

NFLA New Nuclear Monitor Policy Briefing



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Financing the Hinkley Point C project – an analysis by Professor Steve Thomas

i. Overview of Policy Briefing

This edition of the NFLA New Nuclear Monitor is a more detailed written reproduction of a talk given by Professor Steve Thomas, Emeritus Professor of Energy Policy at the University of Greenwich to the joint NFLA English Forum / TASC / BANNG / Stop Hinkley seminar held in Colchester in late 2019. The report has been commissioned and assistance provided on the report by Alison Downes of the group Theberton and Eastbridge Action Group on Sizewell (TEAGS). NFLA sincerely thanks Professor Thomas and Alison Downes / TEAGS for reproduction of this report.

The NFLA joint meeting in Colchester noted above provided detailed information on the concerns of local groups campaigning against the development of new nuclear reactors at Hinkley Point, Sizewell and Bradwell – at present these are the only larger scale new nuclear reactor sites being developed. Hinkley Point C has its concrete base now built, but serious financing issues remain, as Professor Thomas highlights in this report. Sizewell has had four local rounds of consultation and is expected to apply for a Development Consent Order this year. The Bradwell site, now majority owned by Chinese nuclear utilities, is currently having its reactor design being considered by the Office for Nuclear Regulation and the Environment Agency under the Generic Design Assessment process. The Colchester meeting also had a presentation on the decentralised, renewable energy alternatives to new nuclear build.

The presentations from the Colchester meeting can be found at this webpage:
<https://www.nuclearpolicy.info/presentations/new-nuclear-power-plants-in-england-the-climate-siting-waste-and-finance-risks-of-bradwell-b-sizewell-c-and-hinkley-point-c/>

ii. Executive Summary

A funding crisis has put the completion of the Hinkley Point C nuclear power plant in doubt and has been brewing for at least five years. However, it is only part of the financial collapse that the majority owner, EDF is facing. Completing Hinkley will need an open-ended commitment of British and French public money. The sensible course is to abandon the plant now before more public money is wasted. When the deal for Hinkley was announced in 2013, for two reactors using the Areva EPR design, it was the British government's offer to guarantee all the borrowing that would be required, expected to be about £10bn, that was the key. This seemed to open the way to borrowing at rock-bottom rates. The plant was expected to be online in 2023, the power purchase price was set at £92.5/MWh (index-linked in 2012 money) based on an assumed construction cost, excluding finance charges, of £14bn. EDF expected to take a 45% stake in the consortium, £6.3bn.

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By 2015, the outlook had dramatically changed for the worse. The sister plants in Finland (Olkiluoto), France (Flamanville) and China (Taishan) were years late with costs rising and it had emerged that the supplier's quality control documentation was poor including falsification. Areva collapsed and EDF was required to take majority ownership of the reactor business, an unwelcome and potentially loss-making burden. The terms of the UK's credit guarantees were unattractive to EDF, especially for the first tranche of £2bn. The fee was high and there was a little publicised condition that the main tranche would only be released once Flamanville was in operation and this had to be before end 2020. Hinkley costs had increased to £16bn and EDF had failed to attract new investors increasing its stake to 66.5% with the politically problematic China General Nuclear taking the balance. Larger additional and higher priority calls had emerged on EDF's capital. The cost of life extending EDF's 58 French reactors was at least €4bn per year till 2030 and beyond and there was a gaping hole of at least €40bn in EDF's provisions to decommission its reactors and dispose of the high level waste. EDF declined the offer of the first tranche of guarantees and perhaps the second much larger tranche. In its place it launched a fire sale of assets and shares aimed raising about €14bn to meet its capital needs. But only about half of this was achieved, almost all from the French government itself and the profitability of its main businesses in France, UK and Italy was too poor for its profits to provide the capital.

By 2019, it was clear that EDF was unsustainable because it could not finance life-extension, clean-up liabilities and Hinkley. The projects at Flamanville and Olkiluoto were still not complete after 12-14 years of construction and costs were more than three times those forecast. Further quality control issues emerged at Flamanville, this time down to EDF, putting completion back to 2023 at the earliest so the offer of loan guarantees was no longer on the table. The completion of Hinkley had gone back to 2025-27 and the expected cost had increased to up to £23.2bn (EDF's stake more than £15bn) with nearly all of the construction phase, when cost escalation is most likely, still to come. However, the power purchase price remained the same and the deal, which in 2013 looked a cash cow for EDF, looks a loss-maker. EDF gave up its stake in the follow-on Sizewell C project and this will only go ahead if new investors can be found using the planned Regulated Asset Base (RAB) model. Investors will be interested if a 'blank cheque' is signed by the British government on behalf of taxpayers and consumers.

The EDF consortium has already spent about £6.5bn on the plant but with £18bn or more to spend, writing this off is a much better option than completing a loss-making plant. The EPR technology has failed and EDF should abandon it. The French public will have to pump tens of billions of Euros into EDF to keep it afloat and the additional burden financing Hinkley would impose would be unwelcome. Hinkley was supposed to be first of a new fleet of reactors in the UK that would provide the cheapest way to meet the UK's emission targets. But the five follow-on projects have either collapsed or are in serious doubt, and the costs of the alternatives (offshore wind etc) have fallen as dramatically as the costs of Hinkley have risen. The only logical decision is to abandon Hinkley and all the successor projects now.

1. Introduction

The Hinkley Point C project comprises two reactors each of 1600MW, using the French European Pressurised Reactor (EPR) design supplied by the French government controlled vendor, Areva. In June 2013, the UK government announced that credit guarantees would be made available to the consortium of companies led by Electricité de France (EDF) that would build the Hinkley Point C (HPC) reactors. The offer of loan guarantees was widely seen as solving one of the main barriers to the project going ahead, unlocking the finance necessary to build the plants. Yet, six years on, it has emerged that EDF has declined the offer of credit guarantees leaving it with few if any credible options for financing construction.

This raises the questions: how is the EDF consortium expecting to finance construction of the plant; and why did EDF turn down the offer?

