Time to Cancel Hinkley?

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1. Executive summary

Every day that passes makes it more expensive to cancel the two reactor Hinkley Point project. The latest renewables prices have again shown that Hinkley would be a very expensive way to meet our energy policy goals of reliability and sustainability. The proposed European Pressurised water Reactor (EPR), supplied by France's Areva NP is unproven in operation and the four reactors under construction worldwide have an appalling record of cost and time overruns. Areva NP is effectively bankrupt and while the French government is trying to broker a rescue deal it is far from clear whether this will be successful. Areva NP has acknowledged that it has been falsifying quality control records for safety-critical components for up to 50 years. This situation begs four questions: What are the costs and risks of going ahead? What would cancellation mean for the rest of the nuclear programme? What will it cost for Britain to pull out of the deal? Is Hinkley needed to keep the lights on?

The financial terms of the deal were announced on October 2013 and in October 2016, the UK government signed the Secretary of State Investment Agreement and the power purchase agreement (Contract for Differences) that contractually commit the UK to the project. The plant will be built by a consortium led by the French utility EDF. The contracts require consumers to buy all the power produced by the plant at a price of £92.50/MWh (2012 prices) under a 35 year index-linked take-or-pay contract, more than double the prevailing wholesale market price and well above the prices offered in the UK's September 2017 off-shore wind-farm auction.

It is impossible to forecast future wholesale electricity market prices but if we assume that today's prices (about £45/MWh) persist for the period of the contract Hinkley would add about £50bn to consumers' bills. If we assume the cost of sources like off-shore wind remains at about £70/MWh and set the wholesale price, Hinkley would add about £27bn to consumer bills.

The plant can probably only be built if the loans required by EDF, about £14bn, are guaranteed by British taxpayers. In 2008, the government forecast that a single EPR would cost £2bn but by 2017 the cost had risen to £10bn. In 2008, EDF claimed first power would be produced in 2017 but by 2017 first power was still 8-10 years away. Experience suggests there will be further delays and cost increases and it is likely these costs will fall on electricity consumers.

There will be a strong tendency for both sides to overstate the extent of costs already incurred and present Hinkley as a fait accompli. However, until main construction is started, the costs incurred will be dwarfed by those that would fall on consumers if the plant was built.

Hinkley is the first of five projects that the government claims would be on-line by 2030, but the other four projects, Sizewell, Wylfa, Moorside and Oldbury are as unattractive. The technologies proposed are problematic and no cheaper and the vendors are financially weak. Cancelling the Hinkley project should lead to the abandonment of the rest of the programme. Alternatively the government could indicate that it would pay no more than prices offered by renewable plants and that subsidies not offered to renewables such as loan guarantees would not be available.

Throughout the period since the nuclear programme was announced in 2006, there have been warnings that without it, security of supply would be jeopardised because of the need to replace old coal plant by 2025 and the existing nuclear capacity. These warnings have never been credible. The owner of the existing nuclear capacity, EDF, expects to keep most of the nuclear capacity on-line to around 2030. By 2016, the utilisation of the coal plant was less than 10% and the plant will be redundant well before 2025. The slippage of the nuclear programme by a decade suggests reliance on nuclear to fill a capacity 'gap' would be reckless. Energy efficiency measures would not only help us meet climate change goals but would also help deal with the burgeoning problem of fuel poverty. The renewable options have expanded dramatically and their costs have fallen. Even large scale renewables take no more than 2-3 years from start of construction to first power so there is ample time and options to meet any capacity need.

2. Introduction

Every day that passes will make it more expensive and politically more humiliating to cancel the Hinkley Point C nuclear power project for two reactors with total capacity 3.2GW. A recent study estimated that if Hinkley went ahead, it would be the most expensive 'object', in real terms, built on earth.[1] Yet it would use a technology, the EPR, that is unproven in operation and has run into appalling problems of cost and time overruns in the three projects using it. The reactor would be supplied by a company, Areva NP, that is in financial collapse and might not be saveable and which has been found to be falsifying quality control records for major items of equipment supplied for nuclear power plants over the past 50 years.

This bizarre situation begs at least four urgent questions:

- What are the costs and risks of going ahead?
- What would cancellation mean for the rest of the government's nuclear programme?
- What will it cost for Britain to pull out of the deal?
- Is Hinkley needed to keep the lights on?

3. The deal

The main terms of the deal between the UK government and the consortium that would build the plant, NNBG[2], were first announced in October 2013[3], and revised and fleshed out in October 2015[4]. In July 2016, EDF took a 'Final Investment Decision' (FID) to go ahead with Hinkley and in September 2016, the government signed the Secretary of State Investment Agreement (SoSIA) with the members of the consortium that would build the plant.[5] In the same month, the government body that would buy the power and NNBG signed the 'take or pay' power purchase agreement, the so-called Contract for Differences (CfD), (see below).

[1] http://www.bbc.co.uk/news/magazine-36160368 (Accessed August 3 2017)
[2] New Nuclear Build Generation Company
[3] https://www.gov.uk/government/speeches/agreement-reached-on-new-nuclear-power-station-at-hinkley http://media.edfenergy.com/r/130/agreement_reached_on_commercial_terms_for_the_planned (Accessed August 3 2017)
[4] https://www.gov.uk/government/news/hinkley-point-c-to-power-six-million-uk-homes https://www.edfenergy.com/energy/nuclear-new-build-projects/hinkley-point-c/news-views/agreements-in-place (Accessed August 3 2017)
[5] https://www.gov.uk/government/publications/hinkley-point-c-documents (Accessed August 3 2017)

The terms announced in 2013 were subject to negotiation and either side was able to withdraw with no penalty. The deal was referred to the European Union (EU) Competition Commission to determine whether it contravened EU state aid legislation in December 2013 and in September 2014 the deal was allowed with some modifications (see below).[6] This decision has been challenged by, amongst others, the Austrian government but their challenge, which will be heard in the European Court of Justice, has yet to be heard. The October 2015 announcement marked the signing of a 'Strategic Investment Agreement' (SIA). The details of the deal remained to be finalised. EDF took the FID in July 2016 with the expectation that the SoSIA would be signed directly after but the new Prime Minister, Theresa May, asked for a review of the project and this resulted in a two month delay before the SoSIA was actually signed. The terms of this review, who would carry out and the report on which the decision was based (if there was one) were not published. The signing of the SoSIA appears to mark the point where the two parties to the agreement were contractually committed to the project.

3.1. The consortium

When the Hinkley project was mooted in 2008, the consortium was expected to comprise Electricité de France (EDF) with 80 per cent and Centrica (parent company of British Gas) taking the rest. However, Centrica withdrew in 2013 and the 2013 agreement foresaw that Hinkley would be built by a consortium comprising EDF, 45-50 per cent, China General Nuclear (CGN) and China National Nuclear Corporation (CNNC), 30-40 per cent, Areva (10 per cent) and other investors not yet identified up to 15 per cent. The 2015 agreement saw major changes with Areva's effective bankruptcy making its participation impossible, the other investors had not materialised and CNNC had not taken a stake leaving EDF with 66.5 per cent and CGN with 33.5 per cent.[7] This is the structure that was in place for the signing of the SoSIA.

