the various future strategic military, energy and industrial considerations mentioned

above. Debate should take account of the security and defence issues, eg terrorism, Grid vulnerability, WMD proliferation, that the nuclear new-build option creates and which an offshore wind and other options avoids.

The BEIS nuclear directorate is tasked with getting new reactors built, not assessing reasons outside its remit and expertise not to. The security remit and expertise within the Office for Nuclear Regulation and the Environment Agency also precludes authoritative consideration of such major strategic defence issues and options. So there are gaps or chinks in the armour. Consequently the secretaries of BEIS and MOD at least need to ensure that there is a comprehensive overview of energy policy, industrial strategy and National Defence which transparently integrates and assesses all the future options and opportunities.

Continued

Summary

The three stated pillars of the nuclear programme rationale, (timely) low-carbon electricity, energy security and consumer affordability have been completely eroded by the reducing cost of renewables and the major delays in the planned nuclear programme. Hinkley Point C may well, if completed, cost around **£ 30 billion more** than a renewables strategy and a 16 GW programme could now cost **£ 50-85 billion more** than a 100% renewables by 2050 strategy. If there ever was an covert military rationale for a new civil nuclear programme then that too has now spectacularly back-fired, turning seriously counter-productive as renewables costs have fallen.

Future governments would have significantly more funds, amongst other things, to maintain the required submarine construction capabilities and services, and even to procure more nuclear-powered or hybrid electric submarines, if no more costly civil nuclear projects are subsidised (by whatever means) and preferably the HPC deal is cancelled (by whatever means). The children of today would not then be (secretly ?) saddled with this generation's nuclear debts (at Brexit times two scale costs).

Continuing with the planned (largely foreign) nuclear new-build programme while reducing the speed of deployment of offshore wind, PV, PVT, onshore wind, other renewables and CCS has and is likely to cause serious harm to British innovation, invention and jobs in those technologies, which have safe export potential. The Government's industrial strategy is looking day by day more a case of industrial suicide.

Worse, there would be major and seriously long-term national defence and security issues surrounding any new civil nuclear infrastructure which are completely avoidable.

In total contrast, renewable energy systems and infrastructure would be, by their decentralised nature, highly reliable and highly resilient to both strategic-scale malicious and natural events. As the protection of a country's people is one of the first duties of a government then the national defence benefits of a renewables versus a nuclear-inclusive energy system should also be a major consideration.

The planned leviathan new nuclear structures would be built in thick reinforced concrete and would stand until the end of this Century at least and the Spent Fuel stores would remain well into the next. Some sites would be threatened by sea level rise and storm conditions.

These would not be the kind of lasting monuments any political party would want. As of 2018 such structures are already looking likely to become one of the costliest industrial blunders in UK history and an even bigger naval blunder. The **Government now has overriding reasons to discontinue its support for the first-tranche nuclear energy projects** and plan for a major expansion of renewable energy systems in the UK, and for safe export globally, instead.