To answer these questions, it is useful to examine EDF's attempt to raise capital from 2015 onwards and the current efforts to restructure EDF, known as Opération Hercule. Three specific documents provide important information:

- The report on the European Commission's inquiry into whether the Hinkley Point C deal constituted illegal state-aid; (1)
- The report by the UK National Audit Office into the HPC deal; (2) and
- EDF's Reference Document for 2018. (3)

2. Financing nuclear power plants

Large construction projects are typically financed by a mixture of debt, i.e., borrowing, and equity, i.e., funds provided by the developer itself. The interest rate charged on loans will depend on how risky to the institution lending the money to the project appears to be. It has long been clear that the record of nuclear projects being built to time and cost is so poor that no bank will lend money for one unless the risk falls on someone else. In the past, when electricity was a lightly regulated monopoly in most countries, utilities simply passed on whatever costs were incurred to consumers as increased tariffs, so the risk was falling on consumers. In many countries, notably the UK, electricity supply is now a competitive business and this option is not available. An alternative is for a government to provide sovereign credit guarantees. In effect, this means the lender is lending to the government which will repay the loans if the project fails. Lending to most governments is clearly low risk with correspondingly low interest rates but the risk is falling on tax-payers. Credit guarantees protect the entities providing finance but not the recipient of the funds. If the project goes wrong, the recipient could go bankrupt.

Equity is money that otherwise could have been paid to shareholders as immediate dividends. Allowing it to be used to fund investment, at best, postpones when shareholders receive this cash until the investment is operating and making a return for investors and, at worst, means some or all of the money could be lost if the investment produces poor returns or fails. There is no interest to be paid on equity but given that shareholders would generally prefer assured money now rather the hope of money in the future, in a project appraisal, the imputed cost of equity is higher, perhaps double that of debt.

For HPC, a common assumption when it was being negotiated was that debt would cover about 70% of the funds, with equity providing the rest.

3. The UK loan guarantee programme

In June 2012 by Chancellor Osborne announced a programme of government loan guarantees for large infrastructure projects (4) and a year later, it was confirmed that loan guarantees would be offered to the Hinkley Point consortium, New Nuclear Build (NNB) although the statement did not quantify the offer, saying just that the guarantees would be 'multi-billion' (5). At that time, the cost estimate for HPC was £12bn (6). The offer of credit guarantees was not expected and, for example, at a meeting between the Secretary of State for Energy and Climate Change, Chris Huhne, and opponents of the government's nuclear programme, Huhne said credit guarantees were not plausible because the Treasury would never allow them.

Four months later, after HPC was shortlisted for credit guarantees, the outline of the deal for HPC was announced. This set the price that would be paid for power at £92.5/MWh (7) (2012 prices), to be adjusted up with inflation, for 35 years of operation (8). When and if the follow-on Sizewell C project was completed, the price would come down to £89.5/MWh reducing the income from Hinkley Point C by about £67m per year. EDF anticipated taking only 45-50 per cent of the consortium, New Nuclear Build or NNB that would own HPC (£6.3-7bn of the cost) with other investors expected to include China General Nuclear (CGN) and China National Nuclear Corporation, CNNC, (30-40 per cent between them), Areva (10 per cent) and other unspecified investors taking up to 15% (9). The estimated cost of HPC had risen to £14bn and completion was expected in 2023 compared to 2017, which EDF had forecast in 2010.

No contracts were signed then and development costs remained at the risk of the parties involved. The statement said: 'EDF and HM Treasury will continue discussion regarding the terms of a potential UK Guarantee.'

4. **The European Commission Inquiry**

The deal clearly did involve state-aid and was referred to the European Commission to investigate whether it was in contravention of European Union competition law. In October 2014, the European Commission announced its decision that the deal could proceed. This verdict was still under appeal by the Austrian government in January 2020. The grounds for allowing the deal are not clear but they appear to hinge on a particular interpretation of the EURATOM Treaty and the Lisbon Treaty both of which form part of the Treaty on the Functioning of the European Union and which override competition law. Article 1 of the Euratom Treaty states: 'It shall be the task of the Community to contribute to the raising of the standard of living in the Member States and to the development of relations with the other countries by creating the conditions necessary for the speedy establishment and growth of nuclear industries.' Under the Lisbon Treaty, the UK claimed and the Commission agreed that member states had the right to determine their energy mix. Disallowing the HPC deal would, under this interpretation, violate these fundamental treaties. (10)

The verdict did give much more detail on the terms of the credit guarantees than the UK government had published and has since published and it states clearly that the Commission judged that the credit guarantees were State Aid (para 339).

'Credit Guarantee is offered by a public body of the United Kingdom and entails the resources of the United Kingdom. Therefore, the Commission considers that the Credit Guarantee by the UK on NNBG's debt involves State aid.'

The guarantees would apply not to bank loans but for bonds that EDF would issue. The Commission foresaw guarantees for up to £17bn. The Commission required that the fee for the guarantee (11) would be 295 basis points compared to the 250 basis points planned by the UK government. This was based on the assumption that the credit rating of the project was as low as BB+/Ba1, just below 'investment grade'. The credit guarantee would require the investors to supply 'significant' equity. However, the main revelation on the credit guarantees was that they would be offered in two tranches. The first smaller tranche would be capped at a sum that was redacted in the report. The rest would only be released when the 'Base Case Condition' had been fulfilled (footnote 9):

'The Base Case Condition is that satisfactory evidence has been provided that Flamanville 3 has completed the trial operation period and that the requirements of the Guarantor in respect of 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.'

The Base Case Condition was widely seen as having been required by the Treasury to ensure that British public money was not risked guaranteeing a project that used unproven technology.

The approval by the Commission opened the way for further negotiations between EDF and the British government and on October 15, 2015, further agreements were announced although still no contracts were signed. (12) The composition of the NNB consortium was set with EDF taking 66.5 per cent and China General Nuclear (CGN) 33.5 per cent. Other investors foreseen in the 2013 announcement had not materialised but EDF still said it intended to bring in other investors, perhaps taking its share down to 50%. (13) These additional investors have also not materialised. EDF acknowledged that estimated costs had increased to £18bn and that completion had slipped to 2025.