3.2. The cost of the plant

Up to the time of the October 2013 agreement, the expected construction cost of Hinkley, excluding finance charges (the so-called 'overnight cost'), was £14bn.[8] The October 2013 agreement raised the expected overnight cost to £16bn (in 2012 money). The European Commission estimated that with financing costs, the total cost of the project would be £24.5bn, about 50 per cent more than the overnight cost.[9] The 2015 agreement estimated the overnight cost as £18bn (in 2015 money) but EDF claimed costs had been stable since 2013 implying the apparent increase was just due to inflation. In July 2017, EDF admitted the estimated overnight cost in 2015 money had gone up to at least £19.6bn with a significant risk costs could be £20.3bn.[10] EDF claimed these extra costs announced in July 2017 would reduce its projected rate of return (IRR) to about 8.5 per cent compared to about 9 per cent initially. It did not promise that it would not try to pass on at least some of these extra costs to UK consumers.

[6] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2015:109:FULL&from=EN (Accessed August 3, 2017)
[7] The consortium for the follow-on plant at Sizewell would be EDF (80%) and CGN (20%)
[8] The Telegraph 'Hinkley Point nuclear plant: 10 things to know' October 21, 2013.
[9] http://europa.eu/rapid/press-release_IP-14-1093_en.htm (Accessed August 3 2017)
[10] https://www.edf.fr/en/the-edf-group/dedicated-sections/journalists/all-press-releases/clarifications-on-hinkley-point-c-project (Accessed August 3, 2017)

3.3. The cost of power

All the power produced by Hinkley would be bought by a new government-owned company, the Low Carbon Contracts Company (LCCC) under a take-or-pay contract who would sell it on, at cost, to Britain's electricity retailers. The difference between the contract price and the prevailing wholesale electricity price would be paid by consumers (so the retailers would not bear additional costs) via a subsidy, paid by consumers. The contract would run for 35 years from start of commercial operation of the plant The 2013 announcement stated the cost of power (the 'strike price') would be £92.50/MWh in 2012 money) indexed to inflation for the 35 years the CfD would run. There is scope for the price to be renegotiated after 15 and 25 years if operating costs are higher than expected.

3.4. Completion date

In 2008, the CEO of EDF Energy, Vincent de Rivaz predicted the first power from Hinkley would be before end 2017.[11] By the 2013 announcement, first power was not expected until 2023 implying a construction start in 2017/18 and by the 2015 announcement construction start had slipped again to 2019 with first power in 2025. In July 2017, EDF said the 2025 forecast still applied but admitted that this could slip to 2027 with construction start not till 2021. From 2013 onwards, EDF has made numerous announcements about the site work. In October 2015, EDF said construction would begin within 'weeks'[12] and, most recently in March 2017 it announced that concrete had been poured for power station galleries.[13] However, these are relatively small preliminary steps and do not represent start of construction in earnest, conventionally marked by the pouring of first structural concrete.

3.5. Loan guarantees

In 2013, the UK government offered loan guarantees ('pre-qualifying' the project) for the Hinkley project, at the time suggesting that loans worth up to £10bn would be guaranteed. The European Commission investigation into whether the Hinkley deal would contravene EU state-aid legislation suggested the guarantees would be worth £17bn.[14] One of the conditions for the Commission to accept the deal was that the fee for the guarantee would be increased from 2.25 per cent of the sum guaranteed to 2.95 per cent of the sum guaranteed. The fee should be a commercial one reflecting the risks that were being covered and the Commission required a larger fee because of 'concerns of underpricing of the risk'. There was an important condition on the offer of loan guarantees published in this verdict (some figures were redacted in the published report):

> 'During the period up to the Base Case Condition being met there is a cap on the amount of debt drawn being the minimum of: the debt milestone cap for the relevant project milestone and […] per cent of the Base Equity less development equity, i.e. GBP […] billion. The Base Case Condition is that satisfactory evidence has been provided that Flamanville 3 [an EPR under construction in France] has completed the trial operation period and that the requirements of the Guarantor in respect of

[11] Utility Week 'Going nuclear' February 1, 2008.
[12] http://media.edfenergy.com/r/960/agreements_in_place_for_construction_of_hinkley_point_c (Accessed August 10, 2017)
[13] https://www.edfenergy.com/energy/nuclear-new-build-projects/hinkley-point-c/news-views/progress-march-2017 (Accessed August 10, 2017)
[14] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2015:109:FULL&from=EN (Accessed August 3, 2017)

performance during such period have been met. The Guarantor has the option to extend the date for meeting the Base Case Condition into the future by increasing the amount of Base Equity and procuring that such increase benefits from the required credit support. The Base Case Condition date cannot fall later than 31 December 2020'

It appears that the cap referred to above was £2bn as the government released £2bn in loan guarantees in September 2015 'with further amounts available should EDF meet certain conditions and subject to fuller government approvals.'[15] EDF announced that it would not be taking up this offer saying it had found a 'more efficient' way of funding the project by using equity. Some misinterpreted this as a commitment to fund the entire part of EDF's share of the project from its balance sheet. In fact the key word was 'initially' and given the likelihood that EDF could not generate enough equity, this statement merely said EDF was not taking up the initial £2bn leaving open the option of taking up the offer of loan guarantees once the Base Case Condition had been fulfilled.

In October 2016, the government stated: 'The guarantee will be available from 2018 to 2020 if necessary conditions are met and is at government's discretion. Even if made available, and EDF have indicated to the Secretary of State for the Department for Business, Energy and Industrial Strategy that it is not their current intention to take up the guarantee, I judge the likelihood of any call under the guarantee to be very low.'[16] The refusal may be explained by a number of factors: the short duration of the guarantee; the size of the fee; and the lack of need for capital in the period the guarantees were offered. It is clear that without sovereign loan guarantees, no bank will lend money to the project and that EDF will not be able to finance its share of the project from 'equity' (essentially its own funds) so guarantees will be essential.

4. What are the costs and risks of going ahead?

4.1. Cost of the consumer subsidy

The strike price announced in 2013 has been almost universally seen as being very high. The financial cost to consumers of this contract will be the difference between the price paid for power from Hinkley to the price that would have been paid if the power had been sourced from the wholesale market. Adjusting for inflation, the price that will be paid for power from Hinkley will be about £102.50/MWh in 2017 prices. The wholesale price varies from day to day but in 2017 has been in the range £40-50/MWh. If we assume the wholesale price averages £45/MWh over the period of the contract and that Hinkley produces 24 million MWh per year, the annual additional cost borne by consumers will be £1.38bn/year in constant 2017 money or £48.3bn over the 35-year length of the contract.