More details were given on the follow-on Sizewell C and Bradwell B projects. Sizewell C, like HPC, was expected to comprise two EPRs and the consortium would be 80 per cent EDF and 20 per cent CGN. Bradwell, comprising an unspecified number of reactors of Chinese design, Hualong One, would be 66.5 per cent CGN and 33.5 per cent EDF. At about the

same time, Chancellor Osborne announced in a visit to China that the first tranche of guarantees amounting to £2bn would be released. (14)

In June 2016 EDF took a 'final investment decision' on HPC, some five years later than it had first said it expected to take such a decision. In September 2016, the UK government announced that final agreement had been reached with EDF. (15) The contractual basis for the project was finally signed with the Contract for Differences (CfD) (16) under which the power would be sold, and the Secretary of State Investor Agreement. (17)

5. The National Audit Office Review

In June 2017, the UK National Audit Office (NAO) published its evaluation of the HPC deal. (18) This provided further details on the credit guarantees.

It became clear that the credit guarantees would be to NNB, not just to EDF so UK taxpayers would be guaranteeing credit to an entity owned by the Chinese government. However, it stated (para 3) that EDF 'does not expect' to take up the offer' [emphasis added] of the initial £2bn tranche. The conditions for this tranche were also made clear. The offer had to be taken up by December 2018 and the bonds repaid by end of 2020. The second tranche was stated to be up to £13.1bn.

The report also noted that (footnote 28): 'the government has recourse to the shareholders of NNB in case of a default.' This is an important safeguard as it means that if the project goes badly wrong, EDF and CGN cannot just allow NNB to go bankrupt leaving UK taxpayers to foot the bill, the government can pursue EDF and CGN.

Amongst NAO's conclusions were the following:

- When the Department finalised the deal in 2016, its value-for-money tests showed the economic case for HPC was marginal and subject to significant uncertainty;
- The Department's overall case for HPC has weakened since it agreed key commercial terms on the deal in 2013;
- Other parts of government [HM Treasury, Major Projects Authority, Major Projects Review Group] reviewed the deal but did not sufficiently consider its costs and risks for consumers;
- EDF's financial position has weakened since 2013;
- These factors mean there is a risk that NNB will seek further financial support from the government, notwithstanding the contractual terms of the deal.

NAO's brief is to assess value for money on public expenditure and on this, it concluded: 'the Department's deal for HPC has locked consumers into a risky and expensive project with uncertain strategic and economic benefit.'

In the same month as the NAO report was published, EDF published an updated cost estimate for Hinkley raising the expected cost to £19.6bn with construction expected to start in 2019, completion of unit 1 in 2025. However, it said the 'risk of deferral of delivery (COD) is estimated at 15 months for Unit 1 and 9 months for Unit 2. This risk would entail an additional potential cost of around 0.7 billion in 2015 sterling'. (19) It explained: 'The milestone for the first nuclear safety concrete for the building of Unit 1, scheduled for mid-2019, is confirmed, assuming that the final design, which is on a tight schedule, is completed by the end of 2018.' First structural concrete for unit 1, the conventional point used to mark the start of construction, was poured in December 2018 with unit 2 following a year later. (20)

In September 2019, EDF published a further update on costs and time schedule. (21) This stated that the estimated cost had increased to £21.5-22.5bn. The stated reason for the increase was vague. It was attributed to: 'challenging ground conditions which made earthworks more expensive than anticipated, revised action plan targets and extra costs needed to implement the completed functional design.' It also said that the risk of delay noted in its July 2017 announcement had increased with the same additional cost of £0.7bn making the cost estimate range £21.5-23.2bn. The announcement made it clear that the target of completing the final design by the end of 2018 had been missed although start of

construction, which it was implied was a necessary step before start of construction, did not appear to have been delayed.

In its state-aid investigation, the European Commission reported that EDF had estimated the target internal rate of return to be 9.75-10.25 per cent. The September 2019 EDF announcement estimated the additional costs had reduced the internal rate of return to 7.6-7.8 per cent. However, given that the power sale price remains at the same level as in 2013, £92.5/MWH, while the expected construction cost has increased by up to two thirds, it is surprising that HPC is expected to make a positive rate of return at all.

In 2018, when completion of Flamanville was expected in 2020, it was discovered that a large number of welds, about 70, did not meet the required quality control standard and would need repair. It is clear that EDF did not operate proper quality control standards over the welding. (22) Eight of these welds were no longer accessible to humans and these can only be repaired using yet to be developed robot technology. By the end of 2019, it was expected that fuel loading would not be possible before the end of 2022, implying commercial operation not much before the end of 2023. The reactor vessel lid would have to be replaced in 2024 (23) and starting up the reactor in 2022/23 and running it for about a year would mean the replaced lid would be contaminated making replacement more expensive and difficult, and leaving a large volume of low-level waste to dispose of. Particularly if there is any slippage in the weld repair programme, it would seem much more logical to delay start-up until the new lid was fitted, perhaps putting commercial operation back to 2024/25.

6. EDF attempts to generate new funds

By 2015, as noted by NAO, the outlook for EDF and its ability to finance its investments had changed significantly for the worse compared to only two years previously. Its sales remained at about the same level (€75bn) but its profits had fallen from €3.5bn to €1.2bn. The calls on its available capital were increasing. The cost of life extending its 58 operating reactors in France (so-called Grand Carénage, see below) was much higher than expected and it was expected to cost at least €4bn per year till at least 2030. Keeping most of its 58 French reactors in service is the highest strategic priority for EDF as without these, there would be no justification for allowing EDF to retain its total dominance of the French electricity market. So Grand Carénage is clearly a higher strategic priority for EDF capital than HPC.