However, given that the wholesale electricity market is a free market, prices cannot be predicted for next year, much less for the period from 10-45 years forward. In 2017, the power generation market was in transition. The largest source of power was gas with 42 per cent followed by renewables with 25 per cent, nuclear 21 per cent with coal only 9 per cent. By 2027, renewables will be the largest source of power and increasingly it will be their cost that will set the market price. The cost of renewables is falling sharply and, for example, bids

[15] https://www.gov.uk/government/news/2-billion-support-for-hinkley-point-c (Accessed August 3, 2017)
[16] https://www.parliament.uk/business/publications/written-questions-answers-statements/written-statement/Commons/2016-10-25/HCWS216/ (Accessed August 3, 2017)

for new offshore wind-farms only 3-4 years ago were about £140/MWh but recent bids for off-shore windfarms for the Netherlands, Germany and Denmark were in the region £60/MWH.[17] If we assume prices are about £70/MWH and even if we make the unlikely assumption that other renewables are as expensive as off-shore wind and there is no further cost reduction, this would mean the cost to consumers of the Hinkley deal would be about £780m per year or £27.3bn over the length of the contract.

The National Audit Office (NAO) carried out an assessment of the Hinkley contract[18] and their report estimates the 'net present value' discounted to 2016 of what it calls the 'top-up' payments as £30bn but does not give an undiscounted figure to compare the above estimates with. Discounting is a standard procedure and is based on the premise that income next year is worth less than income this year because income earned now can be invested to earn a return. The NAO report assumes a very low discount rate (effectively the real interest rate) of 0.7 per cent. This means a cost of £780m in 2067, the last year of the contract, would have a net present value in 2016 of £585m under the NAO's calculations. Without knowing the costs NAO assumes on a year-by-year basis it is not possible to compare their figure with those given above (£27-48bn) but it is probably in the middle to the lower end of the range.

4.2. What if things go wrong?

The figures above assume the two reactors are completed at the time and for the cost forecast, and that operating cost is not renegotiated upwards or if things do go wrong, the extra costs will be borne by the consortium as claimed by EDF. Given the appalling record of the three EPR projects it seems unlikely that Hinkley would be built to time and cost. The four EPR reactors under construction are 4-9 years late and, where costs are known, they are about three times the forecast cost.

EDF and the UK government have consistently claimed that EDF will bear the construction risk. For example in its press release to the October 2013 announcement, EDF stated: 'EDF group and partners will take the risk of constructing the power station to budget and schedule.' It implied, but did not explicitly state that the cost increases announced in its July 2017 statement would not increase the strike price. This appears to insulate the British public from the project risk in return for UK consumers assuming all the commercial risk that power from Hinkley would be more expensive than power from the market. How credible is this claim that consumers would be insulated from any construction cost increases?

The two partners in the consortium, EDF and CGN, are both large companies owned or controlled by their national governments respectively, albeit EDF's financial condition is deteriorating and is giving concern. However, the company that will build Hinkley will be set up solely to build and own Hinkley, it is a limited liability company with little scope to absorb costs. It is not clear what recourse to the parent companies there would be. If things do go wrong and if the project was not profitable, there would be a serious risk that the parent companies would simply allow NNB to go bankrupt. This would put the British government in a difficult situation. If the plant was already under construction, the government could refuse to assist it and simply leave the plant to be abandoned part-built. All experience with

[17] Offshore Wind 'The next UK CfD auction – how will it play out?' June 1 2017. http://www.owjonline.com/news/view,the-next-uk-cfd-auction-how-will-it-play-out_47903.htm (Accessed August 17, 2017)

[18] https://www.nao.org.uk/wp-content/uploads/2017/06/Hinkley-Point-C.pdf (Accessed August 3 2017)

large projects suggests this will not happen and the government will pour additional taxpayers' or electricity consumers' money into the project to ensure it was completed. If the plant was completed but could not meet its costs from income from the strike price – this might happen if the plant was unreliable or needed major repairs – again the tendency would be for the government to renegotiate a higher strike price so the plant would not be abandoned. There are also risks further into the future if, for example, the waste disposal provisions or the decommissioning provisions prove inadequate.

4.3. Loan guarantees

When the Hinkley project was pre-qualified to receive loan guarantees in 2013, the assumption appeared to be that about 70 per cent (£10bn) of the project's overnight cost (£14bn) would be covered by loans guaranteed by British taxpayers. If the project failed, the financiers would be repaid by the British government. The picture has become less clear since then by the entry of CGN, who might receive guarantees from the Chinese government, by the Base Case Condition and the unwillingness of EDF to take up the offer of an initial £2bn in loan guarantees. Nevertheless, the fundamental issue is unchanged: without sovereign loan guarantees from a credit-worthy country, no bank will lend money to EDF to build Hinkley.

The construction cost, with financing charges is now likely to be in the order £30bn. If we assume that CGN will be able to cover its element of the cost, about £10bn, through equity and loans from state-owned Chinese banks that leaves EDF to raise about £20bn. If we assume that 70 per cent will be borrowing (£14bn) and the rest equity that suggests guarantees worth about £14bn will be required. There is no suggestion that either the Chinese or the French government will be willing to grant loan guarantees so this will fall on British taxpayers.

4.4. Equity

If the Flamanville Base Case Condition is fulfilled and EDF takes up the UK offer of loan guarantees, EDF will need to provide about £5-6bn in equity in the construction period from 2019/20 to 2025/27. If it was to try to fund the project from equity alone, it would need to find about £14bn in that period. EDF has much larger and arguably more pressing calls for the equity it can raise, in particular the need to life-extend its French plants and incorporate the Fukushima upgrades required by the French safety regulator. These are estimated by the French Cour des Comptes to cost EDF up to €100bn between now and 2030.[19] EDF's profits are low and falling, and its shareholders are unlikely to be willing to see a large part of the profits re-invested in the business rather than being paid as dividends. In 2016, its profits (EBITDA, earnings before interest, taxes, depreciation and amortization) were only €16.4bn.[20]

It is trying to raise equity by selling €10bn of non-core assets and €4bn bonds. However, it has had to rely heavily on the French government for this equity. The French government

[19] http://www.world-nuclear-news.org/RS-EDF-faces-EUR100-billion-reactor-upgrade-bill-says-audit-office-1102164.html (Accessed August 4, 2017)

[20] https://www.edf.fr/sites/default/files/contrib/groupe-edf/responsable-et-engage/rapports-et-indicateurs/indicateurs-developpement-durable/edfgroup_cahier-performance-2016-en.pdf (Accessed August 4, 2017)

bought €3bn of the bonds and the only substantial asset sale was a share of the French electricity transmission company, RTE, bought by a French state-owned bank.

If EDF cannot generate sufficient equity this could put the project in jeopardy unless the French government was willing to provide the capital needed, for example, by buying more EDF bonds, an option that would raise again issues of state-aid, this time against the French government. Borrowing more money might reduce EDF's credit rating. The credit rating determines the cost of borrowing and given EDF's high level of indebtedness, the extra costs of a down-rating would be significant. EDF's credit rating has already suffered as a result of its involvement in the Hinkley project. For example, following the SoSIA, Standard & Poors reduced its long-term rating from A to A- and Moody's put EDF's rating of A2 on review with the risk of a downgrade.[21] These ratings are only as high as they are because of the high level of public ownership of EDF, more than 80 per cent, which Moody's states adds two notches to its credit rating.[22]

4.5. Financial collapse of Areva

In March 2015, Areva announced losses for the fifth consecutive year, this time of nearly €5bn[23] and it became clear it could not continue to trade without substantial assistance. The French government provided short-term loans to allow it to continue to trade while a rescue was put in place. Areva comprised two main businesses, the fuel cycle business, Areva NC, and the reactor business Areva NP, and the rescue involves the splitting up of Areva into two new companies. These are provisionally being called New Co for fuel cycle and New NP for the reactor business. The rump companies, Areva SA and Areva NP, will remain to deal with some of the historic liabilities and will be 100 per cent owned by the French state.[24]

The rescue of the fuel cycle company is more straightforward because it has limited liabilities. For the Hinkley and Sizewell projects, it is Areva's reactor business supplying the EPR that is most important. The rescue of the fuel cycle company, including a capital injection by the French government of €4.5bn, was approved by the European Commission as not contravening EU state-aid legislation in March 2017.[25] The rescue will not be completed until the New NP business has been divested (see below) and to tide the business over until then a loan by the French government of €3.3bn was also approved.

The scale of the reactor business's historic liabilities is such that a rescue may be impossible. One major liability is the cost of the overruns at the Olkiluoto plant. Areva gave a fixed price contract to the customer, TVO, for €3bn to build the plant, but current estimates are that the final cost will be more than €8.5bn.[26] Areva has long disputed its responsibility for all the cost overruns and the case is being heard in the International Chamber of Commerce although a final verdict is not expected soon. Nevertheless the initial verdicts have been in the

[21] https://www.businessgreen.com/bg/news/2471703/edf-suffers-credit-downgrade-following-hinkley-approval (Accessed August 4, 2017)
[22] http://www.world-nuclear-news.org/C-EDF-ratings-downgraded-UK-arm-clarifies-Hinkley-cost-13041601.html (Accessed August 4, 2017)
[23] http://www.areva.com/mediatheque/liblocal/docs/groupe/Documentreference/2014/DDR_EN_310315.pdf (Accessed March 22, 2017)
[24] http://www.areva.com/EN/group-749/provide-access-to-cleaner-safer-and-more-economical-energy-to-as-many-people-as-possible.html (Accessed March 22, 2017)
[25] http://europa.eu/rapid/press-release_IP-17-36_en.htm (Accessed March 22, 2017)
[26] http://uk.reuters.com/article/uk-tvo-areva-olkiluoto-arbitration-idUKKBN1350UA (Accessed March 22, 2017)

customer's, TVO's, favour.[27] The liability to Areva will be in the order of €3+bn if the court splits the cost of the overrun between Areva NP and TVO and the French government has agreed to meet the liability. The project will be completed by the rump company, Areva NP, not New NP

The rescue of the reactor business requires EDF to buy 75 per cent of New NP based on a valuation of New NP of €2.5bn. EDF would then hope to sell a minority stake in the company leaving it with a 51 per cent majority stake. In July 2017, MHI announced it would be taking a 19.5 per cent stake in New NP.[28] However, the deal for EDF to take the majority stake, announced in November 2016, is dependent on three conditions:[29]

- 'obtaining favourable conclusions from the ASN regarding the outcome of the tests on the primary circuit of the Flamanville 3 reactor;
- completion and satisfactory conclusions of the quality audits at the Creusot, Saint-Marcel and Jeumont plants;
- approval from the relevant merger control authorities [the European Commission].'

In May 2017, the European Commission decided that the takeover of Areva NP by EDF did not raise sufficient competition concerns for it to be blocked and this was claimed to have fulfilled the third condition.[30] The European Commission has yet to consider whether the deal contravenes EU state-aid legislation and if it finds the deal does involve unfair state-aid, the rescue could be blocked. The other two conditions for EDF's take-over of New NP are highly problematic.

In April 2015, the French nuclear safety regulator, Autorité Sûreté Nucléaire (ASN), announced that the reactor bases and lids Areva had supplied from its Creusot forge to the Flamanville and Taishan reactors did not meet specification with too much carbon in the steel.[31] The reactor vessel is of key importance to the safety case and a reactor vessel failure must be incredible. After the admission of the problem, Areva put together a case that these parts are strong enough. In June 2017, there were indications that ASN would allow Flamanville 3 to start up but rigorous monitoring and with a requirement that the vessel head be reviewed and potentially replaced in 2024.[32] If these indications prove correct, it would appear the first condition will be satisfied. However, such a decision would be puzzling. From an economic point of view, replacing the vessel head after four years, at a cost estimated by EDF of €100m, would be far more expensive than replacing it now, before it has been irradiated and has become radioactive. Replacing it now would delay the start-up of Flamanville because the replacement lid would take some time to order and be delivered and EDF has said it hopes to convince the regulator in 2024 that Flamanville can continue in operation without the replacement.[33] Starting the plant before the replacement was made

[27] Agence France Presse 'Finland's TVO claims partial win in Areva nuclear dispute' July 20, 2017
[28] https://www.mhi.com/news/story/1707312072.html (Accessed August 1, 2017)
[29] http://www.areva.com/EN/news-10873/edf-and-areva-sign-binding-agreements-for-the-sale-of-areva-np-s-activities.html (Accessed March 22, 2017)
[30] http://europa.eu/rapid/press-release_IP-17-1466_en.htm (Accessed June 1, 2017)
[31] http://www.french-nuclear-safety.fr/Information/News-releases/Flamanville-EPR-reactor-vessel-manufacturing-anomalies (Accessed March 22, 2017)
[32] http://www.world-nuclear-news.org/NN-EDF-confirms-Flamanville-EPR-start-up-schedule-1207174.html (Accessed July 13, 2017)
[33] https://www.edf.fr/en/the-edf-group/dedicated-sections/journalists/all-press-releases/approval-of-the-flamanville-3-epr-s-vessel-by-the-french-nuclear-safety-authority-asn (Accessed August 10, 2017)

would however mean the Base Case Condition would be fulfilled allowing the bulk of the UK loan guarantees to be released.