The financial collapse of Areva in 2015 had left EDF with the unwelcome requirement by the French government to take over its unprofitable reactor division, Areva NP, an acquisition likely to increase financial pressure on EDF. The problems at the two EPRs under construction in Finland (Olkiluoto) and France (Flamanville) continued to get worse and it had become clear for the first time that the only other EPR orders, the two reactors in China (Taishan) were also suffering significant delays. The emergence of quality control (QC) problems including falsification of QC documentation going back 50 years at Areva's key forge facility, Creusot Loire and the quality issues with the reactor vessel installed at Flamanville and the vessels made for HPC left the reputation of Areva NP in tatters

For Hinkley, the estimated construction costs had escalated to £18bn and project completion had slipped by two years. All except CGN had failed to sign up to the Hinkley deal as investment partners leaving EDF with 66.5 per cent rather than 45 per cent. This meant EDF's share of the HPC construction cost had nearly doubled from £6.3bn to £12bn.

It had also become clear that the offer of credit guarantees for HPC was far from as attractive as it had first seemed it would be. The first tranche had to be taken up by the end of 2018 but repaid only two years later. To take advantage of the first tranche, EDF would have had to go to the expense of selling bonds at a time when it was already raising a large amount of capital, more than €4bn, with its 'Green Bonds' designed to finance its renewable investment.

The fee of 295 basis points would be reasonable for credit going forward 30 years or more but for two years, a fee of £60m (if it applied to the first tranche) seemed excessive. With hindsight, it is therefore not surprising that EDF chose not to take up the first tranche.

An EDF press release on October 15, 2015 when the HPC deal was announced stated (24): *'The project is due to be equity funded by each partner, **at least during a first stage.**'*[emphasis added].

This seemed to leave the door open to EDF to take up the much larger, more attractive second tranche. However, a press report the following January said that the Chairman of EDF, Jean-Bernard Lévy had announced (25):

'a "radical change" to what he said was a "more efficient" option of delivering its £12bn share of the project from EDF's own balance sheet.'

There has still been no formal announcement by the UK government or EDF that the credit guarantee offer had been declined.

By 2016, it was clear there was a significant risk that the UK government's Base Case Condition of Flamanville being in commercial service by the end of 2020 could not be met meaning that the offer of the second tranche was likely not to be made. This left EDF with a serious problem of how to raise the capital it needed.

As a result, EDF embarked on a programme to raise up to €14bn of capital to help fund investment not only in HPC, but also in installation of smart meters and the programme to life-extend its 58 French reactors. This was partly through a share issue and partly through sale of 'non-core' assets.

In March 2017, EDF announced a share issue worth €4bn. The French government owned 85 per cent of its shares, and it agreed to buy €3bn of the shares (26). The proceeds were reported to, in part, go to the financing of HPC. The risk with share issues is that, unless the company can demonstrate that the extra capital would unlock profitable investments, the share issue would simply dilute existing shareholders' stakes and the share price would fall.

Share issues are thus often unpopular with shareholders, although, in this case, as the dominant shareholder was the French government, this was likely not to have been a major factor.

EDF launched a sale of non-core assets aimed at raising €10bn between 2015-20 (27). A number of assets were mentioned, with the highest value ones being the French transmission company, RTE, British Energy, and a US nuclear generation company CENG. EDF sold a 50% in RTE, the other 50 % had already been allocated to its decommissioning fund, see below, and selling it would not have released equity to EDF. By French law, such assets as the transmission grid had to be held by public entities and it was sold for €4.2bn to government-owned entities, Caisses des Dépôts and CNP Assurances (28). CENG, a US nuclear company in which EDF took a 49.9 per cent share in 2009 was sold in November 2019. Under the terms of the 2009 purchase, EDF had the right to require the other owner of CENG, Exelon, to buy back EDF's stake so Exelon had no choice but to buy back the stake. The amount raised by the sale of CENG has not been published (29).

The UK nuclear generating company, British Energy, was bought by EDF in 2009 in a deal that valued the company at £12.5bn with 20 per cent of the shares held by the UK company, Centrica. Centrica has been trying to sell its stake since 2013 with no success, while EDF has been trying to reduce its holding from 80 per cent to 50 per cent since 2015, but also with no success. Given the age of the reactors, it seems likely that the value of the company will be much less than the inflated price EDF paid for it. In short, if a buyer can be found for the 30 per cent EDF wants to sell, it will pay much less than the £3.75bn such a stake appeared to be worth in 2009.

Overall, the sale of non-core assets had probably raised less than half of the target amount with the majority of money, as with the share issue, raised from the French government. This amount would finance Grand Carénage for no more than two years.

7. The EDF 2018 Reference Document

In March 2019, EDF published its annual report (30) or reference document for the year to end December 2018, the point at which construction actually started on unit one of HPC. By then, EDF claimed to have spent €7.5bn (£6.25bn) (31) on HPC but with borrowing costs of only €108m (£90m) suggesting virtually all expenditure to date had been paid for by equity. In 2018, €1646m (£1372m) was spent on HPC. Given that construction only started in December 2018, it is extraordinary that EDF had already spent 32 per cent of the then expected cost (£19.6bn) with comparatively little of it in 2018. The likely explanation for this high spend and the relatively low spend in 2018 when the project spend ought to have been ramping up is that nearly all the major items of equipment were purchased some time ago. It was reported that EDF ordered the reactor vessel in 2011 (32), five years before the contract for HPC was signed. Subsequently it was found that the lid and base were defective, having too high a carbon content, and must be replaced. Other major high cost items include the steam generators, the turbine generator and the pumps and by 2015, suppliers had already been contracted for these items as well as the large civil engineering contract. (33)

The expected remaining cost at the end of 2018 using the most recent cost estimate is £15.3-17bn and if the project is to be completed by end 2026 as EDF now claims, this implies an average annual spend of £2.2-2.4bn of which two thirds (£1.45-1.6bn) would come from EDF, significantly more than their total net profit (€1177m or £980m) for 2018.

The major item of capital expenditure for EDF in 2018 was for the 'Grand Carénage' or life-extension of the 58 operating reactors in France. By European law, reactors must undergo an in-depth assessment, the Periodic Safety Review (PSR), after every 10 years of operation.

The first of the reactors entered service in 1977 with all but 10 entering service by 1990 and needing a life-extension decision by 2030. In 2019, EDF announced, against its will, that it would retire the two oldest reactors (Fessenheim) in 2022, albeit with generous compensation from the French government (34) but EDF seems determined to life-extend all the other reactors. Expenditure on Grand Carénage started in 2014 and in 2018 €3.9bn was spent and for the period 2014-25, EDF estimated the total spend would be €45bn. The likely spend required in the next decade is discussed in the next section.