As these parts had been installed a few years earlier, they will not be readily accessible and therefore reparable or replaceable. If they are not and ASN rules the vessels are not strong enough the Flamanville plant will have to be abandoned. It seems implausible that if the French safety regulator rules Flamanville cannot be operated the Chinese safety regulator would allow reactors with the same problem to be operated and Taishan would also have to be abandoned. In these circumstances, it would seem inevitable that Areva NP would be held responsible for the abandonment of Flamanville and Taishan and would be liable for a large amount of compensation. The amount involved would be too large for EDF to cover so if Areva NP is to be rescued, this would, like Olkiluoto compensation, have to fall on French taxpayers.

As a result of this problem, ASN asked Areva NP to review its records at the Creusot forge going back ten years. Areva NP clearly found additional serious problems and extended the review back to 1965 and brought in its two other plants, Jeumont and Saint-Marcel.[34] No information had been given on the findings at these other two plants by June 2017. However, an initial review covering 9000 records at Creusot found 400 irregularities for equipment such as reactor vessels, steam generators, main primary system piping and transport packaging. This equipment has been installed not only in France but other countries that have bought Areva parts including the UK, USA, China, Japan and Switzerland. The French prosecutor was examining bringing criminal charges against Areva.[35]

In October 2016, the President of ASN, Pierre-Franck Chevet stated: 'this "purge" of documentation irregularities would continue. There is still one to two years' work. We will find other irregularities. It is obvious.' While the President of Areva, Bernard Fontana, said: 'This [audit] will take place throughout the year 2017, with priority given to files related to the operating fleet. We are expecting to find the same type of practices to those discovered as part of the marked files.'[36] In August 2017, ASN required EDF to review all components made at the Creusot Forge by the end of 2018 and provide adequate documentation two months before the reactors could restart following a refuelling and maintenance shut-down.[37]

In March 2017, Areva said: 'For now we have had no claims from any clients [relating to sub-standard equipment]. We are in talks with the clients & regulators concerned.'[38] The clear implication is that they expect claims and if they have installed equipment that does not meet the required specification, especially if the QC documentation has been falsified, it would be surprising if there were not such claims. If, as a result of the quality control audit significant numbers of large components, like steam generators or reactor vessel heads, have to be replaced because they do not meet specification or that there can be no confidence they do meet specification, the liabilities will be substantial. As with the reactor vessel issue, EDF

[34] http://www.areva.com/EN/news-10777/quality-audit-at-the-le-creusot-plant-end-of-may-status-update.html (Accessed March 22, 2017)
[35] http://www.french-nuclear-safety.fr/Inspections/Supervision-of-the-epr-reactor/Anomaly-affecting-the-Flamanville-EPR-reactor-vessel/Falsification-of-materials-analysis-reports-ASN-is-collaborating-with-the-ongoing-judicial-inquiry (Accessed March 22, 2017)
[36] European Power Daily 'Further Areva review likely to find irregularities' October 27, 2016.
[37] Reuters 'Regulator orders review of Creusot-made components on EDF nuclear reactors' August 16, 2017
[38] http://uk.reuters.com/article/us-areva-results-idUKKBN1683H0 (Accessed March 22, 2017)

could not contemplate facing this liability and if Areva NP is to be saved, the cost would have to fall on French taxpayers.

Areva's initial claim that the takeover of New NP would be completed in the second part of 2017[39] is not plausible as the quality audits are expected to continue well into 2018. Even when the reviews are complete, there is the issue of the liabilities that will arise. Clearly, given its relatively poor financial state EDF cannot contemplate facing large scale liabilities arising from QC issues and will only buy New NP if the French government covers them. Whether the French government will be prepared to underwrite losses that might run into tens of billions of Euro is questionable. If it will not, the second and third of EDF's conditions will not be met and the takeover would seem doomed.

4.6. Abandonment during construction

In July 2017, the risks of buying a suspect technology from a financially weak company were starkly illustrated by the abandonment, after four years of construction and US$9bn of investment, of the US Summer project in North Carolina to build two reactors (2.4GW) supplied by the collapsed reactor vendor Westinghouse. It seems likely a large proportion of these costs will be recovered from electricity consumers.

A twin project in Georgia, Vogtle, under construction for four years, is also at risk for the same reasons. A recent utility estimate suggested the Vogtle project would cost US$25bn to complete about 2.5 times the cost estimate when construction started.[40] This project is supported by US Federal loan guarantees worth US$8.3bn. If the project is abandoned, Georgia's electricity consumers and US taxpayers are likely to face a large bill albeit less, as is the case with the Summer project, than they would face if the plant was completed.

The French government is attempting to broker a rescue for Areva but it is far from clear whether this will be successful. If it is not successful, the Hinkley project would have to be abandoned before construction started because there would be no vendor to supply the reactor. This risk was clearly illustrated by the abandonment of the US Summer project. However, if it is saved, there is no guarantee the relaunched company will not collapse again during the construction of Hinkley. Areva has no realistic prospects for reactor orders other than for UK and its reputation is in tatters following the revelations on its falsification of quality control documentation.

4.7. Early closure

The agreements with EDF specify that if Hinkley is closed early because of a political decision by the British government, the plant owners would, understandably, be paid compensation for the income lost because the British government had chosen to unilaterally renege on the contract. The level of compensation would depend on how long the contract still had to run but the NAO suggested it could be up to £22bn.[41]

[39] http://www.areva.com/EN/news-10923/2016-annual-results.html (Accessed March 22, 2017)
[40] http://www.foxbusiness.com/markets/2017/08/02/tab-swells-to-25-billion-for-nuclear-power-plant-in-georgia.html (Accessed August 4, 2017)
[41] https://www.nao.org.uk/wp-content/uploads/2017/06/Hinkley-Point-C.pdf (Accessed August 3 2017)

5. What will it cost for Britain to pull out of the deal?

There will be strong incentives for both the British government and EDF to overstate the extent of costs already incurred and the compensation payable, and to present the Hinkley deal as too advanced to be cancelled. Is this really the case? There will be bitter recriminations if the deal is cancelled and the compensation payable is likely to be subject to very lengthy process. This is well illustrated by the dispute over the excess costs for the Olkiluoto EPR. This plant was contracted to Areva who gave a fixed price (turnkey) contract for €3bn in 2003 with construction starting in 2005. Costs escalated rapidly from the start of construction and by 2008 were about €2.4bn over budget. At this point Areva NP denied responsibility for these extra costs and in 2008 the matter was referred to the International Chamber of Commerce (ICC) for arbitration. By 2017 the issue was some years away from being settled.[42]

Conventionally the start of construction and the point when cancellation becomes expensive is the pouring of first structural concrete. EDF is not expecting to start construction until 2019 and may well not meet this latest forecast. EDF has acknowledged this will only be possible if 'the final design, which is on a tight schedule, is completed by the end of 2018.'[43] It is surprising that the design was not (and is still not) complete and therefore not fully reviewed when the Office of Nuclear Regulation gave the EPR a 'Design Acceptance Certificate' at the end of its Generic Design Assessment[44] process. This was an apparently exhaustive process that took more than five years. It seems likely that up to the signing of the SoSIA, the costs incurred were at the risk of those making them and that if the deal is cancelled now, only those costs incurred since then should be compensated

It has emerged that EDF ordered equipment for Hinkley as long ago as July 2011. Areva stated that a 'Contract [was] signed between EDF Energy and AREVA enabling AREVA to start manufacturing of the heavy forgings required for critical reactor components.'[45] These components included the reactor vessel lids and bases that were made at the same factory, Creusot, which made the same parts as those that were found to be defective and were installed at the Flamanville 2 reactor in France. The Hinkley parts were destructively tested in the investigation into whether the Flamanville plant should be allowed to operate and in 2017, replacement parts were ordered. It is not clear what other long lead-time parts have already been ordered and what the cancellation penalties would be. If they were ordered before the signing of the SoSIA, this was surely at EDF's risk.

6. What would cancellation mean for the rest of the government's nuclear programme?

As problems have mounted with the Hinkley project and criticism of the high costs has mounted, there are increasing suggestions that the Hinkley deal should be abandoned and the

[42] http://www.world-nuclear-news.org/C-TVO-welcomes-partial-award-in-Olkiluoto-EPR-arbitration-1011164.html (Accessed August 9 2017)
[43] https://www.edf.fr/en/the-edf-group/dedicated-sections/journalists/all-press-releases/clarifications-on-hinkley-point-c-project (Accessed August 4, 2017)
[44] http://www.onr.org.uk/new-reactors/index.htm (Accessed August 14, 2017)
[45] http://www.new.areva.com/EN/global-offer-1477/mediashare-1244/pdf/project-profile-Hinkley-Point.html (Accessed August 8 2017)

other projects fast-tracked. For example, Lady Barbara Judge, former Chair of the UK Atomic Energy Authority said:[46]

> 'So far the French have been late and over budget with their projects in both Finland and France. Now the only way that they will build a nuclear plant is with Chinese investment. It is possible we could have faster, cheaper power delivered by Japan, a country with which we have good relations – why not at least rethink it.'

Are the other projects less problematic? The government has indicated that it expects the power purchase price for reactors built by these consortia, both Horizon and NuGen are Japanese owned, would be cheaper than Hinkley. NuGen and Horizon have said they hoped that power from their projects would be cheaper,[47] but there is no firm commitment from either consortium that the power purchase price will be any lower. There is no evidence from calls for tenders elsewhere in the world that the AP1000 or the ABWR would have lower construction costs (per MW of capacity) than EPR so, unless the cost of borrowing for Horizon and NuGen would be lower than for Hinkley, there is no reason to expect prices would be lower than for Hinkley.

As with the Hinkley project up to the signing of the SoSIA, all costs incurred by the consortia would appear to have been at their own risk so far so abandoning these projects would not seem likely to lead to any need to compensate them.

6.1. The 16GW programme

Since 2006, the British government has been careful not to give targets for the new nuclear programme stating investment decisions were best taken by the private sector.[48] Nevertheless, since 2013, it has frequently spoken of a programme of 16GW of new capacity to be on-line by 2030 with the first to be completed in 2023[49] based on the completion of projects at five sites. The 16GW programme is to be built by three separate consortia, Horizon and NuGen plus NNBG each using a different design (see Table 1).

Table 1 The UK nuclear power programme

[46] http://www.infrastructure-intelligence.com/article/sep-2015/thinking-smart-interview-lady-barbara-judge (Accessed August 9, 2017)

[47] In evidence to the UK House of Lords committee, an official from NuGen said: 'Our aspiration and goal is to deliver a strike price that is less than Hinkley.' An official from Horizon said: 'We believe it [the cost of Wylfa] will be certainly less than Hinkley, and I say that as well from a strike price perspective.' http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/economic-affairs-committee/the-economics-of-uk-energy-policy/oral/42755.html (Accessed March 22, 2017)

[48] In its 2008 White Paper on nuclear power, government stated: 'We do not think it is appropriate to restrict new build to approximately replacing existing capacity because the fundamental principle of our energy policy is that competitive energy markets, with independent regulation, are the most cost-effective and efficient way of generating, distributing and supplying energy. In those markets, investment decisions are best made by the private sector and independent regulation is essential to ensure that the markets function effectively. http://webarchive.nationalarchives.gov.uk/+/http:/www.berr.gov.uk/files/file43006.pdf para 2.266 (Accessed June 1, 2017)

[49] For example, in 2013, the government stated: In the UK, industry has set out plans to deliver around 16 GW of new nuclear by 2030.' https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/168048/bis-13-627-nuclear-industrial-strategy-the-uks-nuclear-future.pdf p 7 (Accessed June 1, 2017). In 2015, it stated: 'The UK is at the forefront of the European nuclear renaissance, with plans for up to 16GW of new nuclear reactors from 2023 onwards.' https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/168048/bis-13-627-nuclear-industrial-strategy-the-uks-nuclear-future.pdf (Accessed June 1, 2017)

Consortium	Shareholders	Site	Technology	Construction start
NNBG	EDF 66.5%, CGN 33.5%	Hinkley Point	2x1600MW EPR	2019/20
NNBG	EDF 80%, CGN 20%	Sizewell	2x1600MW EPR	?
Horizon	Hitachi-GE	Wylfa	2x1350MW ABWR	2020
Horizon	Hitachi-GE	Oldbury	2x1350MW ABWR	?
NuGen	Toshiba	Moorside	3x1150MW AP1000	2020
CGN	CGN 66.5%, EDF 33.5%	Bradwell	1150MW Hualong One	?

Source: Author's research

The Horizon consortium was set up by the two large German utilities, EON and RWE. Horizon bought the Wylfa and Oldbury sites in the government's 2009 auction. In 2012, EON and RWE sold their stakes in Horizon to the Japanese reactor vendor, Hitachi-GE, before it had made a decision on which technology to pursue. Hitachi-GE plans to build two of its Advanced Boiling Water Reactors (ABWRs) at both Wylfa and Oldbury.

The NuGen consortium was set up by a consortium of three European utilities, the other large French utility GDF Suez (now known as ENGIE) with 37.5 per cent, Spain's Iberdrola (37.5 per cent) and the UK's S&SE (25 per cent). In 2009, it acquired the Moorside site adjacent to the UK's fuel cycle centre at Sellafield. S&SE sold its stake in NuGen in 2011 leaving GDF Suez and Iberdrola each with 50 per cent of the company. In January 2014, the Japanese reactor vendor, Toshiba owner of the Westinghouse reactor vendor business took over Iberdrola's stake and some of GDF Suez's stake giving it 60 per cent of the equity. In 2017, ENGIE exercised its right to require Toshiba to take over its stake. By 2014, NuGen had not chosen the technology it would build but the arrival of Toshiba meant the Westinghouse AP1000 was chosen. NuGen plans to build three AP1000s at Moorside.