The other important issue requiring EDF capital is funding for the decommissioning of their reactors and disposal of the high level waste and spent fuel. EDF is not required to have a segregated fund (one that it has no access to for other than for approved decommissioning operations) but since 2006, it has been required to identify assets that are specifically allocated for that purpose. For example, half the value of the French transmission company, RTE, is earmarked to pay for decommissioning and waste disposal. It is not clear from the Reference Document how much money was spent in 2018 on qualifying waste disposal and decommissioning activities, nor is it clear how much EDF added to the available provisions. The impact of these activities on EDF's finances is discussed in the next section.

By contrast to the high level of spend on HPC, only €133m (£111m with €1m in interest charges) had been spent on Sizewell C by the end of 2018. This reflects that little site work has been carried out and no equipment contracted. For Sizewell C, EDF is advocating the adoption of the Regulated Asset Base (RAB) model, under which ownership of Sizewell C would be in the hands of financial institutions (see Box for an account of the RAB proposals). The proposals were put out to consultation in July 2019 (35) but by January 2020, there was no information on when the consultation results will be reported. (36) The 2018 Reference Document states: 'After the final investment decision, the project is not aimed to be controlled at EDF Level. Other investors and lenders should step in in due course.' EDF states the final investment decision is not expected before end 2021. The Generic Design Assessment approval given to the EPR design in December 2012 by the UK's Office of Nuclear Regulation (ONR) lasts for 10 years so, if a final investment decision is not taken by then, the design would require re-appraisal. This is not a process that has been carried out before so it is not known how extensive such a re-appraisal would be and what delay it would cause.

EDF's 'net indebtedness' was slightly higher by €0.4bn at the end of 2018 than it was a year earlier at €33.4bn. However, in the first six months of 2019, its net indebtedness increased by €4bn to €37.4bn. No indication is given on what objective EDF has on its level of indebtedness but given that its credit rating is well below the level it was 5-10 years ago and that further reductions in its credit rating would significantly increase the cost of servicing its debt and raising new debt, it is clear that controlling EDF's net indebtedness must be a high priority.

8. Opération Hercule

EDF was wholly owned by the French government until 2005, when about 15 per cent of the shares were sold. The state share had fallen slightly to 83.7 per cent by 2019. EDF has been in decline for the past decade and arguably since it was part-privatised. In the past decade, its share price had fallen by 75 per cent, its credit rating had fallen from A+ to A- and in 2018, its net profits were only €1.2bn on sales of €69bn.

Its corporate strategies have proved misconceived. A decade ago, it seemed poised to take a dominant position in electricity markets across Europe having acquired companies that gave it strong market positions in UK, Italy and Germany. It had major holdings in Switzerland, Belgium, Poland, USA & China. It also planned to become a major global owner of nuclear power plants, targeting UK, USA, Italy, South Africa and India. To build its position in the UK, in 2009 it bought British Energy, the UK nuclear generating company, for £12.5bn.

A decade on, it has sold its holdings in Germany, Switzerland, USA and Poland. The profitability of its UK and Italian businesses is poor with the UK business losing £382m in 2018. Three of its target nuclear markets (USA, Italy and South Africa) have failed completely, while it has made little progress in India, leaving only the UK.

The poor state of EDF's finances is clearly illustrated by their advocacy of the RAB model for Sizewell C. In many respects, this would be an ideal model for EDF. EDF would supply the reactor through its Framatome subsidiary, it would build the plant through its engineering division as for HPC and it would operate and maintain the plant. All of the contracts would be likely to be essentially on cost-plus terms with none of the risk of cost and time overruns that is associated with owning the plant. This would make the deal essentially a blank cheque signed by British electricity consumers. If it was required to fix the cost of construction, operation and maintenance, this would be a huge risk to EDF and one it would be unlikely to take. The experience of Areva offering a fixed price contract for the Olkiluoto plant and having to pay nearly €6bn to compensate for cost overruns ought to be fresh in its mind given that this was the major factor in the financial collapse of Areva.

In addition to these poor strategic choices, five specific factors have impacted adversely on its business: the HPC project; Grand Carénage; its decommissioning and waste disposal liabilities; the acquisition of the Areva reactor vendor business; and the profitability of its home market.

8.1. Completing Hinkley

By the end of 2018, the expected remaining cost of completing HPC, using the September 2019 cost update, was £15.3-17bn. All experience suggests there is a high chance the costs will be significantly higher. If the project is to be completed by end 2026 as EDF now claims, this implies an average annual spend of £2.2-2.4bn of which two thirds (£1.45-1.6bn) would come from EDF, significantly more than their total net profit (€1177m or £980m) for 2018.

8.2. Grand Carénage

The French safety regulator, the Autorité de Sûreté Nucléaire (ASN), has signalled that it will require major upgrades if it is to give approval for operation in principle for up to 60 years of EDF's French reactor fleet. Much of this cost arises from lessons learnt from the Fukushima disaster. The cost estimate between 2018 and 2030 for this is €50-100bn (€4-8bn per year).

(37)

Expenditure on Grand Carénage started in 2014 and in 2018 €3.9bn was spent and for the period 2014-25, EDF estimated the total spend would be €45bn. The remaining expenditure is difficult to estimate given that by the end of 2019, ASN had not even given approval for operation of the reactors beyond 40 years, much less specifying precisely what upgrades would be needed. However, the cost might be €2-4bn per reactor or more than €8bn in years where large numbers of reactors hit their 40th birthday. From a strategic point of view, given that the cost of replacing the old reactors with new ones would be prohibitive and that EDF's dominant position in France is dependent on continuing to supply a high proportion of France's electricity by its own reactors, it is clear that completing Grand Carénage is a much higher strategic priority for EDF than building HPC.