A fourth consortium led by CGN with EDF taking a minority stake (33.5 per cent) plans to build CGN's own technology, Hualong One, at the Bradwell site. However, the timing and the number of reactors to be built have yet to be confirmed and this project is not included in the UK government's 16GW projection.

Given the extreme difficulties EDF has faced financing the Hinkley project, completion of the Sizewell project, which is at a much earlier stage of development, by 2030 is clearly not credible. Equally, it is clear Hitachi is facing difficulties financing its lead project, Wylfa, and the Oldbury project can also be discounted.

6.2. NuGen

The NuGen Moorside project has similar problems to the Hinkley project. The reactor vendor, Westinghouse, is bankrupt and by August 2017, there was no sign of a buyer for the company, certainly not one that would continue to market new reactors. Of the eight AP1000 reactors under construction, the four in China are likely to be completed as the Chinese partner claims to have enough knowledge of the design to complete the plant, the first probably coming on line in 2018. However, two reactors in North Carolina which have been under construction since 2013 were abandoned in July 2017 because there was no vendor to complete the plants. Two other plants in the state of Georgia are also at risk of being abandoned.[50]

[50] https://www.bloomberg.com/news/articles/2017-08-01/fate-of-new-nuclear-in-u-s-now-rests-on-one-utility-in-georgia (Accessed August 9, 2017)

The record of the AP1000 is no more convincing than that of the EPR. The four reactors in China, like the two EPRs in China, are all at least four years late after 6-7 years of construction. The four reactors in the USA are also at least four years late after only four years of construction.

If a buyer for Westinghouse was found that would continue to market the AP1000, there would still be even more serious problems of financing the reactors than those faced by NNBG. EDF and CGN are large companies and can generate some equity. Even before its collapse, Westinghouse, was a much smaller company with a market value of only £1-2bn. So it is clearly impossible to raise the £30bn that it would take to build Moorside. A NuGen official told a UK House of Lords Committee[51]:

> 'For us, the financing challenge is quite unique. We need to build on the technology, experience and delivery capability of our consortium with Westinghouse and Toshiba and look at ways, if possible, of attracting debt, and share that funding burden with sources of capital that might be willing to provide loans or investments against a technology of this nature. Certainly, with export credit agencies, that is something that is a viable path to pursue and something that we are actively pursuing.'

6.3. Horizon

At first glance the Horizon consortium's Wylfa project is less problematic. The ABWR technology is often portrayed as being proven in operation and Hitachi is not in financial collapse, but the problems with Horizon are hardly less severe than with NNBG and NuGen.

By the end of 2010, there were four Advanced Boiling Water Reactors (ABWRs) in operation, all in Japan, plus two more under construction in Japan and two in Taiwan (Lungmen), all eight using a version of the design dating from the mid-80s. These ABWR orders were split between Hitachi, Toshiba and GE, all of whom cooperated in the development of the design. In 2007, when Toshiba bought GE's main US rival, Westinghouse, the cooperation ended. Toshiba offers its own version of the ABWR, while for Hitachi and GE, orders outside the USA are handled by Hitachi-GE (80 per cent Hitachi) and those in the USA by GE-Hitachi (80 per cent GE). None of these new companies have won an ABWR order since their creation. The construction times of the completed reactors was only 4-5 years but the operating performance up to 2010 was very poor. In July 2007, an earthquake measuring 6.6 on the Richter scale near the Kashiwazaki Kariwa plant caused significant damage to the plants requiring them to be shut down for about two years.[52]

The four plants in Japan have operated very little since the 2011 Fukushima disaster, and it is not clear whether the two under construction will be completed. Construction of the plants in Taiwan has been suspended for several years and these are unlikely to be completed following a series of political, legal and regulatory delays. The vendor, in this case GE, and the customer, Taipower, are locked in a dispute over payment for the work completed and this, like the Olkiluoto dispute, is being assessed by the International Chamber of Commerce.

Hitachi is, like Toshiba, a small company. In 2016, a Horizon official told a House of Lords Committee:

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[51] http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/economic-affairs-committee/the-economics-of-uk-energy-policy/oral/42755.html (Accessed March 22, 2017)

[52] LNG Daily 'Tepco sets May 9 restart date for Kashiwazaki-Kariwa No. 7 unit' May 8, 2009

> 'Very similar to almost any nuclear new-build project, however, in competitive energy markets and competitive financial markets, we are faced with a funding gap. We are looking under all the different rocks. We are looking everywhere to see where that funding might come from, be it equity or debt. We would not preclude or exclude anybody at this point in time. But we are solving, ultimately, what is and what should be a private sector asset. There is no reason long term for an operating nuclear power plant to be necessarily in the hands of a Government. It could be.'

The collapse of Toshiba/Westinghouse clearly illustrated to Hitachi the risks it was incurring with the Horizon project. In June 2017, it announced it was looking to divest some or all of its stake in Horizon. It was reported that: 'If Hitachi fails to do so [divest itself of Horizon] before construction starts in 2019, forcing it to bear practically all the financial risk of the project, it will suspend its plans for the 2 trillion yen ($18.1 billion) project.'[53]

6.4. New consortium owners

The weakness of the NuGen and Horizon consortia has led to a search for new owners more able to provide the financial strength needed to attract the finance needed. There would appear to be only two plausible candidates: Korea Electric Power Company (KEPCO) and the Chinese State Nuclear Power Technology Company (SNPTC).

6.4.1. KEPCO

KEPCO, through its subsidiary Korea Hydro & Nuclear Power Company (KHNP), has been mooted as a potential investor, first in the Moorside project[54] and more recently in the Horizon/Wylfa project.[55] KEPCO is the state-owned electric utility for South Korea and is also the vendor for nuclear reactors in Korea using its own technology, the APR1400.

There are a number of apparent problems to be addressed. It is hard to see what would be to gain for KEPCO to build reactors supplied by other vendors assuming the AP1000 is still being offered. If it was to offer its own technology, this would have to successfully complete the UK's Generic Design Assessment process under which the UK regulator, the Office of Nuclear Regulation, carries out a comprehensive review of the design.[56] It would probably take at least a year before the review could start and the review would take 4-6 years to complete. If the review was successful, this would take the completion date for the first reactor well beyond 2030.

Another problem is that the newly elected (May 2017) President of South Korea was elected on a promise to phase out nuclear power in Korea. His four opponents stood on a similar promise.[57] It therefore seems unlikely that KEPCO will have strong South Korean government backing that would be needed to provide the finance and KEPCO is likely to place a lower priority on the nuclear option if it is not required for South Korea.