8.3. Decommissioning and waste disposal

A European Commission report of 2017 (38) showed the estimated cost of decommissioning the 70 operating and retired power reactors in France was €22.6bn or €0.3bn/GW of capacity. This is the lowest estimate per unit of capacity in the EU and less than half the EU average.

Overall there is little experience of decommissioning worldwide, and cost estimates for decommissioning, worldwide, have been increasing so there must be a high risk that EDF's estimate of its decommissioning liability is a small fraction of what will be required.

For waste management costs, the estimate for France is €45.8bn or €2.2/MWh of electricity produced, compared to the average for the EU of €3/MWh. There is no experience of final disposal of high level waste anywhere so costs are even more uncertain than for decommissioning but, as with decommissioning, there must be strong suspicions that the current estimate will prove far less than the actual amount needed.

The total estimate for France's 'back-end' liabilities (decommissioning and waste disposal) is €68.4bn compared to €23bn in funds available. France has been operating nuclear plants since 1960 and its first generation gas-cooled reactors were closed 26-36 years ago and the most challenging stage of decommissioning, cutting up and disposing of the most radioactive parts, has yet to be started. So if EDF is to meet the requirement stated in the 2018 Reference Document to decommission without a waiting period, expenditures will have to increase sharply and EDF will have to significantly increase its contributions to this to begin to fill the funding gap of at least €45bn.

8.4. Profitability in France

Because of its overwhelming dominance of the French generation and electricity retail sectors, EDF is required by the French energy regulator to make available some of its nuclear output to competitors at €42/MWh, less than its remaining generation costs. This means the profitability of EDF's core business in France will be low while this measure applies.

8.5. Acquisition of Areva NP

In 2015 after consistently incurring losses for several years, Areva, the French nuclear company that supplied reactors and fuel cycle services, could not continue to operate without government financial assistance. The French government provided massive financial support to the company and brokered a rescue deal that required the company to be split into two separate parts, Areva NP, subsequently renamed Framatome, which was the reactor vendor and service business, and Areva NC, subsequently renamed Orano. EDF was required to take an 80 per cent stake in Framatome at a cost to it of about €1.7bn.

Areva's losses were primarily in the Finnish Olkiluoto project which was sold on a fixed price contract for €3bn. When the dispute between Areva and the Finnish owners, TVO, was settled in March 2018, the cost of the plant had increased to €11.4bn with Areva forced to pay €5.9 bn of this cost.

The prospects for Framatome are poor even allowing for the fact that the settlement meant that no further costs from Olkiluoto would fall on it. The one reactor design it is offering, the EPR, has such a poor record, it is hard to see how any new customers would be attracted (39).

Apart from HPC, four EPRs have been sold, Olkiluoto and the French Flamanville plant, both of which are more than a decade late (neither is operating yet) and with costs nearly four times the estimate at start of construction. No reliable cost information is available on the two recently completed EPRs in China (Taishan) but these were both about five years late, in stark contrast to the relatively good record of China otherwise of building reactors to time.

In addition, Framatome's credibility is in tatters as a result of quality control problems. It emerged in 2015 that Areva NP's Creusot facility, the forge that makes some of the largest parts for reactors, had been falsifying quality control records for up to 50 years. The reactor vessel bases and lids for the EPR, safety critical components, being built at Flamanville and for HPC were found not to meet the required specification and new ones must be manufactured for HPC. Construction of Flamanville is too far advanced for the base to be replaced while ASN has said EDF must replace the lid in 2024 (40), the earliest a replacement part will be available. It therefore seems likely that Framatome will continue to be a drain on EDF's resources.

8.6. What will Opération Hercule entail?

By December 2019, the details of Opération Hercule were still to be set, but the basic plan is to renationalise EDF. It would be split into two parts: EDF Bleu, which would contain the nuclear and hydro-electric generation assets; and EDF Vert, which would contain other assets including its networks, its retail business and its renewables. While EDF Bleu cannot conceivably be privatised because of its liabilities, the expectation is that EDF Vert could be part-privatised.

9. How will HPC be financed?

Since 2015, the outlook for EDF has worsened significantly to the extent that a rescue operation brokered by the French government, Opération Hercule, is needed. It is clear another share issue would not be possible and there are no non-core assets to sell that the market would want to buy, so those are not options for EDF to raise capital.

For Hinkley, there is now a significant risk that completion will be delayed again till 2027, and the forecast cost has gone up to as high as £23.2bn. So since 2013, the cost of EDF's expected share of the project has gone up by about 150 per cent. However, the price paid for power (£92.5/MWh) remains as at 2013 leaving the profitability in doubt. If Sizewell C is built, this will reduce the price by £3/MWh costing EDF a further £67m per year.

It is clear that the only way banks or other investment entities would invest in the construction of a nuclear power plant is if the credit was guaranteed by a credible sovereign government.

Given the delays and cost escalation since the European Commission report stated the rating of the project was below investment grade, the rating is likely to be even worse now. The French and Chinese governments have given no indication that they would be willing to give such guarantees so if sovereign credit guarantees were to be given, it seems likely they would have to come from the UK government. Sovereign credit guarantees protect the entities providing the cash, not EDF, and increasing EDF's net debt would risk reducing further its credit rating and increasing the cost of servicing its overall debt. If the interest rate for its €33bn of debt was to go up by just 1 percentage point, this would cost EDF €330m per year.

The NAO report stated that in 2017 EDF did not 'expect' to take up the offer of the first tranche of credit guarantees. As argued above, this was not surprising. EDF would have to organise and incur the cost of the sale of bonds as well as the fee. The bonds would have to be repaid by the end of 2020, a period when expenditure buying equipment had already been completed and before main site work had started. The terms applying to the first tranche might be seen as an offer the UK government was obliged to make but did not want to be taken up.

In 2019, the UK Department of Business Energy and Industrial Strategy (BEIS) confirmed EDF had 'cancelled' the agreement for both parts of the credit guarantee. This raises a number of specific questions for which answers are not available:

- When did EDF cancel the agreement and what if any reason did it give?
- Was the offer of the second tranche dependent on the offer of the first tranche being accepted?
- Was the cancelling a deliberate strategic choice by EDF or just a recognition that EDF could not meet the Base Case Condition for releasing the second tranche so the offer was not going to be available?

However, the key question is what are the options for financing HPC?

9.1. Continuing to finance from equity

This does not appear attractive given that profits are well below the level needed to provide equity and there seems little prospect of profits improving given trading conditions in its two main markets, France and the UK. What equity is available must go to the higher priority demands of the Grand Carénage and filling the gaping hole in its back-end provisions. The option of selling shares and non-core assets to raise equity is not feasible.

9.2. Asking for new credit guarantees from the UK

EDF appears to have had no alternative but to cancel the 2013 agreement for credit guarantees but there may have been a tacit assumption that EDF could go back to the UK government for a new offer. BEIS is unwilling to comment on whether this is an option. Going back to the UK government was foreseen by the NAO, which stated: 'there is a risk that NNB will seek further financial support from the government, notwithstanding the contractual terms of the deal.' (41)

Asking for new credit guarantees from the UK government raises two issues. First, Flamanville will not be in commercial operation until 2023 at the earliest, and perhaps as late as 2025, so could not demonstrate the technology in most of the period when EDF would need finance. It may be that the government will cave in and accept as evidence of the provenness of the technology the operation of the Taishan EPRs and, perhaps, Olkiluoto if it enters service in 2020 as projected at the end of 2019. Second, when the original offer was made in June 2013, the cost of the power from HPC was not known, the main cost overruns and delays had yet to occur and the quality control issues with Areva components and EDF's construction had yet to emerge. Given all that has gone wrong with the HPC project and the fact that the price of the clearest large scale alternative, offshore wind, is only about 40 per cent of the HPC cost, convincing the UK public that new credit guarantees would be a sensible risk to take with public money would be a hard sell.

9.3. French Government support

The rescue of EDF will require huge amounts of French public money to be committed. It is not clear how popular this will be given the large amounts of French public money already poured into EDF in the share issue and the sale of RTE and involved in the rescue of Areva. French public money will have to cover the hole in the provisions for the back-end liabilities. When the UK nuclear generation company, British Energy, collapsed in 2002, part of the rescue deal (allowed by the European Commission as not contravening state-aid laws) was to essentially take over responsibility for back-end liabilities absolving the new owners from any cost. Agreeing to take over responsibility means, if UK experience is a guide, money would not be put into the back-end fund and comparatively little immediate expenditure would be needed, requiring funding only when the operation is carried out, perhaps far in the future. Government support is also likely to be needed to finance the Grand Carénage, a cost of at least €4bn per year, but vital if EDF's future is to be maintained. The government could spin-off Framatome again, freeing EDF from what seems likely to be a burden on its finances.

The French energy regulator, the Commission de Régulation de l'Énergie, only provides advice to the government, which is free to overrule its advice. The government could therefore unilaterally raise the price paid to EDF for the power it sells to competitors to a level that would be profitable to EDF. This would be contentious, raising consumer electricity prices

and seeming to illustrate the weakness and lack of independence of the French regulatory system. Given the riots that occurred when transport fuel prices were increased, politically this would be a risky step.

The French government could replace the UK offer of credit guarantees with one of its own. The French government has, in the past, offered to support Areva in export markets, for example the failed bids for South Africa and the UAE, with credit guarantees and for the Olkiluoto plant, it did give loan guarantees worth €600m. Again, this might be politically contentious given bad experience with Olkiluoto.

Perhaps most radical of all, renationalisation could see the French government guaranteeing all EDF's debts, as was the case up to the time of part-privatisation in 2005. This guarantee was a key factor in financing the French nuclear programme as it meant those lending money for it were essentially lending money to the French government and interest rates were correspondingly low.

9.4. Converting HPC to RAB

If HPC was converted to RAB, this would solve the problem of EDF financing the rest of the build. It would allow EDF and CGN either to retain a share in HPC equivalent to the amount spent so far (about 20 per cent and 10 per cent respectively) or allow EDF (and perhaps CGN) to recover the amount spent so far. The project would be somewhat less risky given that it has got to start of construction, albeit there is plenty of risk arising from the construction and operation phases.

However, there are a number of serious issues that would be likely to prevent the conversion to RAB going forward. There are firm contracts in place between NNB and the British government and, unless a mutual agreement could be reached between the parties to abandon these contracts, EDF would be liable to pay compensation. It remains untested whether investors would be willing to take a share of HPC if it was offered as a RAB project. If it turns out there are not, or the terms they require are unacceptable, the project would be left in limbo with no way forward. CGN might also be hostile to this outcome. Its investment in HPC was made because it opened the way for them to build their own technology at Bradwell B. It is reported that it prefers the CfD route to finance Bradwell B. If EDF ends up investing little or nothing in HPC and Sizewell C, given that EDF only wanted CGN's presence to help with finance, it is hard to see why EDF would want any contribution from CGN and why it would want to fulfil its 33.5 per cent stake in Bradwell B. (42)

The deal could also be unpopular with consumers and politicians. The advantage of a fixed, known but high price that the HPC has would be lost as under RAB, the price paid would vary from year to year rising and falling according to the costs incurred. No doubt, using optimistic assumptions about the remaining construction cost, reliability and operating cost, an indicative price could be calculated lower than the HPC strike price, but it would be clear this would be a best case scenario. Consumers would also have to begin to pay for HPC six or seven years before any power was produced.

Given that construction has started on the Hinkley project is and there would be a need for new legislation to implement RAB, converting the deal to RAB on balance seems unlikely.

10. Conclusions

In 2013, when the HPC deal was outlined, it seemed very attractive to EDF. EDF still believed the problems with the EPR design could be overcome, and it had negotiated a 35-year fixed price deal based on a construction cost more than double that expected for the single EPRs being built at Olkiluoto and Flamanville. The crucial barrier of obtaining finance appeared to have been solved by the UK government's offer to guarantee all the credit needed to build the plant. This meant that borrowing would be possible at very low interest rates reflecting the credit rating of the British government.