Its potential involvement in Horizon is no easier to understand. It has no knowledge or interest in BWR technology so it seems likely that if it was to invest in Horizon it would be to

[53] https://asia.nikkei.com/Business/Companies/Hitachi-scrambles-to-divest-UK-nuclear-risks-after-Toshiba-fiasco (Accessed August 9, 2017)
[54] Daily Telegraph 'Korean power company seeks to save nuclear project in Cumbria' June 29, 2017
[55] http://www.cityam.com/268940/korean-firm-eyes-stake-horizon-nuclear-power-plant-wales (Accessed August 14, 2017)
[56] http://www.onr.org.uk/new-reactors/ (Accessed August 9, 2017)
[57] Nuclear Intelligence Weekly 'South Korea: On Its Way to a Nuclear Phase-out?' May 12, 2017, p 4

build its own technology. If it believed the Wylfa site was cheaper to develop and less subject to local opposition, this might explain its interest.

6.4.2. SNPTC

There is some logic to SNPTC investing in Moorside.[58] It may be able to offer AP1000 technology from its experience, albeit poor, of constructing this design in China. However, it appears disillusioned with the AP1000, especially its high cost and is developing its own design, a scaled-up AP1000 designated CAP1400, presumably based on a belief that there would be scale economies. If it opted for the CAP1400 for the UK this would require a new GDA setting the project back 6-8 years with completion well beyond 2030.

SNPTC is much less experienced than CGN. It was only created in 2007 specifically to import AP1000 technology and the only reactor supply it has been involved in is as Chinese partner for the four imported AP1000s under construction in China. Discussions with SNPTC do not appear to have progressed.

7. Is Hinkley needed to keep the lights on?

This is perhaps the easiest question to answer and falls into three parts. Is there going to be a capacity gap; if there is, can we rely on the nuclear capacity to fill it; and if the nuclear programme is abandoned are there alternatives that can fill any gap.

7.1. Is there going to be a capacity 'gap'?

There have been consistent reference to the need to replace our existing AGR nuclear capacity, claimed to be all closing by 2023 and to replace our coal capacity which must be closed by 2025. The seven AGR stations have a capacity of about 7.5GW.

It is a misconception that these are all about to be retired. They are effectively re-licensed every 10 years for the next 10 years after a Periodic Safety Review.[59] The assumption that all will be retired by 2023 is based on the assumption that when these reactors come to the end of their latest 10 year period they will be retired and the owner, EDF, will not seek life-extension. EDF has said it expects the two oldest plants (Hinkley Point B and Hunterston B) to be retired in 2023 when they will be 47 years old. It made this forecast some time ago when it was still expecting to commission Hinkley Point C in 2023. It may be that the slippage of completion date will mean they will seek to run the plants for a few more years.

The other plants are more than 10 years younger but their PSRs are all due to be carried out in the next year or two. EDF has already said it expects to life-extend them till 2027 or later. If it operates them for 47 years as for Hinkley and Hunterston, this would mean their closure date was well after 2030.

The government has said it will require the existing coal plants to be closed by 2025. By then, the newest plant, Drax, will be 45 years old and the other plants will be about 55 years old so they will be long overdue closure by then. By 2016, their usage was already very low with coal contributing less than 10 per cent of Britain's electricity in 2016. The likelihood is this plant will be retired before 2025 because there is no need for it.

[58] Sunday Times 'Chinese eye rescue of nuclear plant' May 21, 2017
[59] http://www.onr.org.uk/periodic-safety-review/index.htm (Accessed August 17 2017)

The alternatives that would replace nuclear, primarily renewables but perhaps some gas for system balancing, all have much shorter lead-times than nuclear and are much less likely to suffer cost and time overruns – their record of construction is good enough that loan guarantees are not needed. Typically these options will produce power no more than 2-3 years after construction starts. If the nuclear programme is abandoned, there is more than enough time for alternative options to be pursued that would be on line by 2027, when Hinkley is expected to be completed.

7.2. Can we rely on the nuclear capacity to fill any 'gap'?

The record of the technologies proposed for the nuclear programme suggests it would be reckless to rely on nuclear capacity to fill any gap. The Hinkley project is already 10 years late even two years before construction might start. All experience suggests that if the project does proceed, and it could easily yet collapse if Areva NP cannot be saved or EDF cannot raise the finance. The other projects are, at best, at the point the Hinkley project had reached five years ago and face even more severe problems of finance and, in the case of the Moorside project, it appears the proposed vendor will not be rescuable. Two out of three of the technologies are totally unproven in operation while the third has a very poor record of reliability.

7.3. Are there alternatives that can fill any gap?

Energy efficiency measures remain by far the most efficient way to not only fill any capacity gap and reduce our greenhouse gas emissions, they would also make a major contribution to dealing with the other major problem that electricity consumers face, affordability or fuel poverty as well as providing employment in all regions. An energy efficiency programme targeted particularly at low-income households is a 'no regrets' policy

In the last decade renewables have made remarkable and sustained technical and economic progress worldwide. UK policy has been inconsistent with subsidies taken away or sharply cut giving no confidence to companies looking to enter the sector. This is in marked contrast to the unwavering support given to nuclear despite all the problems faced.

8. Conclusions

It is now clear that the Hinkley project and the rest of the nuclear programme is massively misconceived. In the decade since it was announced, costs have escalated alarmingly, the programme is now a decade late and experience with the technologies proposed is all bad. Costs are prohibitively high and the risks to our supply security of relying on a large nuclear programme are unacceptable. The costs of abandoning the Hinkley project are rising substantially now the SoSIA has been signed but while these costs are high, they are much lower than persisting with the Hinkley project. They are also dwarfed by the 'opportunity costs' of the nuclear programme – what options are we not pursuing because we are assuming nuclear power will meet our objectives. Pursuing a consistent policy of energy efficiency measure and promoting renewables would be a much more cost-effective way of meeting our climate change goals.

If Hinkley is abandoned or collapses, there will be those who suggest we should fast-track the other consortia. This would be a mistake. The other projects have problems at least as serious as those faced by Hinkley and the likelihood is their costs would be even higher. The simplest and most efficient course would be simply to abandon the programme. The consortia have

incurred costs at their own risk and it is now clear they cannot deliver on the promise of 'no subsidies' that the nuclear programme was sold to the public on. Alternatively, the government can, as it has with renewables, give a maximum price it would be prepared to contract to buy the power from these consortia at. This might be set at the level of a 'basket' of renewable technologies or at the level of the cost of, for example, off-shore wind farms. It could also make it clear that to bring nuclear in line with the treatment of other low-carbon technologies, loan guarantees would not be offered. This policy would be in-line with the 2010 Coalition government's statement on nuclear subsidies: 'there will be no levy, direct payment or market support for electricity supplied or capacity provided by a private sector new nuclear operator, unless similar support is also made available more widely to other types of generation.'[60]

[60] https://www.gov.uk/government/news/written-ministerial-statement-on-energy-policy-the-rt-hon-chris-huhne-mp-18-october-2010 (Accessed August 10, 2017)