Two years on when the deal was further negotiated, the picture had changed dramatically. The only positive development was that the project had survived the European Commission state-aid investigation. Costs and time schedules for HPC were increasing and investment

partners that would have left EDF's share at less than 50 per cent had not emerged, leaving EDF with two thirds of the project. The costs and delays at Olkiluoto, Flamanville and Taishan had escalated and even the optimists within EDF about the EPR must have had increased doubts about the viability of the design. Areva's safety culture was clearly weak and its credibility was at rock bottom following the discovery of long term quality control failings, particularly the substandard reactor vessel parts supplied to Flamanville and manufactured for HPC. It was in financial collapse and EDF was expected to take on the unwelcome burden of majority ownership of its unprofitable reactor sales and services division.

EDF's profits were minimal and its credit rating was under pressure meaning there was little scope for equity funding from diverted profits, and life extension of the French fleet of 58 reactors (Grand Carénage) had emerged as a much larger and more important call on any capital it had available.

The offer of credit guarantees turned out to be much less attractive than expected. The smaller first tranche of guarantees for £2bn appeared to be far more trouble than it was worth. It was looking increasingly likely that it would not fulfil the condition for the release of the much larger second tranche, i.e. the completion of Flamanville by the end of 2020. There was therefore a desperate need to raise equity to pay for Grand Carénage, HPC and other calls on EDF's capital.

EDF therefore launched a 'fire sale' of non-core assets aimed at raising €10bn and a share sale aimed at raising €4bn. This would have been enough to finance Grand Carénage and HPC for several years.

By 2019, the situation had deteriorated again. Further delays, cost escalation and technical issues had occurred at Olkiluoto, Flamanville and Taishan. Further quality control problems at Flamanville, this time down to failings by EDF, meant that the condition necessary to release the main part of the UK credit guarantees could not be met and EDF had no alternative but to cancel the agreement. It was also forced to seek a new deal for Sizewell C, the RAB method that would mean it did not have to provide any of the finance. The problems with weld quality, assuming repairs are feasible, will, at best, delay start-up of Flamanville by 3-5 years and has put into question the safety culture of EDF.

The attempt to raise capital provided only half the amount targeted with the French government providing nearly all the capital raised. It is therefore hard to see what options EDF has to raise the capital needed to finance Grand Carénage and HPC and to fill the gaping hole in its 'back-end provisions.

EDF's poor financial performance has necessitated the launch of a massive rescue attempt Opération Hercule, which would split the company into two with the nuclear part, EDF Bleu, going back into full public ownership. This will require huge and potentially unpopular amounts of French public money. Perhaps EDF's best hope of completing HPC is if this package included provisions to assist with the finance of the rest of HPC.

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Annex - The Regulated Asset Base model

By 2018, it was clear to EDF that it could not finance its 80 per cent share of Sizewell C. However, if it could find others to provide the finance, the income from supplying the reactor, building the plant, and operating and maintaining it was attractive. It therefore proposed a model, Regulated Asset Base (RAB), that it claimed would see it treated essentially as if it was a network asset, like a transmission line. The owner of the asset would be able to make a 'fair' rate of return on the value of the asset as well as recovering their operating costs. Clearly, two of the key questions are: how will the value of the asset and the fair rate of return be set? A consultation paper was published by the UK government in July 2019, closing in October 2019. By December 2019, there was no indication when the government would report on the consultation.

The model EDF claimed as relevant was the Thames Tideway facility being built to improve water quality for London. This comparison is not valid in several respects. The expected cost of Sizewell C was almost an order of magnitude greater than that of Thames Tideway, nuclear construction is massively more prone to delays and cost escalation than a water facility. Most important, Thames Tideway earns its keep essentially simply by being there. Operating and maintenance costs are low and there is no output to sell and therefore no need for a purchase agreement for consumers to buy all the output.

The RAB model would only be attractive to investors and to EDF if the risks of cost and time escalation in construction, poor reliability and higher than expected operations and maintenance costs did not fall on them. Of course, this means that these risks, and there can be no suggestion that adopting RAB would reduce these risks in any way, would fall on the British public, most likely electricity consumers, through a power purchase agreement that would buy all the power for, perhaps 35 years, at a price that varied from year and was guaranteed to cover all the costs incurred. The RAB model has been sold to the public on the basis that transferring the risk from the owners and contractors would reduce the cost of borrowing. However, the risks are real and when risks materialise, any gains from lower interest rates will be counterbalanced by losses when such risks materialise. It is also implausible that the cost of borrowing will be lower than was anticipated for HPC. When the power price was negotiated, the credit was expected to be covered by sovereign credit guarantees and, given that the UK's credit rating is very high, the interest rate would have been at rock-bottom levels.

In practice, the major attraction to owners was the provision that costs could start to be recovered as soon as costs began to be incurred. Costs for nuclear power plants are nearly always quoted in 'overnight' costs, excluding finance costs during construction. Finance might add 50 per cent to the overnight costs so if this can be recovered from consumers as it is incurred rather than having to wait till the plant is in service, this would substantially reduce the financial burden on developers, transferring it to consumers. When construction times overrun, this has a huge impact on finance costs. For example, with the Olkiluoto and Flamanville projects that are expected to take more than 15 years to complete rather than the five years forecast, the increase in finance costs will be huge.

In the USA, construction started on two reactor projects (Summer and Vogtle, both for two reactors)) in 2013, the first new orders in the USA for nearly 40 years. The regulators in North Carolina and Georgia where the plants are situated allowed the developers to start recovering costs before even construction start – early cost recovery. After four years, costs and time schedules at both projects were out of control and the Summer project was abandoned. The Vogtle project is still proceeding but may yet have to be abandoned. This scheme of early cost recovery has left consumers having paid in excess of \$20bn, with nothing to show for their contribution.

Whether RAB is a serious option that both EDF and the UK government would like to proceed with, or whether it is simply a last-ditch attempt by EDF to keep the Sizewell project afloat that the British government felt obliged to test, will not be known until the consultation is complete and a decision whether to proceed with it is taken. However, if, as the NAO stated the HPC deal has 'locked consumers into a risky and expensive project with uncertain strategic and economic benefit', the RAB model appear substantially worse and should not be proceeded with.